TRAINING AND MISSION REHEARSAL FOR DEPLOYED NAVY AND MARINE AVIATION

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Currently, a family of shore-based training devices is available to train flight crews to safely operate and fully employ their weapons systems. Weapons System Trainers (WSTs) are used extensively to provide mission training and to build and maintain proficiency. This capability is not available at forward-deployment locations for the Navy or Marines, and is not available aboard ship. Additionally, recent operations have disclosed the absolute need for deployed tactical aviation mission rehearsal capability. As a result, the Navy is pursuing the development of a family of training devices designed to serve remotely located tactical aviation units, under the overall program title of "Deployed Tactical Aircraft Training System (DTATS)."

"OK, kid. Before you can fly, you've got to go down to the seventh deck and get your simulator hop. I'll see you there in fifteen minutes."

- long-standing Navy practical joke played on *new carrier pilots*

THE DEPLOYED TRAINING PROBLEM

In the early 1970s, Naval Aviation aircrew training was focused on preparation for two missions: prosecution of the air war in Vietnam, and strategic deterrence of the Soviet Union. At that time, Navy and Marine Tactical Aircraft (TACAIR) were primarily the F-4, A-4, A-6 and A-7. Weapons for these aircraft consisted almost entirely of free-fall bombs, Shrike anti-radar missiles, and Sparrow and Sidewinder anti-air missiles. The delivery mode of these weapons was predominantly visual, using fixed sights and precalculated delivery parameters derived from weapons tables. The A-6 had introduced all-weather "system delivery" of ordnance, including "smart bombs," but actual use of sophisticated weapons was assigned to specially configured aircraft and specially trained crews; the bulk of A-6s continued to drop iron bombs. Meanwhile, the fighters also prepared for a visual war. "Fleet Air Defense" meant point-defense interception of a few threats by a few F-4s.

Today, we expect a squadron of F-14s to be able to repulse a regiment of bombers in the midst of sophisticated jamming, by using Phoenix missiles that can be launched in one of five different modes. We count on F/A-18 pilots to detect and destroy enemy aircraft, destroy enemy surface-to-air missile (SAM) and anti-aircraft artillery (AAA) sites with High-speed Antiradiation Missiles (HARMs), and deliver bombs onto pinpoint targets, all on the same mission -- at night. An A-6E crew must now be equally adept at all-weather, low-altitude attack; high altitude delivery of laser-guided weapons; War at Sea employment of Harpoon missiles and remote operation of Stand-off Land Attack Missiles (SLAMs).

While the TACAIR aircrew tasks of the 1970s were not as complex in comparison with today's, they often called for more individual skill and "hand/eye coordination." Attack pilots were required to physically aim their bombsights at their targets, skillfully noting and correcting for wind effects and deviations from precalculated parameters (such as dive angle). At that time, the Sidewinder was extremely simple to fire ("point, tone, shoot"). but achieving valid launch parameters with an F-4 against a non-cooperative adversary was not easy. As a result of the need to build these *skills*, most mission training was conducted in actual flight, and involved repeated, skill-honing practice. Training meant flying, performing practice intercepts, dropping practice ordnance and firing practice weaponry at practice targets.

Since then, we have worked hard in the design of our new weapons systems to make them easier to use. For example, the "Continuously Computed Impact Point" mode of the F/A-18 makes it much easier for a Hornet pilot to bomb accurately, and theoretically reduces his training requirement. However, the broader range of missions and the complexity of modern weapons and tactics have more than offset any potential training reductions. An F/A-18 pilot is now required to manage Forward-looking Infrared (FLIR) sensors, radar, HARM and advanced Sidewinders and Sparrows, all on the same mission. Thus, in addition to piloting skills, an increased amount of weapons system experience must be developed.

The threat has advanced, too. Even if the Soviet Union should no longer be the Navy's main concern, modern Soviet weaponry still threatens us. The Navy and Marines confront a host of sophisticated weapons from sources all over the world, and some of our own that are in the hands of potential adversaries. In the early 1970s, the threat to TACAIR was AAA, SA-3 and SA-6 SAMs and MiG-21 jets with rear-hemisphere missiles. Today we must consider those same systems, as well as SA-10s, Crotales, Hawks, MiG-29s, Mirage 2000s, all-aspect missiles and sophisticated jammers.

Ashore, we have introduced some new training concepts to keep pace with these increasing training requirements. The effectiveness of our live flying program is greatly enhanced by the Tactical Air Combat Training System (TACTS), which has been integrated with Electronic Warfare (EW), SAM suppression and no-drop bomb scoring. But the biggest difference between shore training now and training "in the old days" is our current reliance upon simulators. Technological improvements in simulators now enable them to support training for most combat missions — a great advance from the basic instrument training and emergency drills of the early 1970s. Simulators have become the first introduction that young aviators receive to their fleet aircraft and weapons systems, and simulators continue to be relied upon for complex mission training after those aviators join the fleet.

Training while deployed is a somewhat different story, and is still almost entirely centered on flying. This means that during deployments, the classic training methods of the early 1970s are still the ones in use today. But the Navy's ability to conduct training in this manner has been steadily eroded by funding constraints. The flying hour program, which sought to provide an A-7 attack pilot with an average of 22.0 hours per month in 1983, will probably only achieve 20.8 hours average for an F/A-18 fighter *and* attack pilot in 1992.

Similar problems exist in providing the fleet with training ordnance, targets and adversaries, both at home and overseas. Training "space" is decreasing around the world, and is generally not sufficient in area or capability to practice tactics and employment the way we need to. We have a difficult problem replicating the complexity of the threat for training in the United States, much less overseas. Simulators have helped counteract these deficiencies at home, but we do not have an equivalent capability aboard ship or at our forward-deployment locations. Unfortunately, overseas is exactly where our training needs are highest.

The Navy is not about to willingly reduce its requirement to fly or to conduct live exercises with ordnance, targets and adversaries. We believe that we are right on the line with flying hours where further reductions will impact on safety. And because Naval Aviation depends so much on the skilled labors of our maintenance, flight deck, ordnance and engine room crews, flying is not just an *aircrew* training issue. The problem is that our live training program is no longer sufficient to ensure the level of combat proficiency we want our deployed aircrews to maintain.

TACAIR MISSION REHEARSAL

Weapons system and threat improvements are not the only causes for increased deployed training requirements. A combination of technological advance and military necessity has made "mission rehearsal" both feasible and in-demand. In the 1980s, Naval Aviation was presented with the task of frequently preparing, and sometimes executing, what became known as contingency operations (CONOPS). In many of these scenarios, aircrews were required to address heretofore unusual planning factors, such as the need to guarantee that no aircraft would be lost or that the strike would occur at a particular time of day, or wherein the "political message" was more important than actual destruction of the target. Many of these CONOPS plans were reviewed at high levels. Tactical surprise, defense suppression, target identification and first-pass delivery accuracy, always key elements of strike planning, became even more important. And unlike during Vietnam, the squadrons tasked with CONOPS rarely had any aircrews with previous experience over their potential targets. The Navy's requirements for mission rehearsal were born in this environment. While Desert Storm was not a classic CONOPS scenario, the potential lethality of Iraqi airspace, the timing of multiple missions and the desire to minimize collateral or friendly damage kept similar elements as major planning factors. Fortunately, early mission rehearsal systems (more properly "mission preview" systems) were available because of previous Persian Gulf operations (like "Earnest Will" and "Praying Mantis"), and their value has now been verified. As a result, the Navy and Marines recognize the need for mission rehearsal capability, and especially to have it on-scene with deployed forces.

CURRENT EFFORTS

The Navy has made several steps toward solving the deployed training problem and satisfying the need for mission rehearsal:

A-6E Systems/Weapons Improvement Program (SWIP) Part-task Trainer (PTT). Because shore-based trainers were not available for the A-6E SWIP aircraft in time for fleet introduction, the Navy developed this Ready Room trainer. The SWIP PTT, made by Delex Systems, combines low-fidelity flight simulation, sophisticated weapon and weapons system simulation and computer-based training. The SWIP PTT provides indoctrination and procedures practice for employment of the SWIP aircraft and the HARM, SLAM, Harpoon, and Maverick missiles, and is currently deployed with A-6E SWIP squadrons.

Networking. In 1990, the Navy and DARPA demonstrated the connection of the Combat Information Center of the USS Wasp to ship and helicopter simulators, with a simulated threat environment that represented a Mediterranean amphibious landing scenario. Simulator Networking (SIMNET) protocols were used, and a secure link was demonstrated. The Navy has signed a Memorandum of Understanding with DARPA to continue this development. The focus of current efforts is on supporting deployed and ashore tactical team training through networking, including the development of aviation networking standards, large-scale interactive threats, interaction between real and simulated systems and breakthrough visual display technology.

Embedded Training. The F-14A has had the capability for over fifteen years to generate simulated large-scale raids of fighters, bombers, missiles and EW on the cockpit displays while inflight. Aircrews maneuver as they would for actual threats, simulate firing missiles and receive a short debrief. For team training, one aircraft can send the scenario to wingmen via E-2C datalink. The system can attach simulated jamming to actual non-jamming targets and can score simulated aerial gunnery against real targets. Embedded training capability has become a requirement for future weapons systems.

Tactical Operational Preview Scene (TOPSCENE). In response to Persian Gulf operations of 1987 ("Earnest Will"), the Navy developed and fielded the first operational strike mission preview system. TOPSCENE generates real-time perspective images of target areas as they would appear from a moving aircraft, from overhead photography. The system, delivered in 1989 from LTV Corporation, presently consists of a database generation and mission preview system at the Naval Strike Warfare Center (NSWC) in Fallon, Nevada, and two carrier-deployable mission preview workstations. During Desert Storm, the two deployable workstations were in theater, aboard USS Theodore Roosevelt and with Marine Air Group 11. Additionally, NSWC produced videotapes of expected strike routes and target areas for the other ships and air groups that didn't have workstations. As a result of this wartime experience, mission preview is now an integral part of mission planning, and additional TOPSCENE systems are being procured.

Combat Training Systems. The various TACTS ranges have added significant value to our live training program through a combination of simulation, stimulation and networking. The TACTS range at NSWC can support 32 live aircraft, simulate SAMs and AAA, and provide detailed observation, recording, debrief and analysis of an entire strike mission. Defense suppression, air combat and target attack are all supported. The benefit of TACTS to live training is so great that the Navy is funding a program to take TACTS to sea, as the Tactical Combat Training System (TCTS). TCTS will track aircraft, ships and submarines; stimulate radar and EW sensors; simulate large numbers of threats and provide engagement, recording and debrief for an entire Battle Group.

While each of these programs is important and successful, they are unable to solve the entire deployed training problem. And each has its limitations. For instance, in a time of fiscal austerity, keeping the A-6E SWIP PTT in the same configuration as the aircraft is becoming a challenge, and the training requirements of the A-6E SWIP community are beginning to outgrow the capability of the current PTT. Networking has great potential, but has a way to go technically, and is meeting cultural resistance — the Navy is not yet ready to force a large group of players to stop work and assemble for *simulated* operations. Embedded training systems can display sensor data, but can't present the visual aspects of the battle. We are examining on-deck, in-aircraft embedded training using helmet- mounted visual displays, but the development expense, aircraft wear-and-tear and loss of maintenance time are significant issues. Even the excellent training provided by TCTS will only be as good as the funding for our steaming and flying hour programs.

It is also important to note that TOPSCENE does not fully meet the Navy's requirements for mission rehearsal. TOPSCENE provides familiarity with portions of the mission environment (the appearance), but not with all of it. The Navy's mission rehearsal system must completely immerse the crewmembers into the same problems that they will face during the actual mission. We desire not just to teach them enroute navigation and target recognition, but to teach them to navigate while being opposed by the threat, and to recognize the target as part of the process of delivering a weapon. The threat, the cockpit, the weapons system and the weapons themselves must be a part of the rehearsal.

THE DEPLOYED TRAINING SOLUTION — DTATS

What is needed is a system that fills the gaps in our training program, that complements what we can do in the actual aircraft with systems like TCTS, and that meets the requirement for mission rehearsal. One approach is to grow the well-regarded deployable PTT concept into a full-fledged WST, and equip it with a TOPSCENE-like image capability and a threat environment based upon the real world, and to place this device where it's most needed. The result would be a Carrier-based WST (CVWST) and a nearly identical Deployable WST (DWST). These would be interfaced with available mission planning and intelligence data systems. The Navy program to develop these devices and interfaces is known as the Deployable TACAIR Training System (DTATS).

The particular requirements for DTATS are based upon fleet inputs and a projection of the technology available in the middle-to-late 1990s. DTATS should:

- Support Navy and Marine TACAIR (F/A-18, F-14 A-6, AV-8, EA-6 and AX) with a single reconfigurable hardware suite. This is to minimize the requirement for several different cockpits aboard ship and to reduce unit costs.
- Provide weapons delivery training for all strike weapons (air-to-air and air-to-ground) including classified weapons. This is to reduce the impact of not having enough captive and training ordnance.
- Provide mission training to include Interdiction, Close Air Support, Special Weapons Delivery, Defense Suppression, Fleet Air Superiority, Combat Air Patrol, Strike Escort, Tactical Reconnaissance, War at Sea and Minelaying. Each of these missions is difficult to practice realistically overseas. DTATS must complement TCTS by including the visual and electro-optical sensor aspects of these missions, such as overland navigation and target recognition, and by providing continuous availability when airspace is limited or flying is curtailed.

- Display realistic and correlated photography-based visual, radar and electro-optical sensor images, as appropriate to the aircraft and weapons being supported. A capability for limited on-site update of databases from the latest intelligence imagery is required.
- Interface with mission planning systems in a manner that simulates the appropriate aircraft's system, and with other available data systems such that actual threat order-of-battle can be simulated.
- Present realistic, responsive and intelligent threats derived from actual order-of-battle.
- Provide multi-crew and multi-aircraft training by connectivity with other simulators, DTATS devices and TCTS.
- Be compatible with the shipboard and forward-deployed environment in size, sturdiness and power and cooling requirements. DWST versions should be self-contained, not requiring special buildings for housing.
- Not require an operator or instructor, or dedicated maintenance personnel. The device should be simple enough to initialize and calibrate that trainees can do it themselves. The device should be self-diagnostic, and require only the infrequent removal and replacement of failed components by onboard military technicians. The goal is for a device that will operate for over 150 hours mean time between failures, and require less than 0.05 maintenance man-hours per operating hour.
- Be low enough in unit cost that sufficient numbers of devices can be bought. The goal is to procure at least one DTATS per aircraft carrier and amphibious assault ship, along with additional units for forward air bases, weapons schools and reserve squadrons.

ISSUES

Meeting all of these requirements will certainly push the simulator state of the art. In particular, the mission training requirement means that a wide field-of-view visual system will be needed. But certainly, the toughest requirement is to meet the packaging constraints imposed by carrier basing — the wide field-of-view visual display will be confined to a very small space.

The current concept of the CVWST version of DTATS is that it will be installed in a van-type enclosure on the ship's hangar bay. In the late 1990s, some EA-6B avionics maintenance vans in the hangar bay should no longer be required. This configuration would force DTATS into a package of about 8 x 8 x 24 feet. Such a configuration is probably also satisfactory for the DWST version, which would then be somewhat mobile and could be secured to a concrete slab without need for a building.

The reconfigurable cockpit approach to DTATS is also an issue, primarily in attempting to meet the needs of tandem cockpit aircraft like the F-14 and F/A-18D along with side-by-side configurations like the A-6. Three training stations might be required to satisfy both configurations. The type of visual display, whether helmet-mounted, virtual, mini-dome or whatever, certainly affects what layout is acceptable. For instance, if helmet-mounted displays are used, then a two-place side-by-side layout with a removable divider might also be satisfactory for tandem cockpit training. The EA-6B, with its four-man crew also presents a problem, although it may be possible to accomplish the desired mission training by training only two or three crewmembers at a time. The "glass cockpit" approach, which uses a video monitor with touch screen as the instrument panel (perhaps with removable custom faceplates and side consoles for the different aircraft), appears to be a satisfactory.

The list of some of the technical and operational issues surrounding DTATS will challenge the Navy and those contractors that seek to build it:

- Visual display and image generator performance requirements
- Database size, source material, and production and update rate requirements
- Interface with mission planning and intelligence data systems
- Maintaining a match of configuration between the device and multiple aircraft and weapons

- Security requirements
- Requirements for Artificial Intelligence in scenario preparation, threat interaction and system operation and maintenance
- Detailed requirements for reliability, maintainability and suitability

A question asked frequently by industry is: "How much fidelity is required?" The actual answer (in specification language) is still somewhat undetermined. But as a guide, we will accept lower fidelity *within* the cockpit (i.e., panels, switches, g-seat, etc.), but demand greater fidelity *outside* the cockpit (visual display, threats, sensors and weapons).

R&D REQUIREMENTS

Obviously, a robust research and development (R&D) effort will be required to resolve these issues and achieve the capabilities that the fleet needs. The Navy has funded a small 6.3 R&D effort to support the CVWST since 1990. This effort is expanded significantly in 1992. In 1993, an Advanced Technology Demonstration is funded to specifically address the visual display issue. For the future, the Deputy Chief of Naval Operations (Air Warfare), OP-05, is committed to the DTATS program and intends to conduct a competitive DemonstrationValidation in 1994, followed by a first article contract award in 1995. The first DTATS/CVWST would go to sea in 1998.

Of course there's no guarantee in today's budget climate that DTATS will ever be built. But the need is there; and sooner or later, we tend to put money where the need is. Meanwhile, it is encouraging to see the simulator industry already addressing, through in-house R&D, many of the technologies critical to DTATS. The developments that the Navy has specifically identified so far include the following:

- Low cost, multichannel, photography-based image generator, capable of providing visual, sensor, radar and seeker images.
- Common, photography-based database for visual, electro-optical and radar displays, produced directly from multi-spectral overhead stereo imagery without human intervention.
- Low cost, wide angle, large field-of-view visual display system, with resolution approaching the eye limit, fitting within strict space limitations.
- Threat generator featuring realistic interactive threats, with order-of-battle imported from real-world Navy intelligence databases.
- Sophisticated simulator which can be operated by the personnel receiving training, capable of self-initialization, security monitoring, easy scenario selection and performance monitoring.
- Sophisticated simulator which is hardened for the carrier environment, highly reliable, self-diagnostic and self-calibrating; designed such that in the event of failure, deployed maintenance requires only removal and replacement of self-diagnosed components.
- Simulator architecture in which the configurations of multiple tactical aircraft can be kept accurate and current.
- An order-of-magnitude reduction in simulator footprint and unit cost.

The capabilities that are envisioned for DTATS will be in demand for all of our training devices: low cost, modularity, commonality, small footprint and mission rehearsal capability. Therefore, whether or not DTATS itself makes it aboard ship, the vendor that has developed technologies for DTATS will find a customer.

CONCLUSION

Other difficult issues and R&D requirements will certainly arise as the Navy attempts to place the first DTATS aboard ship in 1998. The most important immediate hurdle to jump is that of user acceptance. As the introduction to this paper shows, the desirability of a simulator aboard ship is not yet universally recognized, and the idea is not always taken seriously. Often what is taken seriously is that a device of this capability might pose a severe threat to the flying hour program.

There is a level of flying that we cannot safely go below — and the Navy is there already. For the DTATS concept to be accepted, it must not compete in purpose with what we can do in the air. DTATS must not attempt to teach the basics, and it must avoid those things that *simulators are* generally regarded as doing poorly (such as carrier landing training). DTATS must be focused on things that can't be done with the real aircraft: complex scenarios, complex tactics, training for rare and complex weapons and, most importantly, full-fledged mission rehearsal. And the fleet aviator must be willing to utilize DTATS for it to be of any *value. On* its own merits, the device must draw aviators away from their collateral duties and out of their staterooms, or excuses to avoid it will be found. Therefore, DTATS must be challenging and fun: the best videogame on the ship.

Then, we'll need a new practical joke.

ABOUT THE AUTHOR

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