Assessing the Need for a Deployable Training System for the F/A-18 Hornet and Super Hornet

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ABSTRACT

The United States military is maintaining an unprecedented operational tempo. Our service members are currently spending more time deployed and less time training (Lewis, 2006). This may result in a decreased state of readiness and a significant disadvantage as deployments are extended and service members are away from training opportunities for longer periods of time. In fact, 28 percent of military units identify deployments as a major cause of readiness reduction (United States General Accounting Office, 1996). To improve readiness, priority must be given to training opportunities for deployed service members (Taylor, 1997). This translates to providing deployable training systems that meet several constraints for carrier-based F/A-18 squadrons, while still allowing aircrews to receive tactical training necessary to stay proficient across all skill sets. We administered a questionnaire to 77 Navy operational F/A-18 aircrews in order to assess the skill areas that require training while deployed, and to specify the preliminary physical and functional design of the system. The results reveal that two types of trainers need to be developed to provide the necessary training across all identified gaps, predominantly tactical procedures, for deployed squadrons. One trainer should be small and portable, suitable for instruction in tactical procedures and mission rehearsal. The other system should be larger, with a high degree of physical fidelity, and stationed permanently aboard the carrier to provide a platform for standard aircraft operating procedures.

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BACKGROUND

The United States military is maintaining a demanding operational tempo by conducting operations in both the Iraq and Afghanistan theaters. Military members are spending more time deployed than ever before, and in greater numbers (Lewis, 2006). Prior to 2001, only 17% of the active military was deployed. Since that time, that number has risen to over 25%. The length of these deployments has increased from a standard six month deployment to eight months or longer. More time away from home translates to less time available for training, resulting in decreased readiness. While deployed, our service members are performing an expanded mission set, including Military Operations Other Than War (MOOTW) (Lewis, 2006). These MOOTW missions detract from the ability to perform standard military training missions (Taylor, 1997). For deployed squadrons, this translates to more time performing missions in roles other than standard Air-to-Air or Air-to-Ground missions. These factors combine to severely diminish deployed units' readiness levels and their capability to conduct major combat operations.

In 2006, the Commander, United States Naval Air Forces, released an instruction for a Deployable Mission Rehearsal Trainer (DMRT) as part of the training continuum for deployable squadrons (Commander, Naval Air Forces, 2006). This instruction is the impetus for the present investigation. The instruction enumerated five criteria that should be taken into account when developing a training system to meet these needs (Commander, Naval Air Forces, 2006): 1) low footprint, 2) scaled fidelity, 3) low cost and minimal support tail, 4) network capable, and 5) mission rehearsal. These criteria are addressed in this study.

Since 2003, whenever a carrier strike group has deployed, it supported either Operation IRAQI FREEDOM (OIF), or Operation ENDURING FREEDOM (OEF). When deployed to either the OIF or OEF Area of Responsibility (AOR), a squadron's daily flight schedule is written to support the Air Tasking Order (ATO) for that AOR. Navy and Marine Corps Hornet and Super Hornet squadrons predominantly satisfy Close Air Support (CAS) and Reconnaissance (RECCE) missions in these AORs. The drawback in this situation is that aircrews can lose proficiency in other skill areas. For example, deployed squadrons may rarely get the opportunity to conduct Air-to-Air missions. The Inter-Deployment Training Cycle (IDTC) provides training in this skill area, in order to ensure proficiency, but Air-to-Air tactical procedures are a highly perishable skill. Once an air wing deploys and begins flying missions to satisfy ATO operational requirements, skills that are not practiced everyday could begin to deteriorate rapidly (Schendel, Shields, & Katz, 1978). Due to the lack of a viable threat (e.g., a nation with a military capable of matching the United States in size and capability), the United States military should train to its units' specific capabilities (Taylor, 1997). This will allow individual units to maintain proficiency in skill areas not being practiced routinely.

There have been previous attempts at fielding deployable training systems for carrier-based F/A-18 squadrons, most notably TOPSCENE and AirBook. Neither of these systems were successful in filling the full scope of deployed training requirements for F/A-18 squadrons. We discuss possible reasons for this in a later section.

As part of this study, we examined input from senior subject matter experts (SMEs) to determine which skills need the most training and which are the most perishable during deployment. Depending upon which areas are deemed most critical, we will make recommendations about physical and functional characteristics that need to be considered when designing deployed training systems.

METHOD

Aircrews from operational Navy squadrons were used for this study. These squadrons are the target audience for the DMRT and are the most capable of delineating deployed training needs. The only criterion used in selecting participants was whether the participant had completed, or was in the process of completing, an operational deployment. Deployment experience was necessary because of the level of training required to provide valid input. This minimum criterion allowed for a large pool of participants from which to sample. Seventy-seven Navy F/A-18 C/E or F aircrew, representing eleven squadrons[1], both Weapons Schools (SFWSL and SFWSP), and TOPGUN completed the DMRT questionnaire. The squadrons were home-based in NAS Oceana, Virginia, or NAS Lemoore, California, and four squadrons were three months into a six month deployment with Carrier Air Wing TWO aboard the USS ABRAHAM LINCOLN (CVN-72). There were six Commanders, 25 Lieutenant Commanders, 43 Lieutenants, and two Lieutenant Junior Grades. There were 61 pilots in the group, and 15 Weapon System Operators (WSOs), with one participant failing to indicate a designator. The mean and standard deviations for aircrew experience variables are shown in Table 1.

Table 1. Navy Hornet and Super Hornet Aircrew Experience Variables

Experience Variable	Mean	SD	Min Value	Max Value
Number of Deployments	2.5	1.5	1	8
Total Flight Hours	1541.5	753.8	400	3500
F/A-18 Flight Hours	880.1	564.5	100	2400

The purpose of the DMRT Questionnaire was to collect inputs from F/A-18 aircrews with respect to deployed training needs and requirements, as well as possible implementation strategies. The questionnaire was based primarily on a previous study on deployed training requirements by Bergondy, Fowlkes, Milham, & Merket (1998). The content was developed from two main sources: the Training and Readiness (T&R) matrices from each respective aircraft, and the 2006 CNAF instruction regarding DMRTs (Commander, Naval Air Forces, 2006). The questionnaire also included input from F/A-18 SMEs during the development phase, and was pilot tested and revised based upon SME recommendations prior to administration. After incorporating the recommendations, the questionnaire and its administration plan were presented to, and approved by, the Naval Postgraduate School Institutional Review Board (IRB).The questionnaire includes four sections:

1. Mission Task Ratings
Participants were asked to rate each mission task on a five-point scale in terms of "Difficulty to Maintain Proficiency" and "Need for Training While Deployed." In addition to these ratings, participants also indicated the percentage of deployed missions flown that incorporated the mission task. The prior study conducted by Bergondy, Fowlkes, & Baker (1998) used more metrics, but the three mentioned above were all this study required.

2. Free Response
Section two instructs the participants to identify their top ten deployed training requirements from the mission tasks in section 1. They were then asked a series of questions regarding a variety of issues: 1) suggestions for training tasks to support the skills identified as needing maintenance during deployment, 2) the training tasks aircrews would perform on a DMRT, and 3) the perceived need for a deployed training curriculum.

3. System Requirement Ratings
Section three asks participants to rate each system capability on a five-point scale and if possible, provide justification for any capabilities they deemed particularly important, or unnecessary. The capabilities were taken from analysis of the 2006 CNAF instruction (Commander, Naval Air Forces, 2006). An example capability would be the "capability of being shipped anywhere."

4. Demographics
The final section of the questionnaire collected demographic information such as rank, time in service, and total flight hours of the participant.

The Task and Training Requirements Analysis Methodology (TTRAM) methodology, as set forth by Swezey, Owens, Bergondy, & Salas (1998), is designed to identify potential applications of networked simulators. The methodology has proven useful in highlighting tasks that are subject

[1]VFA-143, VFA-83, VFA-136, VFA-211, VFA-94, VFA-41, VFA-14, VFA-34, VFA-2, VFA-137, and VFA-151

to skill decay; the TTRAM methodology formed the basis for identifying deployed training needs. The initial step in the TTRAM methodology is conducting a training analysis to identify practice or training gaps (Swezey *et al*. 1998). This analysis is accomplished by conducting a skill decay analysis and a practice analysis. The present study focused on the skill decay analysis.

The skill decay analysis aids in the determination of mission tasks that are subject to decay if not performed frequently. There are two types of factors that contribute to skill decay: 1) factors that are task-related and 2) factors that are user-related (Swezey *et al.* 1998). The skill decay analysis uses a combination of these factors to form a skill decay index. The initial TTRAM methodology lists three key factors in determining skill decay: task difficulty, frequency of task performance, and degree of prior learning (Swezey *et al*. 1998). The present research uses the following factors: difficulty to maintain proficiency, percentage of total missions flown, and need for training while deployed.

The three measures above were collected for each mission task of the participant's T&R matrix. The measures were first translated to a common scale and then combined to give a relative measure of skill decay. The scoring translations are listed below:

1. Difficulty to Maintain Proficiency
The "Difficulty to maintain proficiency" factor was rated by the participant on a scale of 1 to 5, with 1 equaling "Not at all difficult to maintain proficiency" and 5 equaling "Very difficult to maintain proficiency." A rating of 1 or 2 is given a score of 1, a rating of 3 is given a score of 2, and a rating of 4 or 5 is given a score of 3. This translation formula is recommended in the TTRAM methodology (Swezey *et al*. 1998).

2. Percentage of Total Missions Flown
The "Percentage of total missions flown" measure was scored in reverse of the other two metrics. With the "Difficulty to maintain proficiency" and "Need for training while deployed," a low rating is a low score and a high rating is a high score. The "Percentage of total missions flown" measure is scored inversely because the more often a mission task is practiced in the aircraft, the less a simulator is required to provide additional training. Percentages from 0 to 33% were given a score of 3, percentages from 34 to 66% were given a score of 2, and percentages from 67 to 100% were given a score of 1. This formula was also taken from the TTRAM methodology (Swezey *et al*. 1998).

3. Need for Training While Deployed
The "Need for training while deployed" was rated by the participant on a scale of 1 to 5, with 1 equaling "Not needed while deployed" and 5 equaling "Very much needed while deployed." A rating of 1 or 2 is given a score of 1, a rating of 3 is given a score of 2, and a rating of 4 or 5 is given a score of 3.

Once all of the ratings were translated to the common scale, the skill decay index was calculated by summing all three scores for a particular mission task. The scores can range in value from 3 to 9. Tasks with a low skill decay index show a low potential for skill decay, while tasks with a high skill decay index show high potential. The scale is configured so that mission tasks that are rated as having a high degree of difficulty to maintain proficiency, a low percentage of total missions flown, and a high need for training while deployed, will have a high skill decay index.

A Naval Postgraduate School student and NAWC TSD researcher administered the questionnaires in person. Research trips were made to NAS Lemoore, NAS Oceana, NAS Fallon and the USS ABRAHAM LINCOLN (CVN-72) to meet with squadrons. The participants were given a ten minute introduction to the DMRT project and a full explanation of the questionnaire before responding. The questionnaire took approximately one hour to complete, and the student or researcher was present at all times to answer questions. Once all participants had completed the questionnaire, a 10 to 15 minute discussion session was held in order for the researchers to ask follow-on questions pertaining to the participants' reactions to the DMRT questionnaire, as well as the project in general.

RESULTS

The data were examined across all 77 Navy Hornet and Super Hornet respondents and the mean score and standard deviation of the Skill Decay Index (SDI) for each of the 78 mission tasks or skills was determined. The 10 highest ranked mission tasks are presented in Table 2, with the task with the highest mean SDI at the top and the rest of the tasks following in descending order. The mean SDI across all tasks was 6.18, with a standard deviation of 1.15.

Table 2. Ranked Mean Skill Decay Index for Hornet and Super Hornet Tasks

MISSION TASK	MEAN SDI	SD
SACT	7.96	1.27
Counter EA	7.91	1.24
ATTP	7.88	1.39
High / Very High Fast Flier	7.81	1.23
Dissimilar BFM	7.70	1.29
High Threat Environment Delivery	7.65	1.31
TGT Attack - Moving TGT	7.58	1.58
High-Aspect BFM	7.49	1.37
SAR 2 / AR 1 (Advanced Threat)	7.49	1.57
Defensive BFM	7.46	1.35

Table 3. Frequency Counts from Hornet and Super Hornet Top Ten Deployed Training Needs

MISSION TASKS	FREQUENCY	PERCENTAGE
CAS	41	55%
A/G Strafe	35	47%
SAR 2 / AR 1 (Advanced Threat)	34	45%
SACT	33	44%
ATTP	33	44%
DCA	30	40%
Counter EA	30	40%
TGT Attack - LG Round (Buddy Lase)	26	35%
TGT Attack - Moving TGT	25	33%
TGT Attack- GPS (JDAM)	25	33%

The “Top Ten Deployed Training Needs” section was examined for frequency. If a task was included in a respondents’ Top Ten list, it was included in the frequency, regardless of the position it appeared. For instance, if “High Aspect BFM” was included by one participant as priority #3, and another person listed it as priority #6, both times were counted as inclusions, with no weight given to list location. Table 3 shows the results of the frequency count, as well as the equivalent percentage of respondents, for tasks being mentioned by 33% of respondents or more. It should be noted that 75 of 77 participants completed the Top Ten list section of the questionnaire, so the resulting frequencies are based on n=75.

The data were partitioned into several groups within the population to determine if a certain demographic rated tasks differently. The total population was divided and compared by rank (e.g., CDR vs. LCDR), squadron location (e.g., Oceana vs. Lemoore), aircraft (Hornet vs. Super Hornet), and designator (pilot vs. WSO). The priority order of the tasks did not vary significantly and there were no notable differences between any of the smaller groups and the overall ranking of the tasks.

We next looked at the system characteristics that were identified by the 77 respondents. The mean rating and standard deviation for each capability were calculated and the top ten capabilities are shown in Table 4**.**

Table 4. Top 10 System Capability Ratings

CAPABILITIES/FEATURES	MEAN RATINGS	SD
Accurate cockpit displays	4.75	0.65
Aircraft system replication (e.g., MIDS, DCS)	4.73	0.67
High fidelity controls (e.g., HOTAS)	4.60	0.78
Accurate location of cockpit controls	4.54	0.87
Accurate cockpit control functions	4.51	0.86
High weapon system fidelity	4.48	0.80
Accurate response switchology	4.44	0.90
Simulate representative real-world threat lay-downs	4.30	1.03
Cockpit environment fidelity	4.24	1.12
Minimal impact on support infrastructure requirements (e.g., network connections, bandwidth, computer hardware)	4.23	1.16

DISCUSSION

If we look at the ten top-ranked mission tasks, eight are air-to-air missions and two are air-to-ground. These results are not surprising. As mentioned previously, while carrier-based squadrons are deployed there is a lack of effective training opportunities for air-to-air missions, particularly in an operational environment void of any air-to-air threat. This means that once aircrews go on deployment, they do not receive substantial air-to-air training. Air-to-air mission skills, which are highly cognitive and procedural in nature, are highly perishable, so it is not surprising that the majority of the tasks in the highest priority group are air-to-air tasks (Childs & Spears, 1986).

The air-to-ground tasks receiving high SDIs are the result of operational experience and lessons learned. Squadrons participating in Operation IRAQI FREEDOM and Operation ENDURING FREEDOM primarily perform air-to-ground missions, and the tasks receiving a high SDI are mission tasks that aircrews identify as not being sufficiently prepared for when they arrive in theater. These mission tasks will require more training before entering theater, in order to prevent costly operational mistakes. The majority of air-to-ground tasks are located in the middle of the priority rankings.

Of note are the SDI rankings for the NATOPS and Instrument Check tasks, as well as Emergency Procedures, Out of Control Flight, and Crew Resource Management. These tasks are all near the group mean of 6.18, placing them in the middle of the list with respect to priority. These three mission tasks have a large impact on the design of the training system due to their unique natures. They require a full physical mock-up of a cockpit in order to provide effective training. In the NATOPS and Emergency Procedures tasks, aircrews are asked to operate numerous switches and controls located not only on the displays in front of them, but also on the console panels located on the side of the cockpit. Emergency Procedures are rehearsed so that procedure steps are memorized and aircrews can do them almost by muscle memory alone. In order to train to this standard, a full cockpit is necessary.

Many of the more difficult and highly perishable skills received SDI ratings near the bottom of the ranking list (e.g., Night Vision Devices, Night Carrier Operations, Aerial Refueling, etc.). These results were a little surprising at first, but after some further analysis, they made sense. These skills are performed almost daily while squadrons are deployed, resulting in a SDI rating lower than the group mean. It doesn't mean that these skills are not perishable or difficult; it may simply mean that they are performed often enough in the aircraft that additional training is not warranted in these areas.

The seven attributes generally listed with effective Crew Resource Management (Assertiveness, Leadership, Situational Awareness, Adaptability / Flexibility, Decision-Making, Communication, Mission Analysis / Planning) are all ranked at the bottom of the group. This low ranking is because aircrews incorporate all seven attributes into each flight, making rehearsal or extra training on these concepts unnecessary.

The Top Ten Deployed Training Needs section is included to check the validity of the SDI ratings. It was assumed the Top Ten frequency results would be similar to the high SDI ratings, and could be used as a secondary means of illustrating task importance. This was accurate for some of the mission tasks, but not all. For example, Close Air Support is counted the most frequently (55%) in the Top Ten lists, yet had a SDI of 6.11, below the mean rating for the group. The reason is Close Air Support is the mission being flown most often by squadrons in operational environments and it is a highly perishable skill, making it the most prevalent deployed training need. However, aircrews fly this type of mission often while deployed, so results in a lower rating for the SDI.

The rankings for the Top Ten list and the SDIs will change if operational requirements change. For example, if tactical squadrons were to participate in major combat operations and the majority of sorties were air-to-air, we would expect air-to-air missions to be at the top of the Top Ten Deployed Training Needs list, with more air-to-ground missions receiving higher SDI ratings, similar to the results seen for the Close Air Support mission in this study.

The overall capability ratings are somewhat surprising. A large percentage of the free response answers state that laptop training systems would not be used, and that a larger, more complex training system located on the carrier is preferred. Aircrew respondents state they want at least a division (i.e., four ship) of simulators akin to the ones they have at home station placed on the carrier; however, the capability ratings do not support this claim. If we examine the ten top-rated system capabilities, there are only two that support this; accurate location of cockpit controls and cockpit environment fidelity. The remainder of capabilities requiring a full cockpit trainer are in the middle to the bottom half of the ratings (e.g., accurate tactile feel of buttons and switches, complete displays with actual switches and buttons, complete instrument panels, complete console displays, cockpit touch screen displays). This outcome suggests that, despite the free response input, physical cockpit replication is not as important as aircraft system replication. The training system has to perform like the jet in all respects (e.g., weapons systems, aerodynamics model) in order to be effective, or even used. Also rated high were "minimal impact on support infrastructure requirements," "easily updated by non-engineering/contractor personnel in theater," and "capable of being shipped anywhere." These three capabilities provide evidence that a smaller, portable training system, which is easy to maintain and update, is preferred.

The rating of the "visual fidelity" capability was disconcerting. Since simulators were first incorporated into flight training, aircrews have stated the need for better visuals in order to get better training. Results of this study reveal visual fidelity as the 26th most important capability, which is not even in the top third of all capabilities rated. During the post-questionnaire discussion session, we asked participants why visual fidelity was rated so low, and discovered that visual fidelity was too broad; it encompassed too many aspects of the training system. If we asked about specific individual capabilities related to visual fidelity instead, we gained a better understanding of the training requirements related to visual fidelity.

Six of the top ten rated capabilities are related to visual fidelity. "Accurate cockpit displays" is at the top of the priority list. Aircrews require displays that show them exactly what they see in the aircraft. Aircraft system replication and high fidelity controls are also visually important to aircrews. Modern tactical procedures are so complex they can require manipulation of multiple avionics systems simultaneously, and many of the decision-making steps are based on visual cues. In order for a training system to be effective, these visual cues have to be replicated in the simulation, requiring a high degree of visual fidelity throughout the training system.

"Aero model fidelity" received a rating of 3.68, just above the group mean of 3.51. This was another capability the researchers assumed would rate a high priority, so its near-the-middle rating surprised us. During the post-questionnaire discussion session, we discovered many of the participants did not know what "aero model fidelity" meant, and did not want to ask. When it was explained that aero model fidelity means the training system "flies" like the aircraft, most participants agreed that it should have been given a higher rating.

The capability ratings show that many of the system capabilities related to mission rehearsal (e.g., "Incorporation of recent intelligence updates," "Load real world OP AREA databases," etc.) were not considered to be important. This is due to the nature of operational missions flown by tactical aviation squadrons today. When an aircraft launches off the carrier, the aircrew usually does not yet know what their target is. They know what radio agency they will be speaking to, and the general area in which they will be working. This type of scenario does not lend itself to mission rehearsal. In order to investigate the mission rehearsal issue, the researchers put the participants into a different scenario during the post-questionnaire discussion. The participants were told they were going into a new theater to conduct major combat operations against an enemy with a credible air-to-air threat. They are given target packages before arriving in theater and told to prepare to attack those targets. When the participants were asked whether mission rehearsal would be a beneficial capability for this situation, the nearly unanimous answer was "Yes, a mission rehearsal capability is a necessary requirement and a vital component of this deployable training system."

In the free response section, differing opinions on the usefulness or necessity of a deployable training system abound. Most of the participants that responded to the free response questions identify a definite lack of training opportunities while deployed, due to operational requirements and fuel constraints. The majority also concurred that skill "shelf life" is a valid concern while deployed, given the lack of training opportunities.

There is considerable disagreement as to whether a deployed training system is necessary. The participants who did not think a deployed training system is necessary almost always cited the requirement for more flight hours as their reason. There is strong opposition to adding more flight simulators to the fleet inventory due to the belief that simulators will be used to replace flight hours. Our findings do not suggest flight hours should be replaced with simulation time, however. There are too many factors involved with actual flights, particularly the physical forces and environment, to allow simulator time to be equated with flight time in determining training value. We recommend that deployed training systems be used in conjunction with already-developed training plans in order to make flight time more effective. There is a significant amount of "down time" on the carrier for aircrews that could be spent training in a simulator.

The rated mission tasks suggest that procedural tasks of a tactical nature (e.g., air-to-air or air-to-ground employment procedures) are the training priority while deployed. These are the skill sets that are the most likely to decay while aircrews are deployed, and should be the first training gap addressed. However, the mission tasks pertaining to "Emergency Procedures" or "NATOPS and Instrument checks" received mid-range skill decay index ratings. This suggests that while these skills are not the highest priority, the opportunity to receive such training while deployed would be beneficial.

Training task priority ordering (while deployed) is of critical importance for a deployable training system's design. Tactical procedures do not require a full cockpit to provide effective training because the majority of the systems and displays used by aircrew during these procedures are located on the front console. As long as the front console is modeled so that all the displays work appropriately (exactly the way they work in the aircraft), the cockpit switches function appropriately (including the Hands On Throttle-And-Stick [HOTAS] functions), and the weapons systems are all modeled accurately, aircrews will be able to receive effective training on air-to-air and air-to-ground procedures from a laptop-based training system with aircraft specific control stick and throttles. If "NATOPS and Instrument Checks," or "Emergency Procedures" training is desired, a full-size trainer with an actual cockpit will be required, due to the nature of the tasks. Because training in both of these areas is beneficial to squadrons while they are deployed, we propose dual training systems designed to fill the various gaps in deployed training needs.

Several of the respondents state they did not believe a laptop-based, or low-fidelity, trainer will provide them with the training needed to remain proficient during deployment. This mindset is one of the reasons that both TOPSCENE and AirBook have had minimal impact. Both systems were considered too low-fidelity to provide quality training. A thorough requirements generation process using fleet aviators (the users) for input will allow for a low fidelity device to fill a useful role in the training continuum.

Though the aircrews state that a low-fidelity trainer will not suffice, the scientific data provided by Estock, Baughman, Stelzer, & Alexander (2008) showed that pilot perception of the quality of a low-fidelity training device does not match up with the training effectiveness of the device. In other words, aircrews receive the same *quality* of training in a low-fidelity training system as they do in one with higher-fidelity. Prior research done by Jacobs, Prince, Hays, & Salas (1990) states that high fidelity simulators may actually prove to be detrimental for tactical jet aircraft. The difficulty is getting user acceptance of the device in order for them to employ it. We suggest getting TOPGUN and Weapons School (SFWSL/P) acceptance of the training system in order to garner support from fleet aircrew. For this reason, we are comfortable supporting a low-fidelity trainer as one of the training systems.

CONCLUSIONS

To meet the deployed training needs identified by the data, we recommend dual trainers. The characteristics of the two complementary training systems are discussed below.

1. Deployable Tactical Procedures Trainer

The Deployable Tactical Procedures Trainer (DTPT) is a laptop-based system designed to provide tactical procedural training for all three groups. This system can also provide operational mission rehearsal prior to the actual mission itself. A Super Hornet squadron Commanding Officer said it best during one of the post-questionnaire discussion sessions: "My guys are the best in the world at what we're doing now, but if you were to ask us to do anything else we would suck out loud." As discussed, our tactical aviation aircrews are the best in the world at supporting Close Air Support missions, because it is the only type of mission they have flown in an operational environment since 2003. However, if the scenario changed and aviators were suddenly required to support major combat operations in a different theater, against a strong opponent, the results could be drastically different. In order to prepare our aircrew for any contingency, the capability for mission rehearsal should be included with any deployable training system.

The DTPT system should include aircraft-specific control stick and throttles because the Hornet, Super Hornet and Growler are all designed so that a majority of the switch functions normally are performed using the HOTAS functionality.

Accurate and detailed representations of specific controls are essential for pilot acceptance.

These laptop-based training systems must be given to, and maintained by, the squadrons. This approach will allow each squadron to use its training system as it sees fit. The systems should be designed to allow for networking between systems, so that aircrews may practice conducting missions in sections. The system should be easy to use, with multiple initial condition (IC) sets, and should be designed such that a standard junior aircrew could use the system without much instruction. The system should be rugged in order to withstand the myriad of operating conditions to which it will be exposed. These laptop systems need to be easy to update, because weapons clearances, terrain data, and operational flight programs (OFPs) are constantly changing. The ability to update this system will be essential for it to be used for mission rehearsal. Aircrews must have the ability to load real-time terrain data, as well as enemy threat locations, if the system is to provide an accurate mission rehearsal capability.

2. Deployable Cockpit Trainer (DCT)

A second training system, the Deployable Cockpit Trainer (DCT) should be designed around a full-scale cockpit. This system will be similar to the training simulators used by the Fleet Replacement Squadron (FRS) during initial student training. This system will be larger than the laptop-based system, so we recommend that the simulators be placed aboard carriers and remain there, permanently installed. Placing the simulators in the hangar bay on the carrier and near the ship's center of rotation will provide the most stable platform and help reduce motion adaptation syndrome (Muth & Lawson, 2003). It is also recommended that the DCT not be used in high sea states.

Given the current carrier air wing composition, we recommend that two training systems be placed on the carrier, a Hornet simulator and a Super Hornet simulator. The Super Hornet simulator should be designed to be easily reconfigured into the new EA-18G Growler simulator to allow for Growler specific training. We are recommending only one of these training systems per aircraft type due to the infrequent requirement for NATOPS or Instrument Checks, or refresher training on Emergency Procedures. Obviously, the full-scale simulator will be much more costly than a laptop-based system, and will require a much larger footprint. It will require more space on the carrier, as well as requiring more personnel to maintain and operate it. Scientific evidence does not support a requirement for the simulator to be on a motion base, so the recommendation is that it be a fixed-base platform or have a very limited displacement capability (McCauley, 2006). There are also environmental factors (e.g., heat, humidity, dust) that must be taken into account when designing this system to ensure that it will operate consistently while deployed. There are a number of low-cost trainer options already available, and it is recommended that these options be considered for utilization while deployed. Space on a carrier is at a premium, and finding a location to put two almost full-scale simulators will be difficult without either removing something else, or creating new space (e.g., the ceiling of the hangar bay).

There is real value in providing more training to deployed aircrews. While additional training may impose more pressure on current training budgets, this proposed approach using two simulators is a cost-effective way of managing the situation by targeting training to address the most perishable skills. The laptop-based systems will be much less expensive than a full-scale simulator, so the Navy can purchase more units in order to make the system more accessible for training opportunities. Yet the full-cockpit trainer can provide broader abilities that address training gaps due to limited mission assignments.

We recommend that future studies be done to examine the feasibility of putting full-cockpit-based, high-fidelity training systems aboard aircraft carriers. Not only the physical aspects (e.g., where to put it, physical security, etc.) need to be addressed, but the maintenance and logistics aspects of supporting a high-fidelity training system aboard ships at sea need to be explored. For example, who is going to maintain and operate these training systems? What will the logistics tail be for the systems (e.g., will there be extra parts on the carrier or will parts have to be flown onboard)? These are serious issues that must be answered before the deployment of high-fidelity simulators aboard a carrier.

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REFERENCES

Bergondy, M. L., Fowlkes, J., & Baker, D. (1998). *A preliminary analysis of deployed training: Issues, requirements, and evaluation* (Special Report No. 98-019). Orlando, Florida: Science and Technology Division, Naval Air Warfare Center Training Systems Division.

Bergondy, M. L., Fowlkes, J., Milham, L., & Merket, D. C. (1998). *Analysis of deployed training requirements in the F/A-18 community* (Special Report No. 98-020). Orlando, Florida: Science and Technology Division, Naval Air Warfare Center Training Systems Division.

Childs, J. M., & Spears, W. D. (1986). Flight-skill decay and recurrent training. *Perceptual and Motor Skills, 62,* 235-242.

Commander, Naval Air Forces. (2006). *Navy aviation simulator master plan*. San Diego, California: Commander, Naval Air Forces.

Estock, J.L., Baughman, K., Stelzer, E.M. & Alexander, A.L.(2008). Fidelity requirements for effective training: Pilot perceptions versus objective results. *Proceedings of Interservice/Industry Training, Simulation, and Education Conference (I/ITSEC) 2008*, Orlando, FL.

General Accounting Office. (1996). *Military readiness* (No. GAO/NSIAD-96-105). National Security and International Affairs Division, General Accounting Office.

.

Jacobs, J. W., Prince, C., Hays, R. T., and Salas, E. (1990). *A Meta-Analysis of the Flight Simulator Training Research* (Technical Report No. 89-006). Orlando, Florida: Human Factors Division, Naval Training Systems Center.

Lewis, J. P. (2006). *Planning for the effects on personnel readiness of increased OPTEMPO*. Joint Military Operations Department, Naval War College.

McCauley, M. E. (2006). *Do army helicopter training simulators need motion bases?* (Technical Report No. 1176). Arlington, Virginia: U.S. Army Research Institute for the Behavioral and Social Sciences.

Muth, E. R., & Lawson, B. (2003). *Using flight simulators aboard ships: Human side effects of an optimal scenario with smooth seas. Aviation, Space, and Environmental Medicine, 74*, 497-505.

Schendel, J. D., Shields, J. L., & Katz, M. S. (1978). *Retention of motor skills: A review* (Technical Paper No. 313). Fairfax, Virginia: U.S. Army Research Institute for the Behavioral and Social Sciences.

Swezey, R. W., Owens, J. M., Bergondy, M. L., & Salas, E. (1998). Task and training requirements analysis methodology (TTRAM): An analytic methodology for identifying potential training uses of simulator networks in teamwork-intensive task environments. *Ergonomics, 41*, 1678-1697.

Taylor, J. R. (1997). Trained and ready combat forces: The role of training devices in sustaining combat force proficiency during deployments. U.S. Army War College

LIST OF ACRONYMS

A/G – Air-to-Ground
AOR – Are of Responsibility
AR – Active Radar
ATO – Air Tasking Order
ATTP – Advanced Tactics Techniques and Procedures
BFM – Basic Fighter Maneuvers
CAS – Close Air Support
CDR – Commander
CNAF – Commander, Naval Air Forces
CVN – Nuclear Aircraft Carrier
DCA – Defensive Counter Air
DCS – Digital Communication System
DCT – Deployable Cockpit Trainer
DMRT – Deployable Mission Rehearsal Trainer
DTPT – Deployable Tactical Procedures Trainer
EA – Electronic Attack
FRS – Fleet Replacement Squadron
GPS – Global Positioning System
HOTAS – Hands-on-Stick-and-Throttle
IC – Initial Condition
IDTC – Inter-Deployment Training Cycle
JDAM – Joint Direct Attack Munition
LCDR – Lieutenant Commander
LG – Laser-Guided
MIDS – Multifunctional Information Distribution System
MOOTW – Military Operations Other than War
NAS – Naval Air Station
NATOPS – Naval Air Training and Operating Procedures Standardization
NAWC TSD – Naval Air Warfare Center Training System Division
OIF – OPERATION Iraqi Freedom
OEF – OPERATION Enduring Freedom
OFP – Operational Flight Program
OP AREA – Operational Area
RECCE- Reconnaissance
SACT – Surface-to-Air Countertactics
SAR – Semi-Active Radar
SDI – Skill Decay Index
SFWSL – Strike Fighter Weapons School, Atlantic
SFWSP – Strike Fighter Weapons School, Pacific
SFWT – Strike Fighter Weapons and Tactics
SSC - SME – Subject Matter Expert
T&R – Training and Readiness
TGT – Target
TTRAM – Task and Training Requirements Analysis Methodology
VFA – Fixed-Wing Fighter/Attack
WSO – Weapons System Operator