

MQ-4C Triton UAS Mission Systems Trainer “More than Support Equipment”

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ABSTRACT

Unmanned systems aircrew training has experienced a paradigm shift from conventional aircrew training. Normally training devices lag behind the weapon system and are considered solely support equipment in manned aviation. However, with the introduction of large Unmanned Aerial Systems (UASs) aircrew training must be considered at the beginning of weapon system acquisition. The MQ-4C Triton is developed by Northrop Grumman Corporation (NGC) for the U.S. Navy is a High Altitude Long Endurance (HALE) UAS. The MQ-4C Triton’s Mission Operating Base (MOB) includes a primary Mission Control Station (MCS) and a secondary embedded Mission Systems Trainer (MST). The MST is the main source for generating and managing aircrew training including mission rehearsals. A full Triton mission aircrew consists of three Air Vehicle Operators (AVOs), two Mission Payload Operators (MPOs), and a Tactical Coordinator (TACCO). Since 2011 the MST has directly supported Triton developmental flight tests by qualifying AVOs for first flight of the MQ-4C and continuously training aircrew as software increments occurred in the program. The MST is much more than support equipment and the first system the aircrew uses before conducting any ground or flight tests. A MQ-4C “trainer aircraft” does not exist and is therefore completely dependent upon the modeling and simulation used in the MST to train, qualify, and rehearse flight test events. This creates unique challenges of always being ahead of the weapon system. In addition, since the aircraft had not flown, the MST test team had to make use of multiple sources of software in the loop, hardware in the loop, and prior aircrew knowledge in developing adequate aircrew training curriculum. This paper will focus on the challenges of developing a MST in parallel with the weapon system, shortfalls in UAS aircrew training, and how the MST was able to overcome these obstacles to successfully support first flight of the MQ-4C Triton in May 2013 and a September 2014 ferry across the United States from Palmdale, CA to Naval Air Station Patuxent River, MD.

1.0 SETTING THE STAGE

Training devices play a critical role in the United States Military to ensure forces are ready. The Naval acquisition community while under tight fiscal constraints has been tasked to ensure training is not only operationally effective, but cost effective and integrated across their warfare groups. Historically, training devices have been developed as an element of logistics support equipment. Training devices would be considered after weapon system development or significantly lag behind the weapon system procurement (Sheehan, et al. 2009). A top down systems approach was used to eventually develop training requirements based on weapon system design by the following: Required Operational Capability (ROC), Projected Operational Environment (POE), Performance Based Specification (PBS), Top Down Functional Analysis (TDFA), Front End Analysis (FEA), System Specification (SS), Requirements Traceability Verification Matrix

(RTVM), flight test data collection, analysis of data, and finally a released Naval Air Training Operating Procedures (NATOPS) and steady state training curriculum (Gordon, et al. 2005). Following this development cycle training device acquisition was then designed to match the weapon system performance and simulations validated against previously collected flight test data. This conventional approach did not occur with the Triton Mission Systems Trainer (MST). The weapon system development and training device development were concurrently developed, integrated, tested, verified and validated. This created unique challenges in developing the Triton MST, but also provided unique opportunities to show how important up-front training acquisition is to the execution of flight test, mission capability and the future Training & Readiness (T&R) of Naval Fleet Forces (Owens, et al. 2012). As with anything in Department of Defence (DoD) acquisition, “up-front and early” can help ensure the acquisition community is developing and testing the right system. The answer to the question, are we building the right training device?

2.0 TRITON MISSION SYSTEMS TRAINER

The MQ-4C Triton UAS includes an embedded MST. The MST, developed by Northrop Grumman Corporation (NGC), is the focal point of a blended training system solution and is critical to generating and managing aircrew training. In fact, from the start, the Triton program committed to a training system solution relying 100% on simulation—there would be no dedicated assets for training. The MST, Mission Control Station (MCS), Communications (COMMS) Manager, and associated software make up the system used for training the MQ-4C aircrew. A full mission aircrew consists of three Air Vehicle Operators (AVOs), two Mission Payload Operators (MPOs), and a Tactical Coordinator (TACCO).

The MST hardware consists of three Instructor Operator Stations (IOS) and 8 aircrew stations which are an exact replica of the flight crew stations. The goal is to provide accurate and realistic flight crew training so that the crew cannot tell they are in a trainer or conducting a real flight from the Mission Control Station (MCS). This is extremely important for Triton as noted above since aircrews are 100% trained and certified in the MST. A Triton air vehicle for training will not exist for the fleet, therefore requiring all training to be in the classroom or in simulation. This is a strong shift from manned aviation, which normally includes a stepped training program consisting of simulation, trainer aircraft, and finally operational aircraft. Figure 1 shows a typical MST IOS and the Triton Unmanned Aircraft (UA).

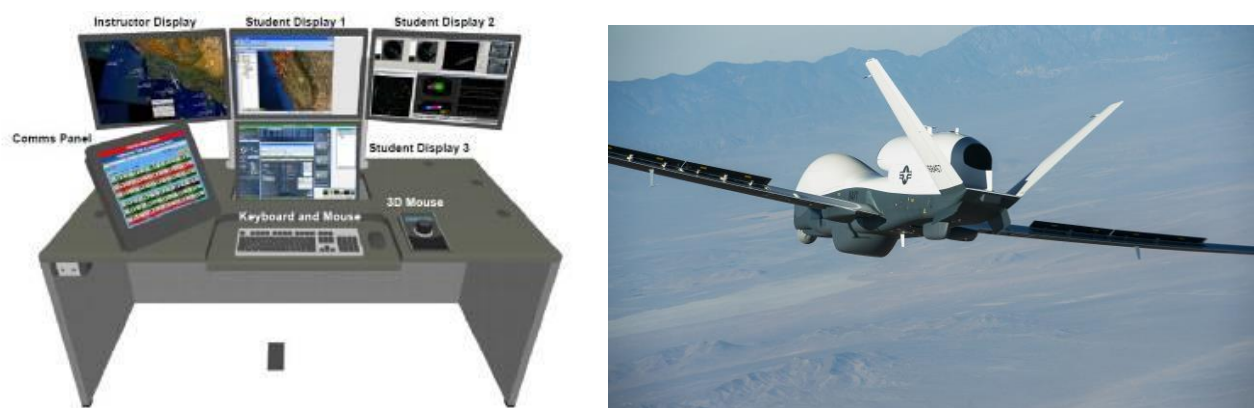


Figure 1: Triton MST IOS and UA (APPROVED FOR PUBLIC RELEASE)

3.0 MQ-4C TRAINING DEVELOPMENT

Training development began by examining the crew plan generated by the Naval Fleet Introduction Team (FIT). How many crews would it take to stand up an orbit? In acquiring Triton, the program committed to “no new growth in manpower” therefore requiring optimization of current manpower and a high fidelity training solution. To do this, the training team used the Fatigue Avoidance Scheduling Tool (FAST) so as to make recommendations to the program regarding the number of crews it would take to safely operate a Triton detachment. FAST allows scientists, planners and schedulers to quantify the effects of various work-rest schedules on human performance. It allows work and sleep data entry in graphic, symbolic grid and text formats. The graphic input-output display shows cognitive performance effectiveness (y-axis) as a function of time (x-axis). An upper, green area on the graph ends at the time for normal sleep, 90% effectiveness. The goal of the planner or scheduler is to keep performance effectiveness at or above 90% by manipulating the timing and lengths of work and rest periods. Figure 2 below depicts an example of the FAST tool. A) 24 hour period covering 30 days, B) Timeline of work/sleep/wake during each 24 hour period, C) Blue indicates sleep periods, D) Red indicates work periods, and E) White indicates awake, but not at work.

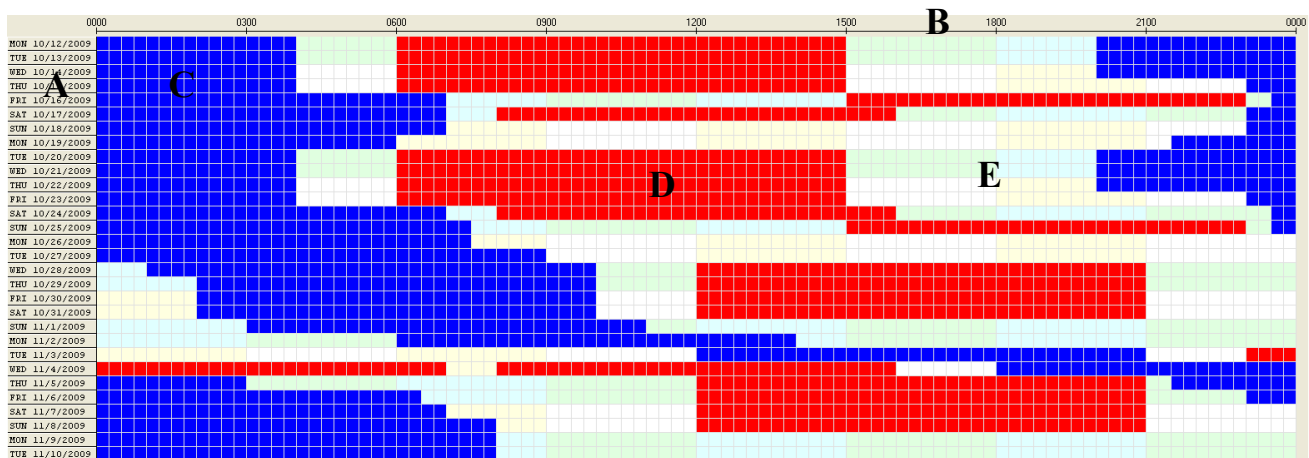


Figure 2: FAST Tool Example (APPROVED FOR PUBLIC RELEASE)

The output is calculating performance effectiveness representing composite human performance on a number of cognitive tasks, scaled from zero to 100%. The tool also allows for looking at estimated performance over time (accounting for shifts in wake/sleep schedule and effects of cumulative sleep deprivation) in terms of Blood Alcohol Content (BAC). Thus, in the analysis, one of the operators was operating at a BAC of .07 somewhere in the 3rd week of the schedule in the 8-crew model. This analysis had impact on the program and was the basis to develop the training curriculum. Doing this analysis up-front allowed optimization of training, not only from a manpower perspective, but also cost.

The Triton program worked to take advantage of the FAST analysis to help develop steady state training. In addition, the Developmental Test (DT) efforts and training of flight test crews for first flight and follow-on flight tests continuously informed the training team of metrics related to courseware, training effectiveness, and fidelity of simulations.

4.0 SIMULATION & CREW MISSION REHEARSALS

Triton flight training included multiple weeks of ground classroom instruction and simulator training sessions in the MST. The aircrews had to be trained and pass NATOPS check rides per Naval Air Systems Command VX-20 standards to successfully conduct first flight and the ferry of three aircraft from Palmdale, CA to Naval Air Station Patuxent River, MD. Though not directly responsible for executing developmental flight tests, Operational Test (OT), and the Fleet Introduction Team also completed this training. This was extremely useful in generating feedback across all the operating communities for training.

During this time simulations were used from contractor Software Integration Labs (SILs) to validate performance. In addition, some re-use of the United States Air Force (USAF) Global Hawk program was used to derive data needed for Triton models. The aerodynamic model was an integral component of the MST. This aerodynamic model created the Closed Loop Simulator (CLS). CLS was used across the development of the program including running verification of hardware performance on actual aircraft components. This meant CLS software would be “locked down” before training could occur. In doing this, aircrew training had to make the best use of simulations given and compensate the lack of fidelity for classroom instruction and actual aircraft ground test time.

One powerful advantage of the early MST development allowed the aircrew to see the Triton system operating in simulation before actual operation of the aircraft. This allowed the aircrew to train NATOPS procedures including start-up, shut-down, flight critical emergencies and mission execution. In addition, the aircrew was able to practice Crew Resource Management (CRM) and run flight test cards with the appropriate test engineers and responsible engineering disciplines. During any flight test program, it is important to rehearse procedures, emergency contingencies, and radio calls. The MST was successful at performing this critical role for the Triton Integrated Test Team. This in large part was a direct impact on the success of Triton first flight and ferry across the United States for three Triton aircraft.

5.0 CONCLUSIONS

The concurrent nature of Weapon and Training System Acquisition was both a challenge and an advantage. A challenge is making decisions in advance of having all the information from design that would normally be available in a post weapon system trainer acquisition. An advantage was allowing understanding of the system needed to be trained coupling tightly with the actual system, therefore ensuring training was addressing the right problems.

The training team discovered early through the utilization of the MST for crew mission rehearsals critical software defects to be corrected before fleet introduction. This training acquisition model also allowed the team to recommend deferment of generating costly interactive courseware as the team learned what needed to be addressed in training (Owens, et al. 2014). The Integrated Product Teams (IPTs) worked hard to ensure that the MST was built to specification; answering the first question, “Did you build it right?” The IPT also worked hard at answering the question, “Did you build the right training device?” The use of the MST as mission rehearsal and tight coupling of Developmental Test, Operational Test, and the Fleet Introduction Team made this possible.

An area of future improvement is in asking and answering the question “Did you build the right training capability to ensure that the weapon system achieves the desired operational results?” This is certainly an Integrated Warfare Capability (IWC) thought and the future of training. Tactical training to achieve mission objectives in an integrated training environment across warfare groups is the future. The MST will hopefully achieve this objective in the future.

6.0 ACKNOWLEDGEMENTS

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