# A TEAMED APPROACH ADDRESSING EFFECTIVE OFT UTILIZATION

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## ABSTRACT

A teamed effort from 1985 to the present involving the user, procuring agency, and the contractor has resulted in a 90% improvement in OFT utilization. Besides significantly improved utilization, issues have been addressed which have resulted in documented user acceptance of the training device. The application presented in this paper is for "schoolhouse" training of USAF pilots at Luke AFB. The structured methodology utilized by the user to achieve improved OFT effectiveness included problem definition, a literature review, and a needs/requirement survey of more than 500 pilots. The results of the user analysis led to changes in the training devices design, training philosophy, and training syllabus. Also, the issues of concurrency and user validation were explored. The problem definition was initiated in 1985 by a General Office Review. The user's literature review, requirements analysis, and survey validated the initial problem definition. Off-the-shelf technology was selected for a limited-field-of-view visual system and a totally redesigned instructor station. Also, task-specific training replaced the mission training approach. A three-tier training device syllabus was used to assure that fundamental tasks were learned prior to being practiced in the aircraft. The outcome of these efforts has been enhanced OFT utilization through user-initiated and defined requirements. The teamed effort was instrumental in addressing these issues in a timely manner.

## INTRODUCTION

The road to user acceptance can be thought of as user initiatives folded into operational vehicle characteristics in a timely manner. An important key to training device acceptance by the user is involvement as an active decision maker in the device's development and evolution. Also fundamental to user acceptance is that the device matches the operational vehicle and the user perceives that the training environment matches his need. Implementing factors such as these require a procuring agency and contractor that are responsive to the user's initiatives, and an overall program plan which supports timely implementation of changes.

This paper reports on a particular USAF F-16 training site where the user was able to "bring it all together." The user championed planned changes to a mature F-16 OFT. These OFT updates included a limited-field-of-view (LFOV) visual and a state-of-the-art Instructor Operator Station (IOS). These user requirements were teamed with the procuring agency and the prime OFT contractor. This teaming achieved a timely match between the user needs and the operational capabilities of multiple updates to the F-16 aircraft.

The training philosophy for the Tactical Air Command (TAC) F-16C Replacement Training Units (RTU) was also revised. This particular planned change is reflected in the current F-16C RTU syllabus.

These planned changes were introduced by a 1985 General Office Review (GOR) which drove a user-developed requirements analysis. The user followed accepted Systems Engineering methodology for this analysis. The requirements analysis developed into an RTU training model which was iteratively and independently validated. The findings of the initial GOR and user requirements analysis, completed in 1985, are still being implemented today.

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The status today at the Luke AFB RTU facility is a training device mix which has proven user benefit and acceptance. Following accepted Systems Engineering methodology has resulted in timely OFT upgrades that include a LFOV visual and state-of-the-art IOS. These upgrades have been timed to coincide with major F-16 aircraft updates that extend into the 1990's.

## BACKGROUND

In 1985 a GOR determined that the F-16 OFT required action because the user determined the OFT was not providing effective training. The GOR directed that corrective action be taken relative to the following four problem areas:

- The OFT was not supporting required training tasks (too few tasks could be trained)
- The IOS was believed to be hard to use
- The OFT was not current with the aircraft (aircraft software updates to the OFT lagged the aircraft updates)
- It was difficult to train in the OFT in a manner that matched the F-16's visual mission (the OFT did not have a visual system)

The GOR directed that Detachment 1, 4444 Operations Squadron at Luke AFB serve as a focal point to deal with these stated problems. The Det 1 mission is to develop concepts of training and syllabi to support initial and transition F-16 pilot training. The purpose of an OFT in a RTU is to expose pilots to procedural and safety-of-flight tasks in a dynamic real-time environment.

To focus the effort directed by the GOR, Det 1 completed an initial requirements study. The purpose of the Det 1 study was to determine the scope and magnitude of the problem, and optimum OFT upgrades. Through *a priori* decision making, the study sought to determine which mix of OFT and off-the-shelf WST elements would provide the most training tasks relative to cost. Also, the issues of an upgraded IOS and concurrency were addressed by Det 1 with ASD and Link.

The methodology chosen by Det 1 closely followed the guidance of chapters 5 and 8 ("System Definition and Mission Requirements Analysis", and "Trade Studies", respec-

tively) of the System Engineering Management Guide.[2] Following an accepted methodology later paid off for the user when their requirements and needs were interpreted by ASD and Link.

Using an *a priori* technique also had benefits in that the Det 1 effort focused on an obvious OFT shortcoming: no visual system. A literature review was conducted by Det 1. A 1984 study by O'Neal[3] noted that a visual system had the potential to increase fighter pilot training value and result in increased trainee acceptance of the OFT.

In 1981 Waag[5] stated that the potential value of visual systems is clear. A visual system allows training tasks to be completed in the OFT that would normally need to be learned in the air. The approach followed by Det 1 matches Waag's statement that "... an evaluation of the training effectiveness of a device is one of the most important types of information for the user." Waag also points out that this data will lead to user acceptance.

The literature researched by Det 1 included numerous scholarly articles on the benefit of visual systems. For example, the previously mentioned Waag reviewed 26 papers and studies. Similarly, for an IOS, Setty, Epps, and Meara presented guidelines in 1984 for the development of user-friendly instructional systems.[4]

In 1987 White[6] emphasized the importance of user insight in IOS development. White's comments are relevant to Det 1, the user, completing the initial OFT capabilities analysis. White states that user insight into the development will avoid technology delivered which is inconsistent with the user's perceived needs. The user's involvement ensures that the requirement, rather than the technology, drives the design process.

What is surprising is most of the literature reporting on user driven development has been completed by either the technical or academic community. In contrast, the analysis results and OFT changes presented in this paper were user developed. This fact makes this paper unique. The original training requirements and OFT capabilities analysis discussed here were completed by Det 1. Therefore, the user's requirements drove the design process and the results are presented here.

## INITIAL DET 1 PROBLEM DEFINITION

The direction from the GOR to Det 1 was to address perceived F-16 OFT problems that included:

- Concurrency
- Providing a user friendly design
- A syllabus that includes OFT tasks that matched the F-16's visual mission

The F-16 OFT being evaluated by the user was a high-fidelity device consisting of:

- A pilot station that closely matched the F-16C cockpit
- A CRT/keyboard instructor station
- A computer system with peripherals

The specific OFT selected was from the fourth production lot and had been accepted from Link by the procuring agency.

An OFT/WST training requirements and effectiveness analysis was completed by Det 1. Training effectiveness was defined as the ability to train without regard to cost. The analysis focused on:

- Current WST capabilities of the OFT (e.g., electronic warfare device)
- Off-the-shelf limited- or full-view visual systems

Since the effectiveness analysis was based on subjective survey data, a non-parametric ranking scheme was used for the results (see below).

The results of the effectiveness analysis and ranking scheme demonstrated that benefit could be derived from an OFT and visual combination. These results are also shown below.

The LFOV and full visual systems were further evaluated for their training utility. Training utility also considers cost. Det 1 determined that, relative to both utility and effectiveness, maximum benefit would be realized with a LFOV visual.

## LINK / DET 1 / ASD P3I STUDY

Incidental to this analysis was a preplanned product improvement (P3I) study. Link, with Det 1 participation, completed the study. The study's stated purpose was to increase the utility of the F-16 OFT. Training utility was defined as the relationship between the skills learned or retained, and the training investment or equipment cost.

A functional allocation specification tree (FAST) was completed to identify product improvements other than the OFT/WST combination analysis completed by Det 1. The OFT features which the FAST identified as product improvement candidates were further subjected to analysis that included technical advantages and disadvantages, and potential cost savings.

Of the twelve cost saving suggestions, seven product improvements were selected by ASD for more detailed study or were implemented by engineering change proposal. Included in these seven product improvements were a "simpler IOS structure" and a fire-control-radar simulator (FCRS) replacement. The IOS was selected as an OFT upgrade to address the GOR directive of a more user-friendly design, and the FCRS replacement was selected for concurrency.

TRAINING EFFECTIVENESS RANKING SCHEME

| Ranking Tasks | Technology Factor | Capability |
|---|---|---|
| Basic training tasks were selected via subjective survey. | Resulted from a combination of "need" and "value" via subjective survey. | Dual combinations of OFT, EW, DRLMS, limited visual, and full visual rated relative to the top 20 basic tasks. |

Weighted Effectiveness Percentages

| | OFT Only | OFT & EWTD | OFT & DRLMS | OFT & LFOV | OFT & FULL VISUAL |
|---|---|---|---|---|---|
| Training Squadron | 39.8 | 46.5 | 42.7 | 75.8 | 83.2 |
| Operational Squadron | 30.3 | 40.3 | 33.7 | 71.9 | 78.0 |

## LINK OFT/VISUAL SYSTEM STUDY

One result of the Link P3I study was an analysis to determine the effectiveness of an OFT/Visual system. The outcome of this analysis was used by Det 1 as an independent validity check of their OFT/LFOV visual data:

Summary of Training Effectiveness with a Partial Visual

| | RTU | Operational Squadron |
|---|---|---|
| Link's Study I | 84.7 | 83.1 |
| Link's Study II | 88.5 | 86.2 |
| Det 1 Study | 75.8 | 71.9 |
| Mean ---> | 82.2 | 81.2 |

Included in these Link study results, and two others, were average scores for RTU and operational units. The mean score for the three studies showed that an 80% training effectiveness could be realized with a LFOV visual system.

While the percentages are close, the differences between the three studies can be attributed to three factors:

- The Link and Det 1 studies used somewhat different ranking criteria
- The Link studies included a broader task base
- The Link and Det 1 studies used different samples and sample sizes to gather the subjective data

These OFT/LFOV effectiveness results were briefed to the GOR by Det 1. Direction was given to Det 1 to confirm these relatively small samples by surveying the fighter pilot community. The purpose of the survey was to assure that the users' needs would drive the design. A questionnaire was developed by Det 1 with the assistance of Human Resources Lab (HRL) behavioral scientists at Williams AFB, Arizona.

The questionnaire was mailed to over 500 tactical fighter pilots. A response rate of better than 90% was realized. The results validated the initial studies and showed that the pilots believed that acceptance of the OFT would increase 300% with the addition of an LFOV visual.

## IOS REPLACEMENT/USER FRIENDLY DESIGN

An initiative by Link and ASD was then undertaken to address the usability of the GOR directive. Generally, the methodology followed was similar to the visual study. Results of this effort are presented in a 1988 I/ITSC paper by Dunnam and Hosler.[1] Key features of the resulting IOS are:

- The instructor pilots' needs were addressed throughout the development
- A modular design with independent workstations was chosen for flexibility
- Repetitive training tasks versus mission rehearsal training drove the overlay/underlay displays
- Standard colors were utilized and icons employed wherever possible
- A touch screen replaced the keyboard
- Software maintainability and reusability was enhanced via the C language

## CONCURRENCY

The Det 1 and the Link training analysis established a training requirements baseline. However, there was a need for mechanisms to ensure the fidelity of the OFT matched the aircraft. This concurrency directive by the GOR was dealt with via three main strategies as shown below.

F-16 OFT Concurrency Strategies

| Strategy | Purpose | Benefit |
|---|---|---|
| Configuration Update Working Group | ASD chairs meetings with Link, the aircraft manufacturer and the user. Planned aircraft updates are reviewed. | A mutually agreed on plan developed for applicable and non-applicable aircraft updates. |
| Design Data Review Group | Major aircraft block updates are presented to Link by the aircraft manufacturer. | The OFT contractor (Link) has a contractual vehicle to obtain timely engineering data to submit change proposals. |
| Phased-development | Multiple, phased OFT contracts are tied to the schedule for major updates of the F-16 aircraft. | The OFT aircraft update schedule lags slightly behind the aircraft schedule.<br><br>Contracts are awarded for development phases (e.g., a contract to PDR only). This allows flexibility as the aircraft schedule and/or capabilities change.<br><br>The multiple contracts allow multiple OFT design data freeze dates. |

## IMPLEMENTATION

Updates and major changes were made to the F-16C OFT at Luke AFB. These changes were based on the Det 1 initiated, and Link supported, studies. The studies addressed the GOR direction for:

- Changes to the OFT so its use would more closely reflect the aircraft's visual mission
- Implementation of "user-friendly" changes to the OFT (e.g., IOS replacement)
- The need for concurrency
- Considering changes to the training philosophy and syllabus

LFOV Visual — Link installed a site unique IMAGE IIIT LFOV visual system. The installation, database development, and maintenance were covered by an unsolicited no-cost change proposal. The purpose of the LFOV installation was to validate the earlier Det 1 findings. Specifically, the question was, "Will a LFOV visual add value and user acceptance to RTU and operational training?".

Besides the visual hardware and interface with the OFT, Link developed a database which supported the previously defined Luke training tasks. Similarly, database characteristics were defined by Det 1 and validated/enhanced by Link, when needed. The database characteristics were developed to support the specific Luke training environment. They included weather, weapons scoring, color, and moving targets.

The utility of the LFOV visual was subjectively evaluated in a planned, three-phased effort spread over seven months. A group of 144 selected evaluators included transition and instructor pilots. The evaluation methodology followed established techniques for developing and using questionnaires. Post-sortie interviews were conducted by HRL behavioral scientists.

Besides Link and Det 1, this teamed evaluation included ASD, Headquarters TAC Training Research personnel, and the Williams AFB HRL. The results of this effort were documented by Wiekhorst in 1987[7] and are summarized as follows:

- Training transfer of skills to the aircraft was documented
- The training tasks identified by Det 1 could, in fact, be completed with the LFOV visual
- The user's perception of the benefit of the LFOV visual was high
- Pilot acceptance of the LFOV visual was 85% or greater

IOS Replacement — The original IOS was upgraded. The singular focus for this Link replacement effort was to provide a user-friendly instructor station using state-of-the-art technology and human engineering principles.

The new IOS was delivered to the 58th Tactical Training Wing in May of 1987. The new design was then validated at the site through user interviews.

Concurrency — A firm GOR directive was concurrency. The specific goal for Det 1 was to have the F-16 aircraft and OFT block updates arrive at Luke simultaneously. This goal has been met through strategies that include phased development, and OFT and aircraft configuration meetings. The concurrency of the F-16 OFTs and first aircraft delivery dates to Luke is shown in the following table:

F-16 Block Updates

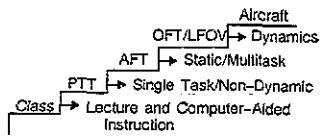
| | 25B* | 30+* | 30B* | OCU** | 40* |
|---|---|---|---|---|---|
| OFT Delivery | Feb.'87 | Jul.'87 | Nov.'87 | Aug.'88 | May'89 |
| First F-16 *Aircraft Delivery**** | Feb.'85 | June'87 | Nov.'87 | Aug.'88 | June'89 |

* F-16C Aircraft
** F-16A Aircraft
*** Nominal Dates

These results show a progressive improvement in concurrency. The Block 25B OFT followed the aircraft delivery by two years. However, the Block 40 OFT has arrived at Luke prior to the training need date.

Training Philosophy — The tactical training philosophy and syllabus concepts were reconsidered. As such, mission rehearsal training was curtailed and repetitive single-task training was inserted.

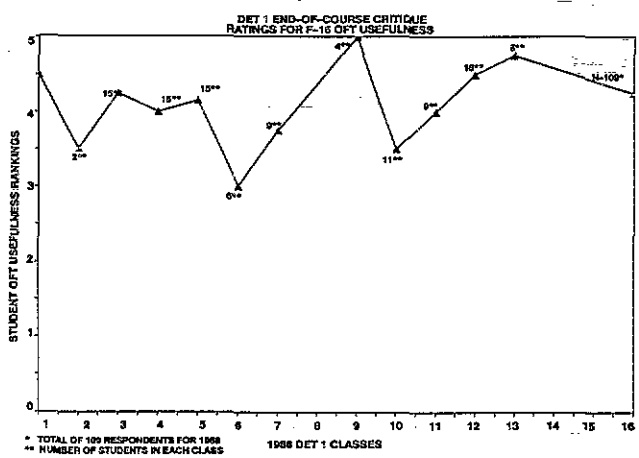
Det 1 adopted an approach that replaced non-dynamic training in the OFT with multi-task, dynamic simulation. Valuable OFT time centered on the practice of dynamic tasks that would be completed in the aircraft. The OFT time was preceded with logical, building-block tasks:




The training syllabus also underwent additional changes. For example, tasks which a partial visual could not support were moved to other media or eliminated. The overriding goal of the syllabus was to provide the student pilot multiple opportunities to practice training tasks in varying types of training devices. Each device has been designed to build on the other. The building block approach has provided a confidence factor which carries over into the aircraft.

## DOCUMENTED USER ACCEPTANCE

User acceptance of the Luke training device building-block approach in particular, and the course of instruction in general, is documented by the end-of-course student critiques. Included in the comprehensive end-of-course questionnaire is an assessment of the usefulness of the OFT. The results are generally 4 to 5 on a 5 point scale, and are shown in the figure below.



## FOLLOW-THROUGH

The Det 1 analysis and the subsequent validation has established an RTU and operational training needs "baseline." These data are being used by Link to assure that the OFT development required by aircraft changes centers on user requirements. Specific examples are:

Block 50 OFT

Two engineering change contracts are planned. The Phase I contract is through System Requirement Review. This contracting strategy allows OFT flexibility as the F-16 Block 50 aircraft design matures.

A beta site software load is planned for the Phase II OFT contract. The capabilities of the interim and final software deliveries are defined by the user's requirement. This approach allows concurrency and will meet both RTU and operational training requirements.

LFOV Visual Procurement

28 LFOV visuals have been competitively procured. Their database and visual characteristics are based on the Det 1, Luke results.

WST Study

The Det 1 training baseline and similar Link training data have been the starting point for an F-16 WST study. The follow-on to the WST study will employ risk management for P3I.

## LESSONS LEARNED

The 28 LFOV visuals are expected to be well received by the user. This expectation is predicated on the user involvement in validating the visual requirements at Luke AFB.

The IOS is being fielded on over 40 production units besides the initial Luke unit. Interview results at Luke and the results of multiple site deliveries demonstrate that the IOS meets both user and performance specification requirements.

Part of the initial Link/Det 1 planned product improvement included the LFOV and IOS. The LFOV was considered separately, and the IOS as part of 12 P3I items. The results of these 12 P3I items are presented in the following table.

Link / Det 1 P3I

| | P3I Candidate | Result |
|---|---|---|
| 1. | Delete Canopy & Support Systems | Not selected. |
| 2. | Delete Mechano-Receptor Cueing System | Not selected. |
| 3. | Simpler IOS Structure | Old IOS replaced. |
| 4. | Delete Oxygen System | Not selected. |
| 5. | Delete Fire Suppression System | Fire suppression system upgraded for Block 40 OFT. |
| 6. | Eliminate the DTU | Not selected. |
| 7. | Simulate the ACIU and Eliminate the Stores Management Simulator | A trade study was completed in 1986. The approach is being considered for the Block 50 OFT. |
| 8. | Replace Fire Control Radar | Replaced by the Radar Display Generator based on a trade study. |
| 9. | Eliminate IOS Repeater Instruments | Repeater instruments retained on the IOS. |
| 10. | Alternate EWTD | Trade study and proposal submitted. EWTD not replaced. |
| 11. | Eliminate One Nord-570 | Based on trade study, the computer system is being upgraded for the Block 40 OFT. |
| 12. | Relax Logistics Requirements | Not selected. |

As noted in the table, not all P3I items were selected, for various reasons. These reasons include:

- Analysis showed that it was not cost effective to delete or change some features
- The long-lead impact of retrofitting numerous production units
- Tying engineering changes across multiple contracts and production lots
- Multiple contractors for the various subsystems which support the OFT/WST
- The ability of the contracting system to handle simultaneous, multiple changes to a "mature" device.

The overall P3I is viewed as a successful GOR initiative. Major changes have been made to a "mature" device while still meeting the concurrency requirement.

## SUMMARY

Positive training that is perceived as "fun" by pilots is a difficult goal to achieve. Based on the Det 1 experience, the keys to meeting this goal include a requirements analysis which is initiated and completed by the user. Transitioning these requirements to the contractor and contracting agency is facilitated when the user follows a rational, industry-accepted System Engineering methodology.

Another key to user acceptance is device concurrency. The user needs established by Det 1 served to focus the efforts of Link and ASD. The RTU and operational training requirements stated by Det 1 were a clear priority for aircraft tasks to be trained in the OFT. Simply put, the Det 1 needs statement established:

- What was needed
- What was nice
- What was not needed

Following these user-defined priorities, Link and ASD have not only delivered significant OFT changes which are concurrent with F-16 aircraft block updates, but are also easier to use and offer training in a manner that matches the F-16 pilot's visual mission.

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