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THE STATE OF THE ART AND THE STATE OF THE PRACTICE

AN INSTRUMENTATION CAPABILITY FOR DYNAMIC TARGETING

Topics

C2 Analysis
Network-Centric Metrics
C2 Experimentation

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Table of Contents

TABLE OF CONTENTS III

LIST OF FIGURES IV

LIST OF TABLES IV

ACKNOWLEDGEMENTS IV

ABSTRACT V

1. INTRODUCTION 1
   1.1. THE PROBLEM AND THE PAYOFF 1
   1.2. PROJECT INITIATION 1
   1.3. PROJECT OBJECTIVE AND GOALS 2

2. CPAS SYSTEM DESIGN AND DEVELOPMENT. 2
   2.1. CPAS SYSTEM ARCHITECTURE 2
   2.2. DT WORK-FLOW MANAGER 3
   2.3. DT COLLABORATION TOOLS 4
   2.4. THE DYNAMIC TARGETING PROCESS AT CAOC-N 5
   2.5. CPAS OPERATIONAL ARCHITECTURE 6

3. CPAS PROTOTYPE SOFTWARE DESIGN AND DEVELOPMENT 6
   3.1. SOFTWARE DEVELOPMENT ENVIRONMENT 6
   3.2. DATABASE DESIGN AND IMPLEMENTATION 7
   3.3. COLLECTOR DESIGN 7
   3.4. DEVELOPMENT STAGES 8
   3.5. THE CPAS X1 AND CPAS X2 PROTOTYPES 8

4. CPAS DEMONSTRATION. 9
   4.1. CPAS CAPABILITES DEMONSTRATED 9
   4.2. POST DEMONSTRATION MEASURES AND METRICS 11

5. CONCLUSIONS 12

POSTSCRIPT 13

REFERENCES 13

List of Figures

Figure 1-1 USAF AN/USQ-163 Falconer AOC 1
Figure 2-1 CPAS Spiral Development Plan 2
Figure 2-2 CPAS System Architecture 3
Figure 2-3 CPAS Display Components 4
Figure 2-4 ADOCS Information Display 4
Figure 2-5 Virtual Rooms for Collaboration 5
Figure 2-6 F2T2EA Process model 5
Figure 2-7 CAOC-N Dynamic Targeting Cell Structure 6
Figure 2-8 CPAS operational Architecture for CAOC-N operations 6
Figure 3-1 CPAS X1 System Architecture @ CAOC-N 8
Figure 3-2 CPAS X2 System Architecture at TBONE LOE #5 9
Figure 4-1 CPAS Event Summary Window 10
Figure 4-2 CPAS Anomaly Display 10
Figure 4-3 CAOC-N Shot Sheet Template 10
Figure 4-4 CPAS Generated Shot Sheet 10
Figure 4-5 CPAS F2T2EA Segments and DT Process Events 10
Figure 4-6 CPAS Chat Search Engine 10
Figure 4-7 Correlation of Key Events and Chat 11
Figure 4-8 CPAS Calculated TST Metrics and Measures 11

List of Tables

Table 3-1 Database Table Schema & Sources 7
Table 3-2 CPAS Collectors and Data Sources 8
Table 4-1 TST Metrics of Interest 12

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Abstract

The air and space operations center (AOC), also deployed as Joint (JAOC) or Combined (CAOC), is the Air Force's weapon system for planning and executing theater-wide air and space forces. Like any USAF weapon system, trainers and warfighters need to assess AOC performance on a continual basis. Currently, no automated methods or tools exist to assess this performance, which may explain the current lack of thorough AOC assessment.

To address this need, JHU/APL developed a prototype assessment capability, the CAOC Performance Assessment System (CPAS), with sponsorship from the USAF Command and Control Battlelab. Working with subject matter experts at the CAOC-N, JHU/APL engineers identified the information required to support dynamic targeting training and assessment. JHU/APL engineers then used a rapid-prototyping spiral development to demonstrate a "non-intrusive" data capture (collection and archiving) capability and an informative user display. Specifically, CPAS collects AOC process data, correlates AOC data sources, and displays events and decisions that occur within the dynamic targeting cell of the AOC to support post-mission assessment of AOC process performance.

The functional CPAS X1 and X2 prototypes were successfully demonstrated at the CAOC-N during RED FLAG 05-4.2 and at the USAF Transformation Center during TBONE's fifth limited objective experiment, respectively. The capabilities demonstrated by CPAS are the first step towards realizing the operational-level instrumentation needs of an AOC weapon system. On-going efforts include expanding the capabilities of CPAS to support CAOC-N instructors and JNTC exercise and JEFX assessment teams.

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1. INTRODUCTION

The mission of the 505th Operations Squadron (OS) at Nellis AFB (CAOC-N) is to conduct continuation training for USAF Falconer weapon system crewmembers and to support exercise operations for the USAF Air Warfare Center. The CAOC-N has provided on-going, continuous support to training and experimentation activities for both USAF and Joint forces (e.g., RED FLAG, VIRTUAL FLAG, Joint RED FLAG, JEFX, et al.) for over two years. During that time, 505th OS personnel have identified the need for an instrumentation system to support their day-to-day operational-level activities.

The instrumentation system envisioned by the CAOC-N is the operational-level equivalent of the air combat maneuvering instrumentation (ACMI) system used by tactical forces to provide a geospatial "air and ground truth" replay of air-to-air and air-to-ground test and training events. This paper describes the technical approach taken and the design used by engineers from the Johns Hopkins University Applied Physics Laboratory (JHU/APL) to produce the functionality of the successful CAOC Performance and Assessment System (CPAS) prototypes.

1.1. THE PROBLEM AND THE PAYOFF

The air operations center (AOC) AN/USQ-163 Falconer, senior element of the Theater Air Control System (TACS), is the weapon system the commander of Air Force Forces (COMAFFOR) provides the Joint Force Air Component Commander (JFACC) for planning and executing theater-wide air and space forces.

FIGURE 1-1 USAF AN/USQ-163 FALCONER AOC

When the COMAFFOR is also JFACC, the AOC is also the Joint Air Operations Center (JAOC). In cases of allied or coalition (multinational) operations, the AOC is also a Combined Air & Space Operations Center (CAOC). The AOC, manned by a dedicated cadre of trained command and control (C2) professionals, enables the JFACC to exercise C2 of air and space forces in support of the Joint Force Commander's (JFC's) campaign plan. The JFACC will employ the AOC to maneuver and mass overwhelming air and space power through centralized control and decentralized execution to produce desired operational and strategic effects in support of the JFC's campaign.[1]

Training of AOC personnel is conducted in graduated phases: Initial Qualification Training (IQT), Mission Qualification Training (MQT), and Continuation Training (CT). Operational and maintenance system training is accomplished with Computer-Based Training (CBT). Additional training devices and concepts include embedded training in software applications, on-line tutorials, part-task trainers, mockups, and simulation systems. Continuation training in time sensitive targeting (TST)/dynamic targeting (DT) operations are a main focus area of the activities that are performed at the 505th Command & Control Wing's CAOC-N facility at Nellis AFB.

In order to efficiently and effectively teach CT students at CAOC-N, instructors require an efficient means to collect, store, correlate, and retrieve key information items pertaining to DT[2] operations. Armed with this information, instructors can reconstruct a time history of activities and events that occurred during real-time DT operations and are better able to show students what they did right and what they did wrong during training operations.

No such automated "machine-to-machine" capability was in place before the CPAS project began. Creating this capability was the challenge that the JHU/APL engineers took on.

1.2. PROJECT INITIATION

The CPAS demonstration project was initially conceived in December of 2004. During a visit to the Air Combat Command's primer training base, JHU/APL engineers were challenged by the leadership of the CAOC-N facility to develop and demonstrate an instrumentation and display system designed to provide real-time situational feedback to DT instructors.

[1] [1], pg 1-1.
[2] DT will be used interchangeably with TST throughout the remainder of this paper.

Over the course of 30 days, JHU/APL engineers conceptualized a capability to instrument, collect, and display DT process information. The idea was compelling and was proposed to the leadership of the USAF's Command and Control Battlelab (C2B) as a pseudo-initiative in Feb 2005.

1.3. PROJECT OBJECTIVE AND GOALS

The USAF C2 Battlelab was established by the Chief of Staff of the Air Force in 1997 to validate high payoff concepts and initiatives with minimum cost and investment.

The C2B is a small, highly focused organization whose mission is to rapidly identify and prove the worth of innovative ideas for Command & Control which improve the ability of the United States Air Force to execute its core competencies to support Joint Warfighting. The C2B seeks great ideas involving technology, concepts, doctrine, tactics, techniques and procedures to improve C2 of aerospace forces.

Ideas are submitted to the C2B from the field, research and acquisition communities, headquarters, industry, academia and in-house. Those with the highest payoff potential are accepted as initiatives for assessment [2]. CPAS was one such idea.

The objective of the CPAS project was to demonstrate a capability to reconstruct and display events and decisions that occur within a DT cell to support post-mission assessment; a very suitable initiative for the C2B to sponsor.

The CPAS project goals, established by the JHU/APL CPAS team and approved by the C2B, were to:

- Develop a "non-intrusive" data capture (collection and archiving) capability for DT-related information at CAOC-N
- Develop a reconstruction capability that will portray event and decision activities that occurred during the execution of DT ops
- Develop an information injection capability that enables an instructor or assessor to input comments/observations into the data archive
- Implement the CAOC Assessment System capability at CAOC-N and demonstrate it during RED FLAG 05-4.2 (Sep 2005)
- Develop initial capability to work with the C2B Theater Battle Operations Net-centric Environment (TBONE) initiative and CAOC processes using TBONE

If a non-intrusive data capture and replay capability could be developed that was adaptable to current and future CAOC systems, then the effectiveness of training operations would be greatly enhanced. Demonstrating such a capability in the "limited" domain of dynamic targeting operations was viewed as a first step towards "instrumentation" of the entire CAOC. Monitoring C2 processes in strategy development, planning, air tasking order (ATO) production, and the entire domain on execution operations is the vision of the "objective" CPAS system capability.

2. CPAS SYSTEM DESIGN AND DEVELOPMENT.

After approval by the C2B, the CPAS demonstration project began. The CPAS team established a spiral approach for CPAS development (see Figure 2-1). The two-pronged spiral accommodated the needs of the two organizations that would benefit most from a successful CPAS demonstration – the Nellis training CAOC and the C2B's TBONE initiative.

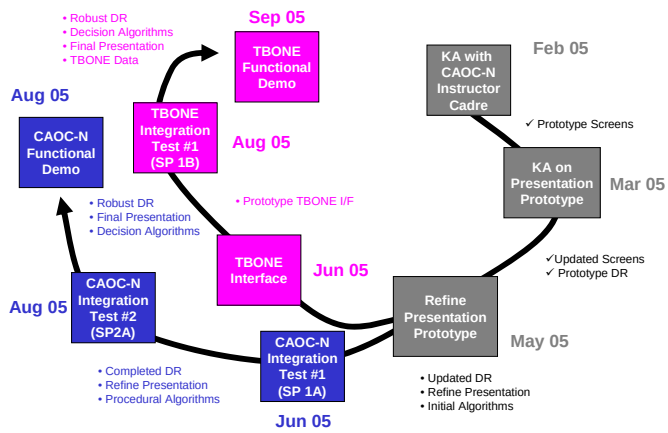

FIGURE 2-1 CPAS SPIRAL DEVELOPMENT PLAN

The system architecture for the CPAS instrumentation capability, characterized in the block diagram in Figure 2-2, was modeled after the architecture of the air combat maneuvering instrumentation system used to train tactical fighter pilots.

2.1. CPAS SYSTEM ARCHITECTURE

The CPAS concept treats each individual collaborative entity (person) as a "black box". Insight is gained by measuring the external stimulus to the "black box" and the interactive/collaborative actions that occur. These actions are observable and measurable during the data collection activity.

The CPAS system has a set of **data collector components** designed to collect specific data available from multiple CAOC C2 data sources. A **database management system** is used to archive data sampled from the data collection components. A family of **analytic functions and algorithms** based on a well-defined **process model** are required to operate on the sampled data and create the **"analysis-processed" output** which is stored in data tables. The "analysis-processed" data tables are structured to support specific C2 processes and user displays. They contain sampled data augmented with information input by subject matter experts (SME) and outputs of algorithms. The data tables are formatted to provide analytic output, time-history displays, and are designed specifically to support warfighter training needs.

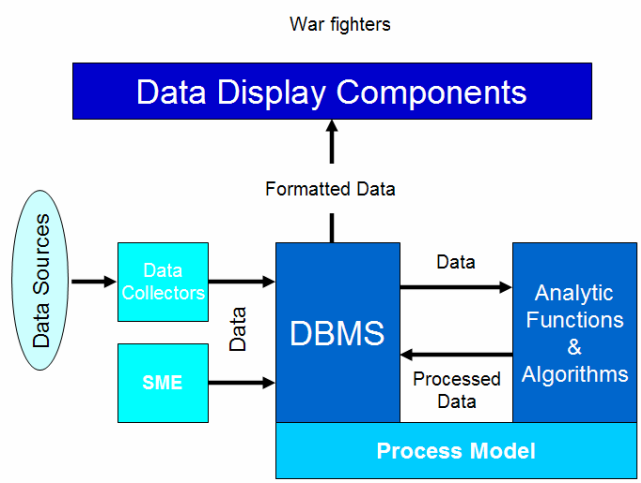

FIGURE 2-2 CPAS SYSTEM ARCHITECTURE

The CPAS display components[3] (see Figure 2-3) are based on the well-defined "kill chain" process model and the DT tactics, techniques, and procedures (TTP). These components provide the interactive interface to the analytic functions and include the user interfaces for data extraction from the analysis-process tables to be used by analysts, trainers, and reviewers alike. The CPAS system architecture is intended to support a degree of isolation between the systems segments (data collection, database management system, analysis-output databases, analytic functions, the analysis-processed output, and the user interface display). By doing so, the most appropriate software design and implementation may be applied to each of the separate segments. For example, this architecture enables a high-performance C++ implementation to be used for data collection, with the database management system (DBMS) being implemented through a commercial database. It allows for the analysis and display components to be implemented in Java (for portability) or C# (for rapid prototyping in a Windows environment). Either display capability may access the analysis-processed output which is stored in data tables contained within the prototype database implemented in Microsoft Access (due to potential customer needs and cost issues).

The design, development, and demonstration phases followed an initial knowledge acquisition process. CPAS team members set out to learn the CAOC-N DT training process and the software tools used to execute the process by attending and observing a RED FLAG training exercise at Nellis AFB in Feb 2005.

2.2. DT WORK-FLOW MANAGER

The USAF has adopted several tools to manage, coordinate, collaborate, and control the DT process described above during mission execution. The principal mission management software application enlisted in early versions of the CAOC's enterprise software system[4] to support the orderly flow of work is the Automated Deep Operations Coordination System (ADOCS) conceived originally by DARPA and implemented in the mid-90s by General Dynamics[5].

The ADOCS work-flow manager provides an "all-in-one" capability for geospatial situational awareness, process execution status, and target-related information storage. For each target that has been nominated as a DT, or has been designated as a DT, ADOCS stores key information items. Furthermore, as the DT process is executed, key items related to the target and the process that change and evolve are archived.

The ADOCS status display (see Figure 2-4) provides all members of the DT cell with an instantaneous view into the state of the process (through the colors of the status display "Chiclets®") and access to tasking and targeting information associated with all missions being planned or executed.

[3] Details describing each of the display components can be found in Section 4 CPAS Demonstration.

[4] Theater Battle management Core Systems (TBMCS)

[5] ADOCS has been fielded as a component of TBMCS versions 1.1.1 and 1.1.3. It is forecast to be replaced in TBMCS 1.1.4 by a web-enabled version developed under a USAF contract. The replacement application is known as the Web-enabled Execution Management Capability (WEEMC).

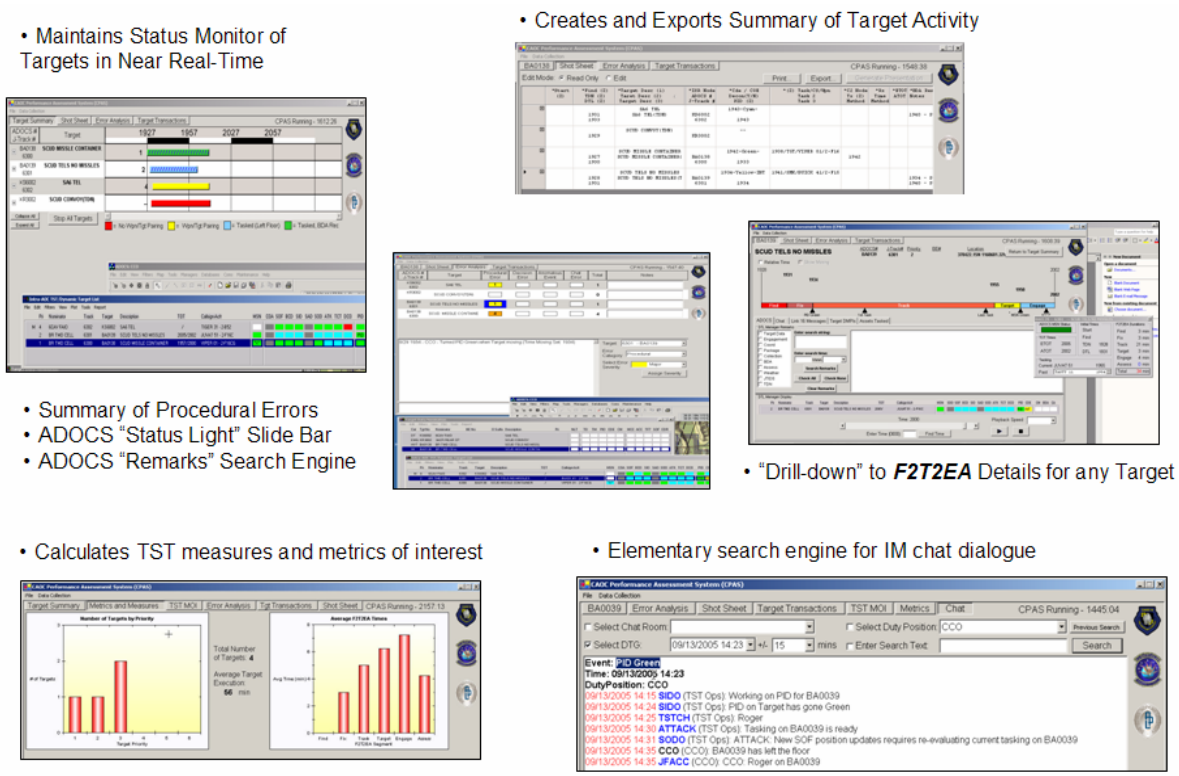

FIGURE 2-3 CPAS DISPLAY COMPONENTS

2.3. DT COLLABORATION TOOLS

The DT work-flow manager provides members of the DT team with insight into the state of the DT process and a means to collaborate during process execution. However, instant messaging and chat tools are the principle means for team members to communicate with each other. Text dialogues between members occur within "virtual rooms" (see Figure 2-5) defined by the functional information exchange that occurs within them throughout the DT process. For example, conversations about intel-related activities occur in a chat room labeled "SIDO" (senior intel duty officer), discussions associated with targeting and tasking occur in the "TST Ops" room, and info exchanges between instructors regarding exercise control occur in the "White Force" room.

The information exchanges that occur within the chat rooms have several different structures. For example, there are one-to-many broadcasts; there are one-to-one dialogues, and there are many-to-one exchanges. In addition to chat exchanges, some collaboration tools have a capability to display posted notes containing information viewable by all who enter the virtual rooms.

There are several software applications in use today in Falconer AOCs that provide this type of collaboration capability. The most widely used is called Information Workspace (IWS) developed by the Ezenia Company [3]. The open-source Jabber technology is also being used in the experimental venues such as the JEFX 2006.

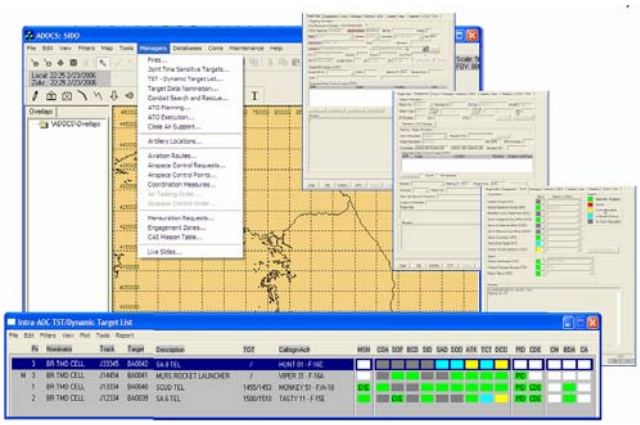

FIGURE 2-4 ADOCS INFORMATION DISPLAY

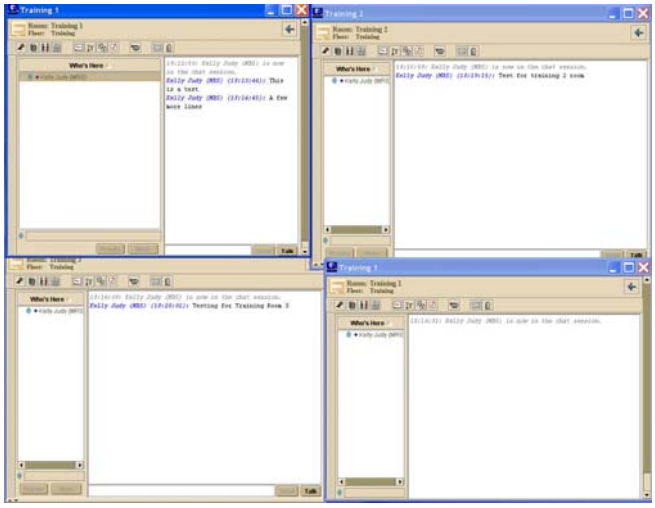

FIGURE 2-5 VIRTUAL ROOMS FOR COLLABORATION

2.4. THE DYNAMIC TARGETING PROCESS AT CAOC-N

The DT process used in the CAOC during OPERATION ENDURING FREEDOM (OEF) and OPERATION IRAQI FREEDOM (OIF) was developed by "a band of brothers" during the early days of the CAOC-N at Nellis AFB. The process proved to be very successful and was established as the de facto standard.

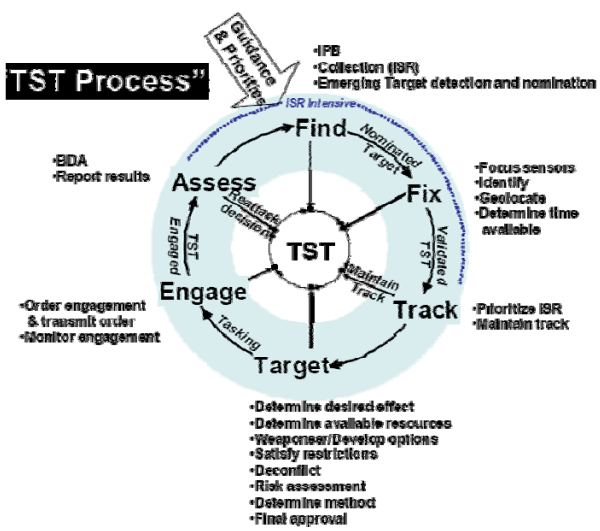

FIGURE 2-6 F2T2EA PROCESS MODEL[6]

The Find Fix Track Target Engage and Assess (F2T2EA) "kill chain" process model depicted in Figure 2-6 and the DT process have been institutionalized and recorded as the Air Force operational procedure for dynamic targeting in Air Force guidance.[7]

Because CPAS was designed to provide a capability for DT training, the CPAS prototype was implemented with a focus on the F2T2EA model used in CAOC combat operation division, dynamic targeting operations.

The layout of the DT cell which executes the DT process during training operations at CAOC-N is diagramed in Figure 2-7. The process, or TTP, that is followed is summarized in the following steps:

1. The CAOC-N White Force (instructors) provide a initial Intel input on a possible target to DT cell
2. Target is nominated as a potential DT and target info is entered into ADOCS target data nomination manager (TDN). Intel develops and refines targeting data.
3. Target is classified as a DT by TST Chief and target info in TDN is moved into ADOCS dynamic target list manager (DTL).
4. Targeting data is developed for target folder by Intel cell and DT Targeting Duty Officer (TDO)
5. Positive target identification (ID) is accomplished by the Intel cell
6. Attack Coordinator searches ATO for available weapon platforms to be tasked to engage DT, ensures collateral damage estimate (CDE) complete and develops mission plan with TDO.
7. Mission "package" is provided to TST cell chief for review of compliance with the rules of engagement (ROE). Chief of combat operations (CCO) or the senior offensive duty officer (SODO) approves tasking order.
8. Tasking order (15-line text message) is drafted by C2 duty officer (C2DO) and transmitted by ground track coordinator (GTC) via Link-16 or voice to airborne weapons controller (AWACS).
9. AWACS acknowledges receipt and passes info to weapon platform who either accepts or rejects tasking.
10. Acknowledgment is provided to C2DO with estimated time-over-target (TOT) from the weapon platform
11. Target is attacked

[6] [1], Figure 5-4.

[7] [1], pg 5-39

12. Weapon platform provides a mission report (MISREP) to AWACS from fighter with actual TOT and battle damage assessment (BDA) if available.
13. Target's F2T2EA kill chain is complete

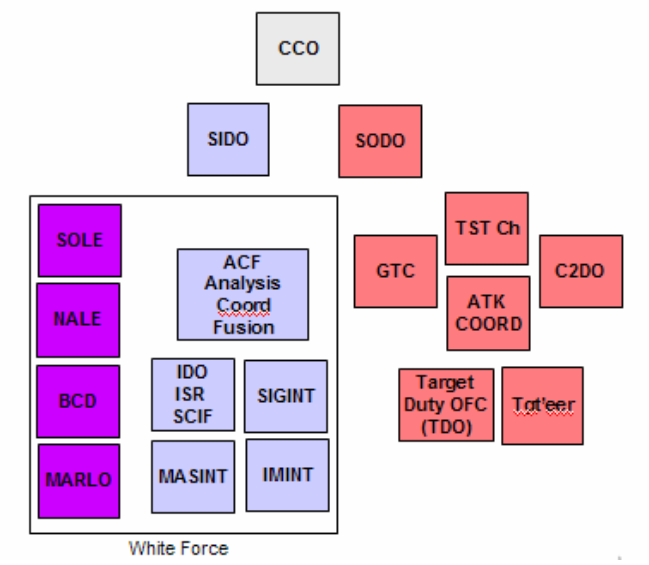

FIGURE 2-7 CAOC-N DYNAMIC TARGETING CELL STRUCTURE

2.5. CPAS OPERATIONAL ARCHITECTURE

CPAS was designed for use at the CAOC-N during training operations such as RED FLAG, VIRTUAL FLAG, and USAF Weapons School supported exercises. During these exercises, live-flying aircraft, and in some situations simulated aircraft, perform tactical-level activities on military ranges within the Nellis and other southwestern US airspace. Simultaneously, AOC warfighters conduct operational-level activities and man the DT cell in the CAOC-N where they execute the DT process described earlier.

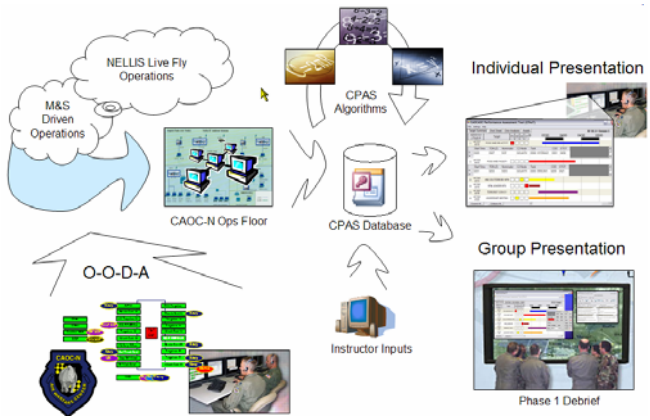

FIGURE 2-8 CPAS OPERATIONAL ARCHITECTURE FOR CAOC-N OPERATIONS

The CPAS system is designed to run continuously during training activities. CPAS "collector" software attached to the CAOC-N network collects data from multiple sources and stores it in the CPAS database along with inputs (e.g., notes and comments) made by CAOC-N instructors. CPAS algorithms continuously work on the collected data, transforming it into insightful information to support the training process. CPAS then provides a near real-time, continuous display of the "state" of the DT process, by depicting the status of each dynamic target being prosecuted.

When the exercise period is over, instructors use the CPAS debriefing tools to "reconstruct" the process that occurred during training, after-the-fact, and provide students with feedback on how they performed. The operational architecture of CPAS that enables this is portrayed in Figure 2-8.

3. CPAS PROTOTYPE SOFTWARE DESIGN AND DEVELOPMENT

Once the concept of employment, the functional requirements, and the technical design of CPAS were established and documented, prototype development began.

3.1. SOFTWARE DEVELOPMENT ENVIRONMENT

The first task accomplished in the software development phase was to establish the CPAS development environment. Decisions made considered software development languages, backend database platform/vendor, ease-of-deployment, and capability for rapid, robust prototype development.

The team decided to develop CPAS in the Microsoft .Net framework using the programming languages C# and C++. Initially, the Java programming language was considered for its cross-platform capabilities, but CPAS was only required to interact with Intel PCs running Microsoft (MS) operating systems (either Windows 2000 or Windows XP). In addition, CPAS needed to interact with various Microsoft Office products (Excel for the "shot sheet"[8] export and Access for the backend database) and Component Object Model (COM) and MS Office interoperability is better supported in the .Net framework. Furthermore, the developers had more experience in C# and C++ than Java, reducing the need for additional technical training.

The software developers used the Microsoft Visual Studio 2003 Professional Integrated

[8] The "shot sheet" is described in paragraph 4.1

Development Environment (IDE) to write the ADOCS Collector (in C++) and the Jabber chat collector, IWS collector, user interface and algorithms (in C#). Since the CPAS architecture called for separate collector and user interface applications, software developers coded in languages they knew best, helping to reduce development time and cost. In addition, the ability to export various code "modules" as dynamic link libraries (DLLs), allowed code written in any of the .Net framework-supported languages (Visual C++, C#, and Visual Basic.Net) to work with any other CPAS code segments or applications.

3.2. DATABASE DESIGN AND IMPLEMENTATION

During initial CPAS design meetings, team members discussed several database architectures. Potential architectures included Microsoft Access, Microsoft SQL Server, MySQL, and Oracle. While each had advantages and disadvantages, Microsoft Access was ultimately chosen as the CPAS database backend. Several key advantages led to this selection:

1. The .Net framework provided built-in functions and methods to connect, read, and write information from Access databases. Developers only needed to write small amounts of code to read and write data from the database.
2. Many people are more familiar with using and manipulating Access databases than administering a SQL Server, MySQL, or Oracle database management system and/or server. The average end user could, though was not expected to, interact directly with the raw data.
3. The expected concept of employment (CONEMP) of CPAS described storing each analysis session separately, i.e. CPAS would use a new Access database for every session. Although the individual databases can be combined into one large Access database using tools within Access (or simple copy and paste methods), this design decision allowed easy transmission or distribution of individual session data to various other organizations or interested parties.
4. All intended users of CPAS owned licenses for Microsoft Access. Installing or providing licenses for SQL Server or Oracle databases would cut into development and project costs.
5. No special applications or training were needed to administer or maintain the CPAS database.
6. The expected read and write data rates and number of concurrent open connections to the database were small enough that performance issues were not a concern.

Depending on future CPAS requirements, the database platform may change. For the X1 and X2 implementations, Microsoft Access meets all user and developer requirements.

The database schema was created using tools in Microsoft Access. The schemas for several CPAS database tables and the source of the schema design is described in Table 3-1.

TABLE 3-1 DATABASE TABLE SCHEMA & SOURCES

CPAS Access Database Table	Schema Source
ADOCS	Copied from ADOCS Mission History format
IWS Chat	Determined chat information needed to suffice end user requirements
WEEMC	Modeled after WEEMC Mission History format
Jabber Chat	Directly ported from schema used by Jabber Inc's chat database (Oracle 9i)

3.3. COLLECTOR DESIGN

The overall design approach for collectors was simple: keep collectors lightweight and independent from other collectors and the user interface. This approach worked. All the collectors developed extract data from independent data sources. Collectors were developed concurrently and updated separately as modifications were needed.

All collectors share similar capabilities. Some collectors are more automated, such as the ADOCS collector, while others require more user interaction, like the IWS chat collector. All collectors, however, attempt to minimize user involvement. In general, collector design is straightforward: collect and/or parse data from a specific data source (database, binary data files, text files, etc) and write the collected/parsed data into the shared CPAS database for that session. Table 3-2 shows the developed collectors and their respective data sources.

TABLE 3-2 CPAS COLLECTORS AND DATA SOURCES

Ver	Collector	Data Source	Data Source Format & Connection	Level of User Interaction
X1	ADOCS Collector	ADOCS Process Mgrs	ADOCS binary mission history files	Monitor
X1	IWS Collector	IWS Chat Client	Exported IWS chat logs (.txt)	Save chat as .txt logs; Open chat logs in Collector
X2	WEEMC Collector	WEEMC Process Mgrs	Exported Mission History log in Microsoft Excel (.xls)	Copy and Paste msn history into Excel SS; Run Excel macro to format data; Run Access macro to import Excel SS
X2	Jabber Collector	Jabber, Inc Chat Client	SQL Connection to Oracle 9i database	Monitor

3.4. DEVELOPMENT STAGES

The CPAS prototype development occurred on two tracks, one for the user interface and one for the collectors. CPAS algorithm development was accomplished in the user track.

The user interface track consisted of four primary stages: paper prototype mockups, low-fidelity software prototype, high-fidelity software prototype, and modifications, updates, and capability exploration. Throughout each stage, user interaction and information requirements were constantly reassessed. Developers and human systems engineers created the initial paper prototypes to flush out interface and information display ideas.

Next, a low-fidelity software prototype was developed for a user design review. This shallow prototype demonstrated the concepts of numerous capabilities and was used to flush out final user requirements as well as explore technological limitations and capabilities.

During the high-fidelity software prototype (X1) stage, the refined algorithms that determined each F2T2EA segment time[9], watched and highlighted anomaly occurrence, and calculated numerous analytic measures and metrics, were developed and tested to ensure they sufficiently met the majority of user requirements.

The final stage -- modifications, updates, and capability exploration -- consisted of modifying the finalized X1 prototype to work with WEEMC and the TBONE environment (X2), add various measures and metrics, and alter display preferences.

The collector track also had four primary stages: analysis of desired data source and data format, alpha collector, extensive testing, and beta collector. Before developers could code the collectors, they needed a thorough understanding of the data source, data format, and possible avenues for collection. After this exploration stage, developers created alpha collectors. These collectors were proof-of-concept applications of varying degrees of fidelity that connected to or parsed the various data sources and wrote the data into a CPAS database.

Extensive testing in high-stress environments provided insight into collector issues including binary file formats, concurrency, and resource utilization. With this insight, the developers either rewrote the collector or modified the alpha collector to arrive at the beta collector. The beta collectors were finalized versions of the collectors, but left in beta state since both CPAS X1 and X2 were prototypes.

3.5. THE CPAS X1 AND CPAS X2 PROTOTYPES

As discussed previously, two versions of the prototype CPAS software were implemented – CPAS prototype one (X1) was designed for demonstration during a CAOC-N training operation. CPAS prototype two (X2) was for demonstration at the C2 BattleLab's TBONE limited objective experiment (LOE) #5. The prototype software configurations are described below.

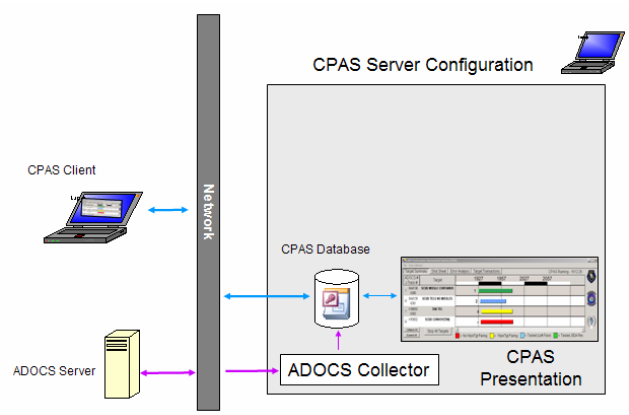

FIGURE 3-1 CPAS X1 SYSTEM ARCHITECTURE @ CAOC-N

[9] F2T2EA segment time refers to the length of each of the time periods during which one of the find-fix-track-target-engage-assess activities occurs.

The CPAS X1 system architecture was implemented as shown in Figure 3-1. One laptop was configured as a CPAS presentation client and ran the user interface, a.k.a. presentation, software. A second laptop was configured as a server. The server ran the collector software for ADOCS (version 9.0.2.15) and the CPAS presentation software. Additionally, the CPAS database was installed on the server and accessed by both presentation apps as well as the ADOCS collector.

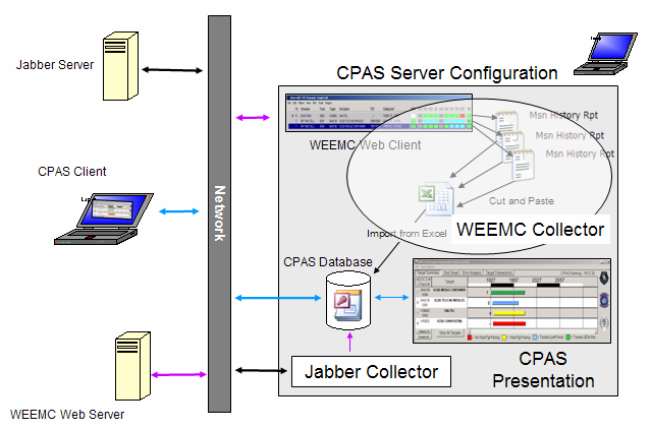

FIGURE 3-2 CPAS X2 SYSTEM ARCHITECTURE AT TBONE LOE #5

The CPAS X2 system architecture was also a two laptop configuration, similar to the X1. On the X2 server, the manual WEEMC (JEFX Sp 0 version) collector replaced the ADOCS collector and the new Jabber chat collector software was added (see Figure 3-2). The second laptop was configured as a CPAS presentation client and, as with the X1, ran the user interface software. The CPAS database was installed on the server and accessed by both presentation apps and both data collectors.

4. CPAS DEMONSTRATION.

Demonstration of the CPAS prototypes was scheduled to occur during actual USAF training exercises. The choice of the late August RED FLAG (05-4.2) was driven by the ability of the CPAS team to obtain the appropriate security accreditation and be authorized to connect the CPAS X1 laptops to the secure network at the CAOC-N. Likewise, the Langley AFB Transformation Center (TC) would require a security accreditation seal for the CPAS X2 laptops.

Both the RED FLAG and the TBONE venues provided CPAS developers with an excellent opportunity to demonstrate the CPAS prototype functionality, not only to the SMEs who helped to create it, but also to the warfighters who would ultimately be the targeted customers of the value of CPAS.

Demonstration of the X1 prototype occurred at the Nellis AFB CAOC from 22 – 26 August 2005. Overall, the X1's capability was very well received by the 505th OS staff. The instructor cadre predicted that a fielded CPAS would reduce their workload in debrief preparation and had the potential to enhance the accuracy of their feedback to students.

Both development and demonstration of the X2 prototype occurred at the Langley AFB TC from 12-16 September 2005. The X2 software was a modification of the X1 prototype. While the X1 and X2 prototypes employed similar architectures, the X2 prototype contained various modifications, including new data tables in the data layer to hold chat data, two new data collectors for the new data sources[10], and correlation capabilities between chat and process data in the presentation layer.

Overall, the demonstration of the X2's capability was well received by the numerous individuals who saw it. Unfortunately, the X2 provided very limited functional use in support of the DT operations during the TBONE LOE #5. During the execution of LOE #5, unlike at CAOC-N during the RED FLAG exercise, not a single DT process thread was executed from start thru the finish.

4.1. CPAS CAPABILITES DEMONSTRATED

During both the RED FLAG and TBONE demonstrations, CPAS executed concurrently with real-time operations. The CPAS data collectors were started when operations began in the DT cell. At CAOC-N, a single ADOCS collector ran unattended throughout the evening's events. During TBONE LOE #5 two collectors were used. The WEEMC collector was manually controlled because data query services were not implemented in the current WEEMC build. The Jabber Chat collector ran unattended and executed queries on the Jabber chat database throughout the day's events. CPAS provided users with the ability to monitor the status of a targets "state" as the DT process was executing. The main event summary window, see Figure 4-1 below, provided a timeline presentation of information and the user was able to browse thru various tabs and drill-down windows to obtain additional information on the state of the target or mission.

[10] The new data sources were now the Web Enabled Execution Manager Capability (WEEMC) for work flow and process data (vice ADOCS) and the Jabber Messenger chat server for chat data.

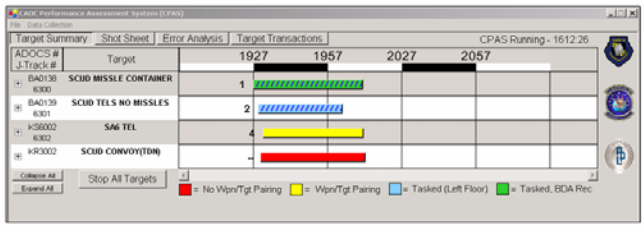

FIGURE 4-1 CPAS EVENT SUMMARY WINDOW

CPAS provided an anomaly display which summarized procedural anomalies that were made by the members of the DT cell during the DT execution process. The display showed the number of anomalies that occurred, a description of each anomaly, when it was made, and who was responsible for it (see Figure 4-2).

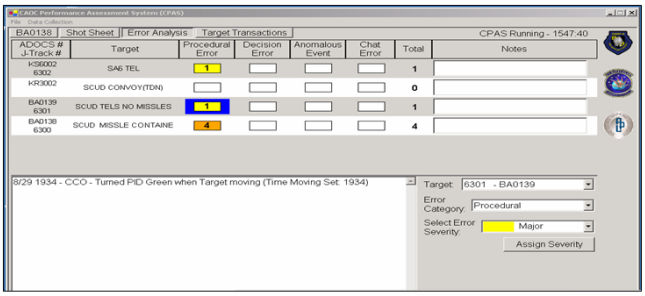

FIGURE 4-2 CPAS ANOMALY DISPLAY

The CAOC-N instructor cadre developed a mission summary sheet that they used to synopsize each evening's training events. The "shot sheet" (Figure 4-3), as it was called, contained the key event times and information associated with the day's training exercise and was used as the fact sheet that supported the debriefing process, also referred to as "reconstruction".

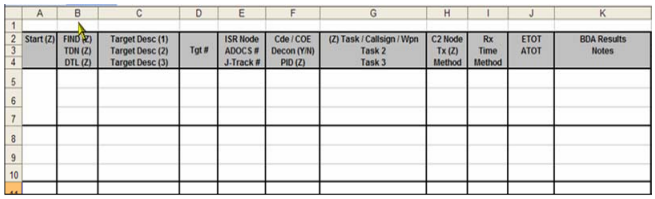

FIGURE 4-3 CAOC-N SHOT SHEET TEMPLATE

During the course of each training event, a significant amount of instructor and student time was dedicated to manually collecting the data required to fill-in the shot sheet. The CPAS data collectors were programmed to collect all this data, and more, and did so effortlessly, storing it in the CPAS database. Both the X1 and the X2 prototypes were able to continuously complete the surrogate shot sheet (Figure 4-4). This capability was a significant improvement over the methods in use at the CAOC-N.

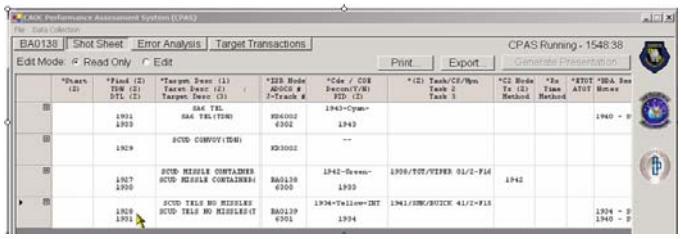

FIGURE 4-4 CPAS GENERATED SHOT SHEET

The CPAS target "drilldown" window (Figure 4-5) provides a timeline display of much of the shot sheet data. For each target, the drilldown showed how long it spent in each segment of the F2T2EA kill chain. Overlaid below the timeline, all the key DT process events (such as when positive identification was assured, when the collateral damage estimate was completed, when tasking was sent from the DT cell, and actual time over target occurred) were also displayed. The drilldown provided a near complete temporal depiction of each target prosecution.

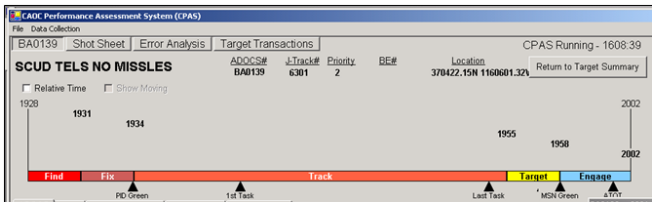

FIGURE 4-5 CPAS F2T2EA SEGMENTS AND DT PROCESS EVENTS

The chat display and search engine was a major enhancement to the CPAS functionality demonstrated in the X2 prototype. The chat collector captured and wrote every line of chat written by any person in all the active chat rooms and the chat search engine provided a means to selectively retrieve any line of chat (Figure 4-6) for review.

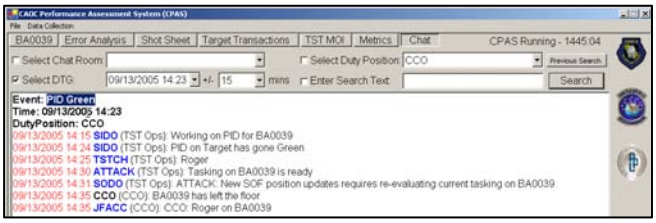

FIGURE 4-6 CPAS CHAT SEARCH ENGINE

CPAS X2 had multiple sources of process information in its database. This provided a means for the CPAS to demonstrate that greater insight into what had occurred during the DT process execution could

be achieved with more sourced data. The ability to cross-correlate the chat strings with key DT process events was implemented thru the drill-down display and the chat search display. The correlation was accomplished by providing a link from the event milestone to a chat search centered on the time the event occurred and who the event was performed by (see Figure 4-7). The three key parameters that provided the means for the cross-correlation were the event time of each occurrence, the ADOCS or WEEMC login id associated with the duty position, and the Jabber chat login ID.

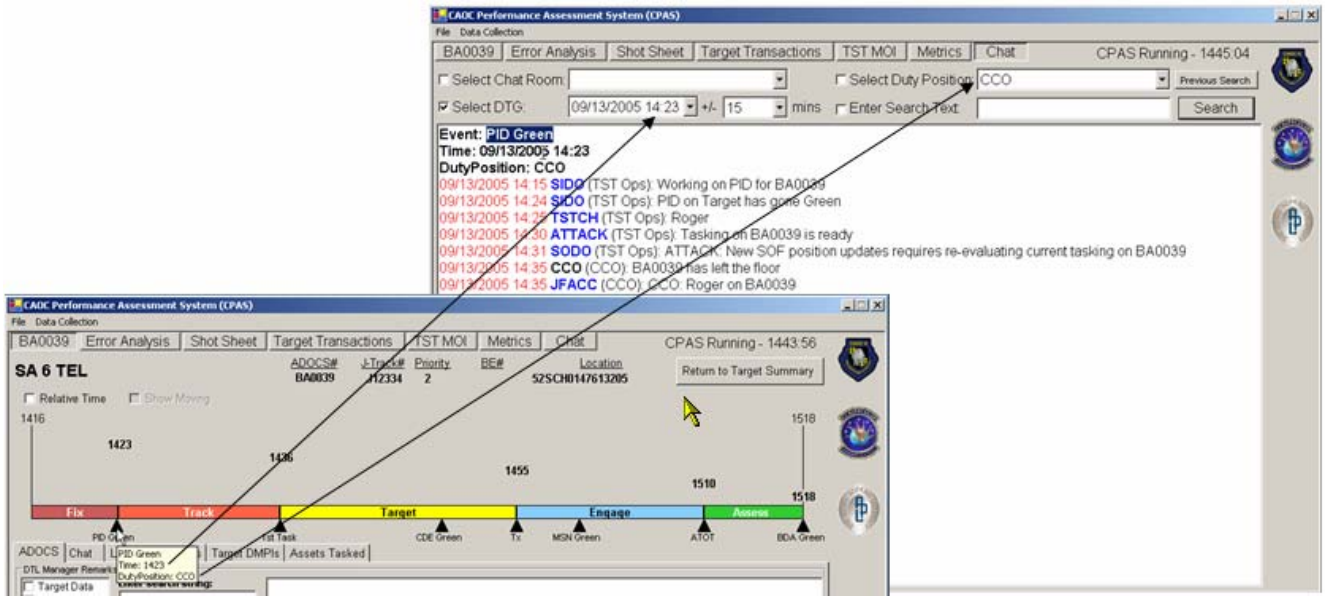

FIGURE 4-7 CORRELATION OF KEY EVENTS AND CHAT

In addition to the collection and display of timeline information, both CPAS prototypes were programmed to calculate conventional metrics based on the captured data. During the RED FLAG demonstration, CAOC-N instructors expressed an interest in seeing summary metrics such as: the number of targets prosecuted listed by their priority number, the total number of targets prosecuted, the average time of target prosecution, and the average time a target stayed in each kill chain segment. CPAS code was quickly developed to display these metrics (Figure 4-8).

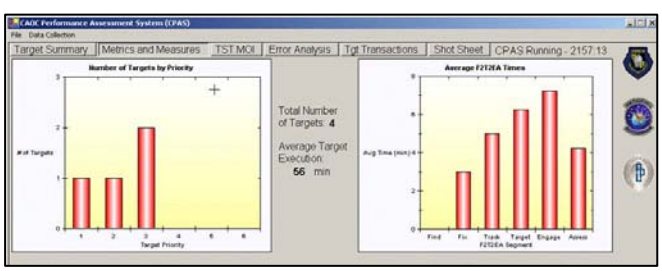

FIGURE 4-8 CPAS CALCULATED TST METRICS AND MEASURES

The calculation of metrics during TBONE LOE #5 was not meaningful because the DT threads were not brought to closure. However, CPAS X1 was demonstrated to members of the Joint Expeditionary Force Experiment (JEFX) 2006 Assessment Team and they became very interested in exploring the use of the CPAS capability in support of the assessment process being developed for JEFX 2006.

4.2. POST DEMONSTRATION MEASURES AND METRICS

The ability to quickly and efficiently calculate numerous metrics and measures, such as those listed in Table 4-1, during, and immediately following, experimentation execution has been a requirement for the Air Force Experimentation Office's (AFEO) assessment team for many years.

The process in-place to perform the data extraction and metric calculation is very labor intensive. As a result, the assessment team would routinely process data for only a few targets during any one day's experiment. The demonstrated capability of CPAS to generate a "shot sheet" in near-real time for all the targets being prosecuted was seen a means to enable a more complete assessment. The collectors of CPAS could collect the data required to calculate almost all of the measures and metrics of interest

(those that are highlighted in yellow, green and white in Table 4-1). Furthermore, the capability to cross-correlate key events with chat logs (another task the assessment team performs manually) excited the analysts. Meeting the needs of the experiment assessment team is the focus of the next steps in the CPAS evolution.

TABLE 4-1 TST METRICS OF INTEREST

		TST Measure of Interest
1		Detected entities correctly identified (%)
2		Detected entities incorrectly identified (%)
3		Detected entities reported without sufficient ID (%)
4		Source of detection and ID (entity name or node)
5		Source of ID error (entity name or node)
6		Detection to to ID (elapsed time)
7		ID to target nominated (elapsed time)
8		Target nominated to target approved (elapsed time)
9		Target approved to weapon tasked (elapsed time)
10		Positional accuracy of reported targets coordinates (TLE)
11		ISR reported targets on Track Data Nominator (quantity)
12		ISR reported targets on ITM-Dynamic Target List (quantity)
13		Completeness of ISR reported targets (%)
14		Targets tasked to shooters (quantity)
15		Targets tasked to shooters via data link (quantity)
16		Targets tasked to shooters via voice (quantity)
17		Targets tasked to shooters via both data link voice (quantity)
18		Target location provided verbally to shooters via coordinates or bullseye (quantity)
19		Target location provided verbally to shooters via talk-on from geographical features (quantity)
20		Target location provided via digital cueing-e.g., track number and SPOI (quantity)
21		Targets successfully attacked (quantity)
22		Targets unsuccessfully attacked (quantity)
23		Targets assigned (quantity)
24		Time from target tasked to target attacked (quantity)
25		Targets attacked (quantity)
26		Targets not attacked (quantity)
27		Time form target detected to target successfully attacked (elapsed time)
28		Unsuccessful Attacks: Attacked wrong enemy target (quantity)
29		Unsuccessful Attacks: Attacked friendly (quantity)
30		Unsuccessful Attacks: Other (quantity and characterization)
31		Cause of unsuccessful attacks: C2 error (quantity)
32		Cause of unsuccessful attacks: Aircrew error (quantity)
33		Cause of unsuccessful attacks: Environmental (quantity)
34		Cause of unsuccessful attacks: Other (quantity)
35		Timeliness of DT processing (time) ?

5. CONCLUSIONS

The authors believe that the capabilities that CPAS provides to Falconer AOC instructors will enable a transformation in the way AOC training is accomplished. This training transformation will be similar to that which occurred when the ACMI and the cockpit video camera recorder (VCR) were introduced to support tactical fighter aircrew training in the mid-1970s. With these new tools in the hands of the instructors, the training was no longer based solely on the perceptions of the instructor and the student. The more reliable, objectively measured facts were available from the ACMI logs, the VCR tapes, and now, the CPAS presentation.

CPAS is also a training-force multiplier. No longer will instructors be forced to spend valuable training time collecting data for reconstruction. CPAS will provide an automatic collection and compilation of the required data. Instructors will be afforded time to observe and interact and have a more continuous perception of the training environment

Lastly, although CPAS was designed based on requirements established by the trainers at CAOC-N, the use of a CPAS instrumentation tool during experiment execution assessment (such as in a JEFX), or during CAOC weapon system operational test and evaluation (OT&E) will reduce work-load on data collectors and enhance the quality of the assessment by providing pedigreed information to the analysts quicker, more complete, and more accurate.

Postscript

The CPAS Prototype Demonstration Project was completed in Sep 2005 after demonstrating the capability of the X1 and X2 prototypes. The USAF Research Laboratory Aircrew Training Research Center and the CAOC-N teamed together to pursue a follow-on project that would advance the technology readiness level (TRL) of the CPAS prototypes from TRL 5 to TRL 6. The product of the CPAS V1 project is scheduled to be delivered to the sponsoring agencies in May 2006.

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[1] AFOTTP 2-3.2, Air and Space Operations Center, 13 December 2004.

[2] AF Command & Control Battlelab, "Mission" (2006), http://www.afc2isrc.af.mil/c2b/mission.htm, (Accessed 1 Mar 2006).

[3] Information Workspace, Launchpad, https://www.ezenia.com, (Accessed 3 Mar 2006).