Visually Based Timeline Debrief Toolset for Team Training AAR

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ABSTRACT

Large-scale team training presents a challenge for instructors who must coordinate after action review for distributed teams. This paper presents a visual timeline-based debrief toolset that enables instructors to quickly construct and present playback vignettes for salient training points.

The AAIRS (After Action Intelligent Review System) application being developed for the Marine Corps' CACCTUS (Combined Arms Command and Control Trainer Upgrade System) identifies training points through the use of intelligent data collection and causal analysis methods. AAIRS records the training mission execution, which includes a synchronized collection of exercising force audio communications and human in the loop interaction with system components (operational C4I and simulator interface tools). Key exercise data relevant to training points is tabulated by the debrief construction tool and presented visually along a timeline for instructor review. The time consuming process of reviewing sequential recorded radio communications is eased by visually representing individual transmissions on the timeline, grouped into dialogs and annotated with speech analysis results. The tool's presentation capability allows instructors to preview their planned debrief presentation and customize it prior to formal debrief. This facilitates a highly configurable after action review, where the presentation of each training point in the debrief can include descriptive causal analysis text, voice communications playback, and 3D views of the battlefield, either frozen in time (visually, a "snapshot") or played back as vignettes.

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INTRODUCTION

Large-scale team training presents a challenge for instructors who must coordinate after action review for distributed teams. This paper presents the concept for and description of a visually-presented, and timeline-based, debrief toolset that enables instructors to quickly identify, construct, and present playback vignettes for salient training points.

The AAIRS (After Action Intelligent Review System) application being developed for the Marine Corps' CACCTUS (Combined Arms Command and Control Trainer Upgrade System) identifies training points through the use of intelligent data collection and causal analysis methods. AAIRS records the training mission execution, which includes a synchronized collection of exercising force radio communications and human in the loop interaction with system components (operational C4I and simulation/simulator interface tools). Key exercise data relevant to training points are tabulated by the debrief construction tool and presented in a visual format along a timeline for instructor review. The time consuming process of reviewing sequential recorded radio communications is eased by visually representing individual transmissions on the timeline, grouped into dialogs and annotated with speech analysis results. The tool's presentation capability allows instructors to preview their planned debrief presentation and customize it prior to formal debrief. This facilitates a highly configurable after action review, where the presentation of each training point in the debrief can include descriptive causal analysis text, radio communications playback, and 3D views of the battlefield, either frozen in time (a visual "snapshot") or played back as vignettes.

This paper describes the training requirements that constitute the objectives for the subject effort, with a short discussion of several previous efforts that have provided timeline-based debrief playback capabilities. Initial feedback from the user community is also discussed, as well as the way forward for continued concept development.

TRAINING OBJECTIVES

CACCTUS will support a live, virtual, and constructive training environment that facilitates the interaction between and among levels and echelons of command and control agencies normally found in the tactical environment in the conduct of real-time combined arms fire support operations. Combined arms exercises train and rehearse the exercising force (EXFOR) personnel in the tasks of coordinating multiple supporting arms with maneuver. Training exercises take place in Combined Arms Staff Trainer (CAST) facilities, and may involve 100 or more participants at various stations in the facility, carrying out their respective operational responsibilities. There is an emphasis on providing the EXFOR the experience of performing a role in scenario-based combined arms exercises, so that training is experiential. As a result, EXFOR responsibilities during training mirror those during operational actions, including the employment of skills in communication and coordination, and tactics, techniques, and procedures in support of specific training goals.

As an example, the battalion level Fire Support Coordinator (FSC) is responsible for clearing requests for fire missions and air strikes from subordinate units, and therefore must maintain a clear and accurate operational picture. This also requires coordination with senior and adjacent units, with a constant flow of requested and disseminated information. In a specific example, if a forward observer requests an artillery fire mission, the FSC must have a correct operational picture in order to make a determination that is both timely and consistent with the scheme of maneuver, rules of engagement, and safety constraints.

Within this operational context, the training objective is not only to detect execution event outcomes and report key training points back to EXFOR, but also to trace the decision-making and possible errors that precipitated the event outcomes. This end-to-end objective requires a robust data collection and analysis capability that monitors events and actions during an exercise and stores data in a form that can be rapidly retrieved in after action. From a user perspective, a debrief toolset is required that supports a two-step process. First, human instructors must have *Debrief Construction* tools with which they can quickly form their own knowledge of the training points, and assemble debrief materials accordingly. Second, *Debrief Presentation* tools must provide clear context to the training audience, ideally in a visual format that doesn't obscure training points in text and statistics.

The need for such capabilities is common to many team training domains, especially where communications and coordination play a key role in success, and thus where the after action aims to highlight specific decision points in playback and show their relationships to simulation events. Accordingly, this paper focuses less on the approaches for supporting specific domain training points (e.g., battlespace geometry conflicts in combined arms operations), and more on the general methodologies for providing flexible tools for quick exercise review, and debrief preparation and presentation. The intention is to support objectives ranging from a quick automatically generated debrief, to situations where instructors, operators, or controllers seek to review training points in detail before presenting a debrief, and to possibly customize the debrief in a variety of ways, using tools to make this process fast and clear.

Debrief Construction Objectives

The simplest Debrief Construction use case involves assembling the automatically generated debrief materials in one step, if the instructor is satisfied that no customization is required. In cases where instructors prefer to review training points in detail and tailor them for debrief, the emphasis on visual presentation of exercise data accelerates these tasks, with a goal of keeping total preparation time to 30 minutes or less. The specific objectives of the Debrief Construction tools include:

- Make use of automated analysis and event detection capabilities performed during exercise execution to collect training points for after action review.

- Provide sorting and filtering capabilities to support the review of all training points generated during the exercise.

- Enable the creation of custom training points, when desired. For example, an instructor may want to draw attention to conditions of interest such as cases of *good* execution or decision-making that are not automatically identified by the system.

- Represent exercise events along a visual timeline, in a symbolic format consistent with the operational domain. The primary purpose is to make the temporal relationships between actions immediately apparent. For example, was an indirect fire mission approved before or after a friendly force ground unit initiated a movement?

- Provide a visual representation for voice communications and dialogs in the timeline structure in order to give faster access to transmissions of interest compared to linear audio playback. Automatically annotate transmissions with speech recognition results to indicate content.

- Automatically configure an initial debrief playback for each training point, consisting of synchronized audio communications with a 3D view (and optional 2D view) of movements and missions executed on the battlefield.

- Provide tools to preview and customize the initially prepared debrief content for any given training point.

Debrief Presentation Objectives

The objectives for Debrief Presentation are fundamentally similar to the goals of the preview capabilities in Debrief Construction. Both require a visual platform for quickly conveying what happened and what the training point is, with respect to exercise events. Further, it is critical to provide instructors with a common look and feel in the tools they use for both functions, as they facilitate both tasks. The Debrief Presentation objectives include:

- Provide visual playback of events from exercise execution, synchronized with audio playback of voice communications.

- Include the event timeline with playback, in order to maintain the context with operational events outside the visualization field of view or moment in time.

- Provide playback controls to freeze or jump ahead in time.

- Provide the ability to change the 3D point of view during playback.

- Provide text display capabilities, which can be called up as overlays during playback, to present automatically generated causal analysis results, training point descriptions, or additional specific comments drafted by instructors.

- Provide controls to show or hide annotations or to present operationally significant graphics overlays on the 2D or 3D view of the battlefield during playback, including annotations attached to single entities.

CHALLENGES AND RELATED WORK

There are numerous playback oriented after action review tools that establish the precedents for solving fundamental challenges of logging exercise events and delivering playback at distributed stations for the training audience. The AAIRS debrief toolset attempts to build on previous efforts by constructing an information-rich timeline which provides visual representation of key events in an exercise. Further, the visual symbology on the debrief timelines reflects the results of automated analyses on exercise events and EXFOR actions during execution, for the purpose of offloading some of the analytical workload on human instructors. If a certain proportion of possible training points are automatically detected by the system and offered as cues or bookmarks for the after action playback, then the instructor can focus on catching non-standard training points, or making a determination of which training points to emphasize in debrief.

Existing AAR playback systems have been built around both military simulations and game engines and in some cases a mixture of the two. (Korris, 2004) describes a playback AAR capability built around the Full Spectrum Warrior game for the Xbox gaming console as a squad level tactical trainer. This provides a visual playback with a time slider and "VCR-like" controls.

The Aviation Combined Arms Tactical Trainer – Aviation Reconfigurable Manned Simulator (AVCATT-A) provides an AAR capability based on playback of logged event data from the OneSAF Testbed Baseline (OTB), as well as recorded voice and digital messages (Knight et al, 2001). AVCATT-A playback capabilities include "jump-to" features and faster than real-time stealth view features.

A distributed AAR system was developed for the Joint Training Experimentation Program (JTEP), providing playback with 2D and 3D display capabilities at three distributed sites (Ford et al, 2004). Due to limited bandwidth, local instances of playback data, consisting of simulation state messages and recorded voice data, are stored at each site, while the control information regulating the playback is sent over the network in after action.

The Dismounted Infantry Virtual After Action Review System (DIVAARS) provides stealth capabilities for instructors to observe a virtual dismounted exercise and deliver AAR with playback (Clark & Lampton, 2004). The AAR tools include a variety of controls for manipulating the playback and incorporating additional information such as radio communications. DIVAARS also uses a timeline with the playback capabilities, primarily as a navigational tool as opposed to a representational method for presenting exercise events through symbology.

A logical next step that builds upon frameworks providing debrief playback capabilities is to incorporate an automated processing function for highlighting key events from the exercise. The Virtual Soldier Skills Assessment (ViSSA) prototype incorporates an analytical capability to support its AAR functions, in a training domain focused on small unit dismounted operations (Gately et al, 2005). ViSSA playback tools are supplemented by a visual timeline where significant events are identified for the reviewer. Similar to other AAR systems, ViSSA supports playback of both visual and audio data, however the analytical component does not attempt to process radio communications or convey their content to instructors. This kind of automated causal analysis is one of the key objectives in the AAIRS debrief tools.

In contrast to a number of training efforts constructed such that smart semi-automated forces can "explain" their actions in after action (Lane et al, 2005), a common objective in many team training domains is to

derive causal explanations for the actions of humans in the training audience. Due to the complexity of this task, particularly in large scale team training, the traditional approach is to rely on human instructors to perform this kind of diagnosis, albeit aided by stealth monitoring capabilities. However, supporting automated causal analysis requires significantly more depth in data collection than a log of simulation events.

The task of building utilities for adequate data collection in support of after action review is often one of the major development challenges in team training applications. For some domains the training requirements are limited to the tabulation of statistical measures of performance outcomes, or quantitative values such as amount of fuel or munitions expended, which can be assembled by monitoring one stream of data direct from a simulation environment. However, when the goal is to provide training on decision making in addition to outcomes, and in fact to draw connections between the two, the data collection task is broader. In such cases, it becomes necessary to collect and analyze data from all possible input sources, starting from the interfaces that EXFOR use to directly interact with each other and with the training system, and ending with the event data within the simulation.

Particularly in team operational domains like combined arms, the executed events in the simulation are only half the story of what happened. As an indicator of decision making, voice communications on virtual radios during an exercise comprise one of the most valuable sources of data, and therefore a ripe source to mine. Language processing on voice communications as they happen can provide direct insight into the cognitive states of the EXFOR participants (Jensen et al, 2005). For example, determining whether a given fire mission was approved, and by whom, is critical for assessing the causes if the fire mission led to a conflict with friendly forces. This establishes the difference between a poor operational picture and mistaken execution.

Although language processing methods cannot achieve 100% recognition accuracy on loosely constrained speech, they can provide sufficient accuracy to generate cues for the instructor reviewing an exercise. Such cues can guide an instructor not only where to look for causes, but also the likely conclusions about what the causes were, without requiring linear playback of communications audio.

An additional challenge for an AAR system that will present causal analysis results is the means of presentation. The objective of the AAIRS system is to provide tools not only for preparing and controlling playback, but also to offer the timelines themselves as a means for visually representing "what happened." Effectively, this can establish a mutually reinforcing relationship between debrief playback and an event timeline, which combine to make trainee understanding even richer than when either is used in isolation. (Bahr et al, 2005) discuss the use of Graphic User Interface Embedded Timelines (GETs) to facilitate rapid understanding of after action training points. The GET tools enumerate a range of functionalities from snapshots to playback to "living timelines" with event markers and duration bars. In concept, this is similar to the aims of the implementation of the AAIRS debrief tools.

SYSTEM DESCRIPTION

The debrief toolset is organized around the concept of individual training points. A training point is any training or AAR topic to be presented to EXFOR in the debrief, whether automatically generated from events detected and analyzed by AAIRS during execution, or custom created by an instructor. The debrief toolset provides a variety of utilities for tasks such as indexing and filtering training points, and creating custom training points, but the focus of this paper is the visual timelines and the debrief playback functions of the toolset.

Debrief Construction Tasks

The Debrief Construction tool interface aims to provide a quick visual reference for information relevant to the current training point, organized along a common timeline. By representing radio communications and simulation events visually along a timeline, the goal is to provide insight as to the relationship between the two, especially with respect to the causes of errors that led to the given training point.

Reviewing radio communications
The communications timelines depict radio communications relevant to the current training point. Communications timelines are structured around individual radio nets, with rows for each active listener on the net. Individual transmissions are represented with the times and durations where they occurred, and these are grouped together within bounding boxes that represent dialogs between two or more speakers. Automated language processing takes place during the exercise as communications are sent, to detect key content that reflects EXFOR decision making and commands. In cases where key spoken content is

detected, the visual representations of the dialogs are annotated accordingly. In addition to serving as visual cues, the transmissions are playable in the timeline interface, so that the audio can be previewed in the process of reviewing a training point. Transmissions can be manually annotated if desired. Figure 1 below shows the communications timelines in the overall interface for the initial review of a training point in the Debrief Construction tool.
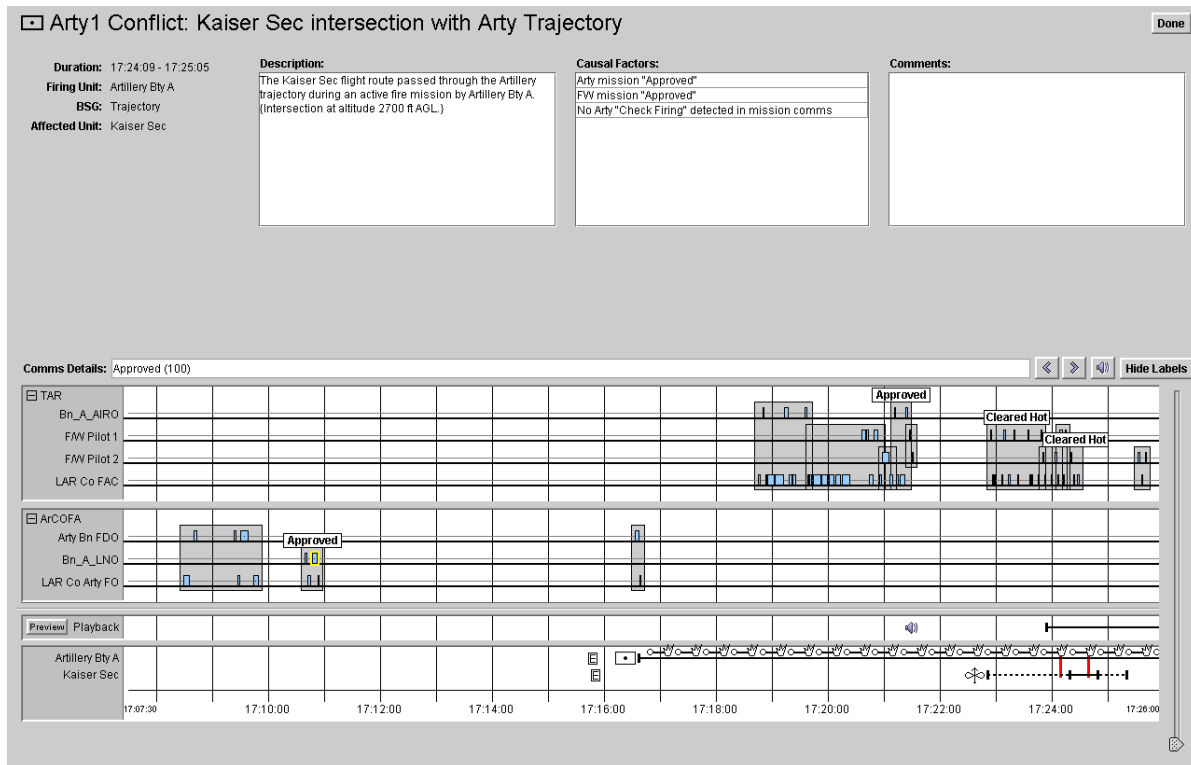

Figure 1. Debrief Construction – Timelines with Training Point Details

Reviewing causal factors
There is a direct relationship between the causal factors for the training point and the conclusions about the content of the communications. For example, in the training point shown in Figure 1, the first causal factor identified is that the Artillery fire mission was approved. This is a direct result of the automated detection of the approval dialog on the ArCOFA radio net prior to the execution of the mission (ArCOFA is the communications plan designated name for the Artillery Conduct of Fire radio net). If approval had been given with non-standard language, then a secondary route to the same conclusion could be carried out manually. If the instructor listens to the dialog on the ArCOFA net and hears something that amounts to approval in a non-doctrinal syntax (e.g., "that mission's good to go"), then with a manual annotation of the transmission as an approval, the causal analysis results are updated automatically.

This can be an important step in preparing a training point for debrief, because the causal factors can be displayed in bullet form during debrief presentation, as a slide-like overlay on the playback view.

Reviewing simulation events
The simulation event timeline provides a reference for the tactical situation through the time period relevant to the current training point (shown at the bottom of the screen in Figure 1). The objective is to show the relative times for when movements and fire missions took place, and especially highlight critical times associated with the current training point, such as a battlespace geometry conflict, or the risk of a conflict. The content of this timeline is specifically designed to visually correspond to the representations in a fire series worksheet, using symbology that will be familiar to the training audience.

In the example shown, the training point involves an Artillery fire mission conflict with an Air section

executing a close air support mission, on a route that passes through the Artillery trajectory on final approach. To represent the interval in which the conflict condition occurred, the rows for the Artillery unit and the Air unit are linked. There are two aircraft in the mission, so there are two linked intervals shown, both with very short duration due to the high speed of the aircraft passing through the trajectory.

Customizing playback contents

Part of the purpose for structuring the debrief tools around individual training points rather than one inclusive playback for the entire exercise is to facilitate the process of preparing targeted after action review. Particularly in team training domains, the length and complexity of the training exercises means that a significant burden is placed on instructors if they are responsible for placing all markers for significant events and driving the debrief playback accordingly. Further, in a complex operational exercise (including distributed and live, virtual and constructive training), different events corresponding to unrelated training concepts may occur simultaneously at different locations, for which different viewing positions are best suited for playback. The goal is to reduce this burden by automatically constructing a default playback vignette for each training point, which can be customized in the debrief construction process.

The playback timeline (just above the simulation event timeline in Figure 1) represents the content of the debrief playback, including markers for vignette start times, and icons for the audio that will be included from recorded radio communications. AAIRS automatically chooses an initial set of relevant communications to include in the playback. The playback timeline serves both to show what is currently included in the planned playback, and also to allow for specific transmissions to be added or removed. AAIRS also automatically configures the viewing position and angle for the 3D view in the playback, based on the nature of the training point. Typically a final step in preparing the debrief for a training point will be a preview of the playback. Figure 2 shows the debrief tools in preview mode.
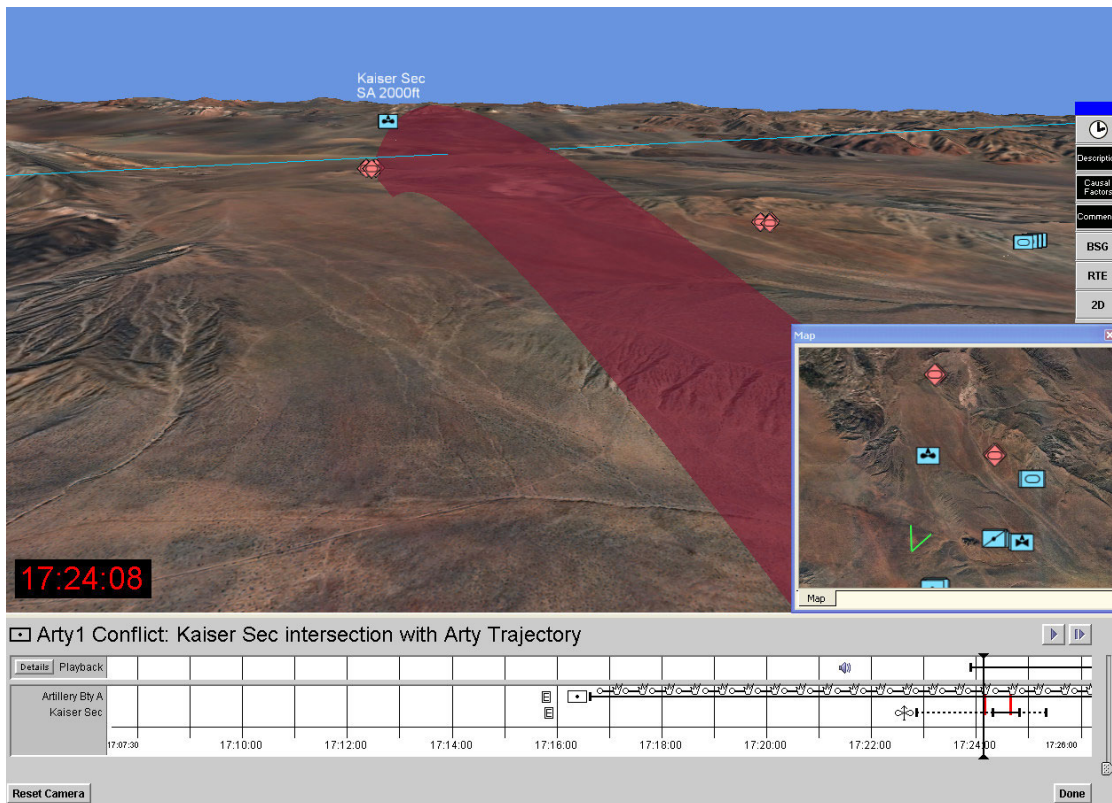

Figure 2. Debrief Construction – Playback Preview with Event Timeline

The preview mode provides a means to see in advance what the playback for the current training point will look like when presented in the debrief. The playback timeline and the simulation event timeline persist in

preview mode, with a time slider appearing on top such that the 3D view depicts the state of the battlefield at the time indicated. The playback controls include VCR-like play, pause, and skip-ahead buttons, as well as a time slider that can be freely moved directly to any time of interest. In preview mode, this allows instructors to see how simulation events in the timeline are correlated with events in the 3D view. For example, in Figure 2 above, the instructor can clearly see that the "stay above" parameter of 2000ft above ground level, as passed to the aircraft, was not high enough to clear the danger area for the Artillery trajectory. A 2D plan view can also be turned on, mapped either onto graphic terrain or a map background.

Navigational tools within the 3D viewer are available as well, to change the position or viewing angle from the default values initially calculated by the system, and save these settings with the training point for playback.

Debrief Presentation Tasks

After completing the debrief construction process, the task of presenting the debrief in after action is controlled in an interface almost identical to the preview mode. As discussed earlier, this is intentional in order to provide continuity between the construction and presentation tasks, as they are frequently performed by the same individuals, even if carried out at different times and even different stations.

The debrief presentation interface adds controls for navigating between training points in the debrief. A simple toolbar provides instructors the ability to show overlays with text content including the automatically generated training point description or causal factors, as well as any comment text they created in reviewing the exercise training points. Additional overlay tools allow for the display of graphics and control measures representing routes, danger areas, and other significant visual artifacts in the battlefield. This is particularly useful for training points that involve battlespace geometry conflicts, where instructors can clearly show actual danger areas in the 3D space and allow the exercising force to see where intersections occur. Just as in preview mode, the 3D view can be freely navigated to change the point of view during playback.

All content in the debrief, including any custom training points or custom settings, is retained with data collected during the exercise. The entire database can be exported as a take-home product from training.

USER FEEDBACK

The evolution of the AAIRS debrief toolset involves a spiral process of user feedback through workshops dating from the initial concept stage in 2003. A preliminary concept of operations document served as the first concrete vehicle for feedback from the end user. Initial comments emphasized the need for supporting both 2D and 3D views of the battlefield in playback. Emphasis was also given to intuitive placement of controls in the user interface to minimize the need for "training the trainer" and frequent consultation of a user manual. Early user feedback also motivated the use of bullet-style text to index the causal factors identified for a given training point. This was in place of an earlier approach which provided causal analysis results via text templates instantiated with data specific to a given training point. Clear, concise causal factor text such as "Arty mission was approved" provides a much more direct suggestion of the conditions in which the training point occurred, as well as where to look for more information.

After the concept of operations document, the first implementation of the debrief toolset was presented at a subsequent user workshop with visiting Marines at the CACCTUS development lab in Orlando. This elicited a wealth of helpful feedback, including the following:

- Marines consistently expressed a specific intention to be highly selective about the training points they include in debrief. Given the time constraints of the training setting, instructors frequently use their discretion to select the most significant events to highlight in after action. As a takeaway for the debrief toolset, this amounts to a requirement to allow the assembly of a debrief that supports use cases involving a small number of detailed training points on a regular basis, while ensuring that the full set of automatically generated training points can be assembled when required to support large scale training events.

- Marines would like to see an ability to combine training points when they involve related simulation events, such as simultaneous fires on the same target.

- In addition to the automatic analysis capabilities which find errors and trace causal factors, instructors would like the ability to index through a list of *all* fire events from an

exercise, regardless of outcome. An ability to create a custom training point for any fire event, review it on the timelines, and rapidly generate a debrief playback accordingly, can be useful for positive training and for meeting other flexible training goals.

- If the EXFOR avoids a conflict by accident in the simulated battlefield, even though their decision-making would have allowed the conflict, then this should be presentable in the debrief. For example, if a mortar fire mission is approved for a certain time interval, and an aircraft flies through the space of the mortar trajectory during that interval, but inadvertently at a precise time after a detonation and before a subsequent fire event in the simulation, then the analysis capabilities should provide the ability to show this decision-making error as well as the fortunate simulation outcome.

- Annotations on entities during playback, such as an altitude tag on aircraft icons, provides helpful information for debrief.

- Although the initial default is for AAIRS to automatically generate the point of view settings for 3D playback, it may be helpful to expand this capability to generate 2 or 3 camera positions for each training point. During playback the instructor could switch between points of view to focus on different roles or battlefield agents.

- A grid overlay on the 2D view in either preview or playback is necessary for the training audience to be able to compare what they see with their maps and also get a sense of scale.

- There is value in having fire series names and target names entered into the system during the exercise, so that these can be referenced in the debrief. This translates to a data collection requirement.

- AAIRS pre-selects the radio nets that are relevant to a given training point, and provides these in the timeline interface for visual and audio review. Although this frequently captures all relevant communications, instructors still want the flexibility to choose additional radio nets to review in the timeline interface, to get further

context for the events surrounding a training point. Similarly, if an additional net is added to the timeline view, the debrief construction interface must support the inclusion of any content from that net into the playback for the training point in debrief presentation.

- Chat messaging in C4I tools is increasingly being used as an operational surrogate for radio communications, and therefore represents an important future additional source of data reflecting EXFOR decision making.

Many of the general comments from the user community at workshops have been consistent with initial requirements and objectives established early in the program. This is a positive result, as it essentially validates the vision of program management, as well as the early knowledge engineering, which preceded design and development.

Another iteration of user feedback came from a subsequent on-site demonstration of the system at the Twentynine Palms training site. Aside from generally positive comments about the toolset as a whole, further specific input was noted, including:

- It is important for the modeling of indirect fire trajectory arcs and time of flight to match the tables that Marines use in their own decision making. This means that the simulation models need to be consistent with the analytical models used by AAIRS, which need to be consistent with the EXFOR tools.

- Due to the potentially large size of training events to be held with the system, there can be many communications taking place simultaneously on a given radio net. This suggests an additional goal for the representations in the communications timelines, such that the reviewer can be given visual cues showing which communications specifically *do* apply to the current training point.

- Reiterated interest in capabilities to create training points for any exercise events, for any reason at the instructor's discretion. An initial implementation of this has since been completed.

THE WAY FORWARD

There are both near term and long term plans for the continued development and deployment of the AAIRS debrief toolset. With the first installed versions of the toolset at CAST sites, the user community will be generating feedback and specific requests, which will be supported on the development side to tailor the toolset to their needs as familiarity increases. Longer term plans for the toolset include:

- The export capability on the training database will be extended to support playback on machines where a full installation of the CACCTUS baseline is not available.

- Ongoing advances in speech recognition technology will be incorporated into the toolset's analysis component for processing voice communications.

- Additional sources of data, including a variety of C4I tools that EXFOR may bring to training exercises, will be supported in the system by way of data collection in the exercise database. Additional data sources will also provide further insight into cognitive states and models held by the EXFOR. For example, if they use digital tools to maintain operational maps, then these provide insight into "perceived truth," which can be contrasted with ground truth as reflected by simulation data, and shown in playback.

- Program goals include support for simultaneous distributed exercises run with participation from different training sites at different geographic locations. The architecture for data collection and debrief construction and delivery will be extended to accommodate this training goal.

- Program goals also include support for live, virtual and constructive training, where simulated elements may be included with live elements in the same exercise. This will also require extensions to the data collection and debrief schemes in the toolset.

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