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Advances in the Federal Aviation Administration Testing of the User Request Evaluation Tool Using an Off the Shelf Animation Package

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Abstract
The Federal Aviation Administration's Simulation and Analysis Group (ACB-330) was sponsored by the Free Flight Program Office (AOZ-200) to support the accuracy testing of the User Request Evaluation Tool (URET). URET is a conflict probe or decision support tool that provides the air traffic controller with predictions of conflicts (i.e., loss of minimum separation between aircraft) within a parametric time (e.g. 20 minutes) in the future. The accuracy testing required detailed analysis of URET's predictions of conflicts. ACB-330 utilized an off the shelf animation package by Wolverine Software Corporation, Proof Animation, to develop an animation capability, which aids the analyst in examining this testing data. It allows the analyst to focus on the accuracy analysis and not the time consuming mechanics of presenting air traffic data. The paper presents an example application of ACB-330's accuracy animation tool.

Background
In the United States, the overall system of managing and controlling air traffic is known as the National Airspace System (NAS), which is administered by the Federal Aviation Administration (FAA). Detailed procedures involving restrictions on routings, speeds, and altitudes are an integral part of the NAS. These restrictions severely reduce the amount of aircraft traffic that NAS can accommodate. Free Flight is an air traffic control concept that increases the efficiency of aircraft operations while maintaining safety by reducing the restrictions imposed by NAS. To achieve the goals of Free Flight, broad categories of advances in ground and airborne automation are required. One of the most important ground based tools is a conflict detection tool or conflict probe. A conflict probe is a decision support tool that provides the air traffic controller with predictions of conflicts (i.e., loss of minimum separation between aircraft) within a parametric time (e.g. 20 minutes) in the future. In contrast to the current, more tactical methods of air traffic control, a conflict probe aids the controller in the strategic planning of aircraft separation management.

The User Request Evaluation Tool (URET), developed by MITRE Center for Advanced Aviation System Development (MITRE/CAASD), is a strategic conflict probe. As a result of its success and controller acceptance as an operational prototype in the Indianapolis and Memphis Air Route Traffic Control Centers (ARTCCs), the FAA contracted Lockheed Martin Air Traffic Management (LMATM) to build and deploy a production version, known as URET CCLD for Core Capabilities Limited Deployment, to seven ARTCCs and now has plans to implement it to the remaining thirteen. As part of the URET CCLD deployment, the FAA tasked the Simulation and Analysis Group (ACB-330, formerly ACT-250) at the FAA William J. Hughes Technical Center to provide traffic scenarios and monitor the formal accuracy testing of the system. The testing involved measuring the URET CCLD conflict prediction accuracy. The testing required the LMATM and ACB-330 engineers to examine particular aircraft pairs involved in prediction errors to provide the appropriate corrective action. If done manually, this investigation would have required extraction of input aircraft position data, air traffic clearance directives, and URET CCLD conflict notifications. Next, the data would have had to be plotted in several dimensions and conflict notifications examined against the flight pair data. This analysis would have been very labor intensive. This prompted ACB-330 to develop an automated method to accelerate the analysis. The objective was to allow the analyst to focus on the problem and not the mechanics of calculating it. ACB-330 developed an animation tool using an off-the-shelf product called Proof Animation (provided by Wolverine Software[1]), which animates the conflict encounter data. This paper presents an example application of this tool.

Description of Animation Tool

The ACB-330 Conflict Probe Assessment Team (CPAT) developed a Java software program, called Proof Encounter Preparation Software (PREPS), on a Sun Ultra workstation. It currently runs on a Solaris 8 operating system interfacing with an Oracle 8.1.6 relational database. First, PREPS extracts user selected air traffic data located in a set of Oracle database tables. These tables contain traffic data populated by CPAT's accuracy measurement tools. Next, PREPS creates Proof Animation trace and layout files with the extracted data. These files are input into the Proof Animation Tool running on a Microsoft Windows personal computer.

The user has three modes from which to build animations: Single Flight, Encounter, and Alert Animation. Single Flight Mode displays the surveillance and vertical air traffic control clearances for one user defined flight. Encounter Mode displays a pair of aircraft and the separation distances between them. Alert Mode displays the same separation data as in Encounter Mode but also presents the conflict probe's associated conflict prediction data.

Example Application of the Animation Tool

To illustrate an animation, CPAT extracted a flight example, referred to in this paper as ABC100, from a Memphis ARTCC (ZME) test scenario. This flight was first presented in Reference [1] to illustrate how the trajectory prediction accuracy methodology is

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applied and was later presented in Reference [2] where conflict prediction accuracy was defined. Flight ABC100 is an over flight, entering the ZME airspace at Flight Level 350 (FL350), descending to FL310, and then exiting the ZME airspace at this altitude. The aircraft is cleared to descend to FL310 at 14:25:05, resulting in a top of descent point five seconds later. In Single Flight Mode, the horizontal and vertical profiles of ABC100 are animated. The Single Flight Mode of ABC100 will not be presented in this paper, since the profiles are also displayed when running under Encounter Mode. This is illustrated in Figure 1 along with a second flight, XYZ200.

Under the Encounter Mode in Figure 1, the flight XYZ200 is cruising at FL310 and crosses ABC100's route at an encounter angle of 38 degrees. The crossing encounter occurs while ABC100 is descending to FL310 causing a test conflict. The conflict starts at 14:27:10 and ends at 14:27:40. This aircraft-to-aircraft conflict is not real but induced in the test scenario simply by time shifting the flights. However, the URET conflict probe tested with these flights is expected to predict the conflict as if it were real. Figure 1 is an animation screen shot of this example. It was captured slightly less than five minutes after the test conflict ended. The animation does use color to distinguish the flights, so callouts were added in Figure 1 to distinguish them here.

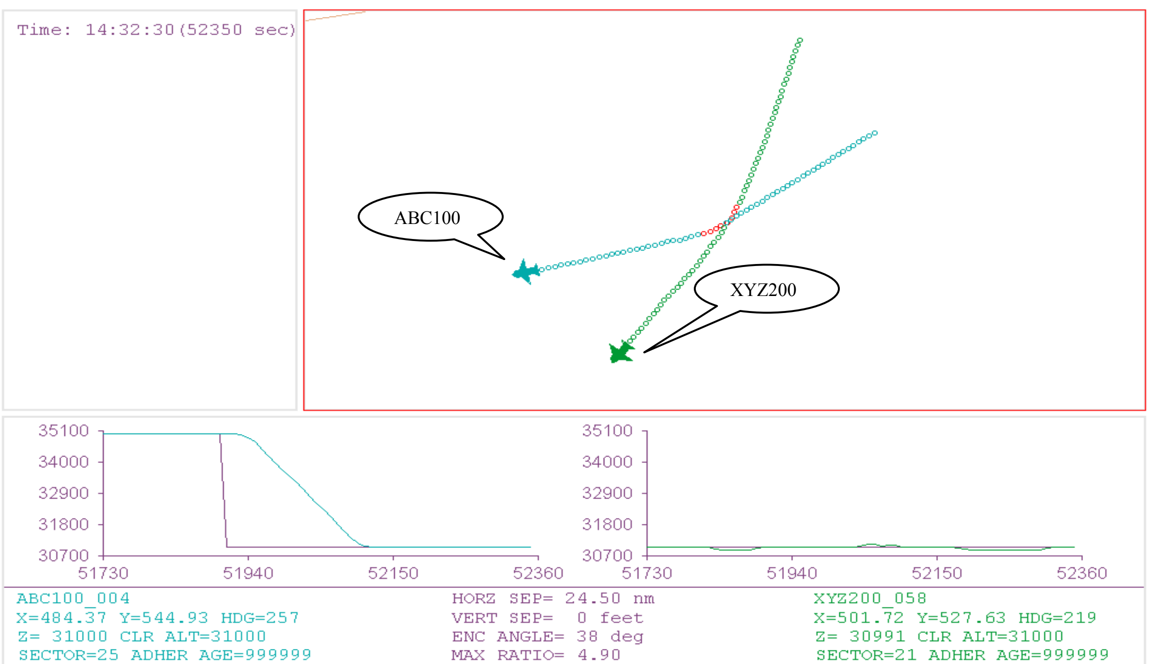

Figure 1: Example for Two Flights In Conflict Encounter Mode.

The animation displays the flight paths for the aircraft simultaneously in real time and indicates when in conflict. As shown in Figure 1, the top right horizontal window plots each aircraft's surveillance track reports supplied by the ARTCC's Host Computer. When below the minimum separation, circles are drawn around the planes with a radius equal to the horizontal separation and the associated track reports are altered in color. The two line charts display each aircraft's cruising altitude and cleared altitude. On the bottom of Figure 1, textual conflict data is displayed such as current position coordinates, cleared altitude, controlling sector, horizontal separation, vertical separation, and minimum separation ratio, which is a ratio of the current separation and required separation (see Reference [3] for a detailed definition).

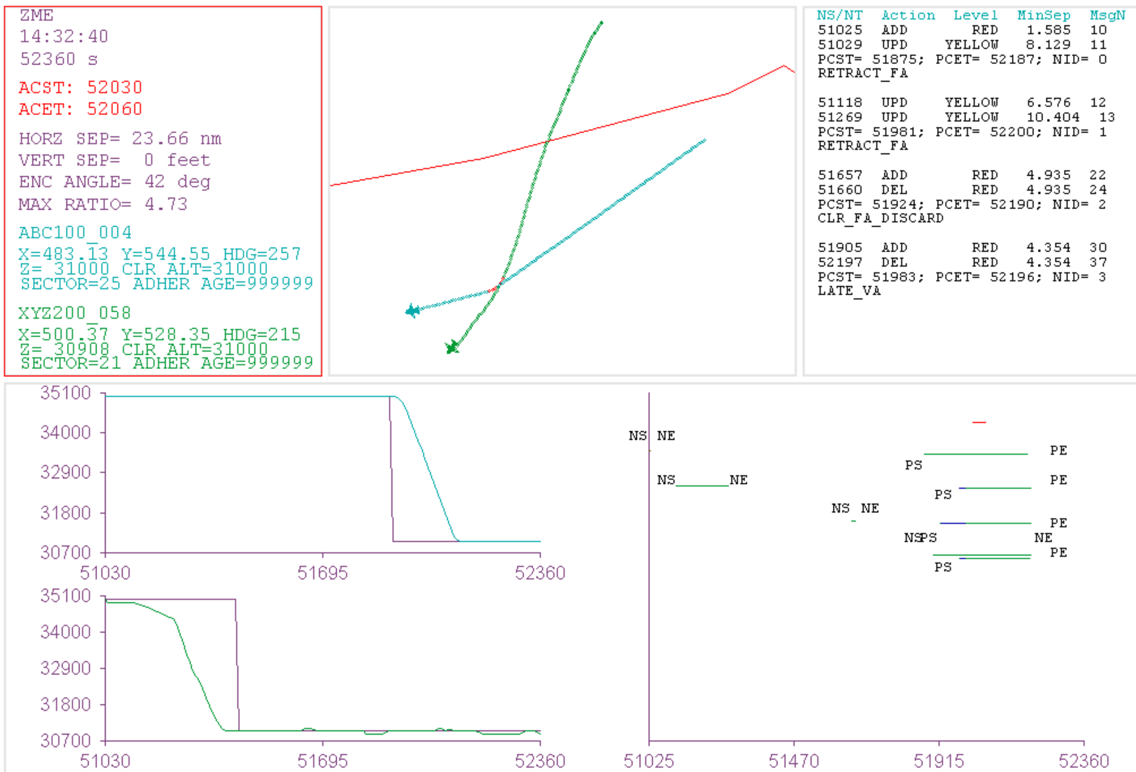

Figure 2: Example Test for Two Flights in Alert Mode

In Alert Mode, the same Encounter Mode separation and positional data are presented, but the conflict probe's predictions are also displayed. In Figure 2, an Alert Mode screen shot was captured for the same flight example. Now, the textual separation data is in the upper left window, the vertical profiles are in the bottom left window, and the top center contains the horizontal profiles. These were all previously described in the Figure 1 discussion.

In Figure 2, the top right textual data contains a listing of the alert notification sets posted by the URET Prototype for this example. The initial posting of an alert and its final deletion forms a notification set. The four Figure 2 notification sets are matched to the example conflict. The first two are evaluated as retracted false alerts. These occur when the conflict probe posts a conflict prediction but deletes it before the conflict start time. In Figure 2, the retracted false alerts are removed at 14:10:29 and 14:14:29, respectively, which is well before the conflict start time of 14:27:10. The third listed notification set is a discarded false alert. This is a situation where a notification was posted by URET and removed before conflict start time, but the removal is associated to an air traffic control clearance and therefore is excused. The fourth and final notification set in this example is a valid alert. A valid alert is the correct conflict prediction of an actual conflict. A valid alert notification set must be posted and not deleted sufficiently before the actual conflict start time. The Figure 2 valid alert notification set was posted at 14:25:50 and removed at 14:29:57 (51905 and 52197 seconds). The conflict started only two minutes and five seconds later, making this a late valid alert. The rules that define a valid alert, late valid alert, retracted false alert and others are documented in detail in Reference [2].

In Figure 2's bottom right corner, a set of line plots graphically depicts the notification set start time (NS), notification set end time (NE), predicted conflict start time (PS), and predicted conflict end time (PE) for each notification set sequentially. The top line listed without labels (e.g. NS or PS) depicts the start and end of the actual conflict. The line chart in Figure 2 illustrates graphically that all four notification sets predicted conflict start and end times overlap the actual conflict. Also as previously discussed and textually presented in Figure 2, the fact that the three first notification sets are deleted before the conflict started is graphically displayed as well.

Summary

To support conflict prediction accuracy analysis of a conflict probe, CPAT developed a Java software program, called PREPS, which extracts the team's processed accuracy data from a relational database and formats it for presentation by an off the shelf animation tool, Proof Animation. The paper presented screen shots of an example conflict and described the displayed data. Since the software automates the mechanics of displaying the data, attention can be focused on the conflict prediction analysis, expediting the analyst's task. This was successfully used in the Formal Accuracy Testing of URET CCLD in September of 2001 and March 2002 and will be used for future studies. Furthermore, it illustrates the FAA's use of an off the shelf tool to achieve its testing objectives.

References

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