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Safety Study Report on Aircraft Discrimination and Masking Evaluation for the Proposed Runway 17R End Around Taxiway (EAT) at Dallas/Fort Worth International Airport (DFW)

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The Dallas/Fort Worth International Airport (DFW) proposes the construction and operation of End-Around Taxiways (EAT) for their north/south runways. This study was a follow-on study to the Proof-of-Concept Demonstration for the proposed Runway 17R EAT at Dallas/Fort Worth International Airport (DFW). The objective data showed that approximately half of the pilots did not recognize that an evaluator-induced incursion had occurred and pointed to the need for specific visual and operational mitigating factors. Based upon a review of airport ground safety considerations and regulations, we proposed a study of the use of a frangible barrier, to be placed past the departure end of the runway (DER) at a distance commensurate with Runway Protection Zone (RPZ), Runway Safety Area (RSA) and Precision Obstacle Free Area (POFA) considerations. This study evaluated both an above-ground barrier and a depression in elevation of the EAT. Of the two, the feature that best helps to shorten response time in aircraft discrimination is a barrier. A depression, while not optimal, does improve performance more than no barrier or no depression at all. We evaluated the difference in masking effect (height of barrier or depth of depression) between masking up to the Top of Engines and masking up to the Top of Passenger Windows. Our analysis of the results indicated that there is no significant difference between either of those, within the barrier or depression variable, respectively. In other words, the lower of the masking conditions (in this case, 13 feet) is sufficient to provide a masking effect that will enhance aircraft discrimination. During post-evaluation debriefings, pilot responses and comments indicated a high degree of certainty in making a decision as soon as an EAT or Crossing Aircraft breaches the widest lateral limits of the simulated barrier. This suggests that as width of the barrier is increased, aircraft discrimination response times may decrease.

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End Around Taxiway (EAT) at Dallas/Fort Worth (DFW) International Airport

DOT-FAA-AFS-420-12 **June 2005**

EXECUTIVE SUMMARY

The Dallas/Fort Worth International Airport (DFW) proposes the construction and operation of End-Around Taxiways (EAT) for their north/south runways. There are no regulatory criteria or standard(s) that specifically dictate EAT design and/or operation, nor are there any present standards that prohibit EAT operations. To address this issue, the FAA is now in the early stages of developing an "End-Around Taxiway National Standard," of which the results of this evaluation will be considered.

This study was a follow-on study to the Proof-of-Concept Demonstration for the proposed Runway 17R EAT at Dallas/Fort Worth International Airport (DFW). For the purposes of this study, the terms End-Around Taxiway and Perimeter Taxiway are interchangeable. Based upon the findings of the previous study (FAA Technical Report #DOT-FAA-AFS-440-6), we determined that there was sufficient evidence, within both the objective and subjective data collected, that indicates it is difficult for pilots to determine whether an aircraft is incurring the runway or safely operating on the respective EAT. The objective data showed that approximately half of the pilots in the incursion condition did not recognize that an incursion had occurred. The subjective data reflects pilot comments and concerns about the difficulty in determining whether an aircraft is incurring the runway or on an EAT. The presence of this condition could make actual incursions more difficult to detect, increase the time it takes the flight crew to react to an incursion, and logically increase the number of aborted takeoffs as a result. These indicators pointed to the need for specific visual and operational mitigating factors as well as pilot training that addresses EAT operations.

It was the consensus of personnel from the Dallas/Fort Worth Airport, Commercial Airlines, Airline Pilots Association (ALPA), NASA, FAA (Flight Standards, Air Traffic, and Airports), the Center for Advanced Aviation System Development/MITRE and others that we must minimize potential confusion in the minds of the flight crew (individually or collectively) between what might be a crossing aircraft versus an EAT aircraft, before EAT operations can be put in place. Given that basic premise, a determination was made to mask or hide from view, aircraft that are negotiating the EAT system. Based upon a review of airport ground safety considerations and regulations, we proposed a study of the use of a frangible barrier, to be placed past the departure end of the runway (DER) at a distance commensurate with Runway Protection Zone (RPZ), Runway Safety Area (RSA) and Precision Obstacle Free Area (POFA) considerations.

Specific to this study, we investigated strategies for dealing with discrimination between aircraft on an EAT and aircraft that may be crossing/incurring the active runway, given certain masking barrier dimensions and depressions of EAT elevation.

This study evaluated both an above-ground barrier and a depression in elevation of the EAT. Of the two, the feature that best helps to shorten response time in aircraft discrimination is a barrier.

A depression, while not optimal, does improve performance more than no barrier or no depression at all.

We evaluated the difference in masking effect (height of barrier or depth of depression) between masking up to the Top of Engines and masking up to the Top of Passenger Windows. Our analysis of the results indicated that there is no significant difference between either of those, within the barrier or depression variable, respectively. In other words, the lower of the masking conditions (in this case, 13 feet) is sufficient to provide a masking effect that will enhance aircraft discrimination.

During post-evaluation debriefings, pilot responses and comments indicated a high degree of certainty in making a decision as soon as an EAT or crossing aircraft breaches the widest lateral limits of the simulated barrier. This suggests that as width of the barrier is increased, aircraft discrimination response times may decrease.

This evaluation was conducted in accordance with the approved plan. In keeping with the stated purpose of evaluating specific visual and operational mitigating factors, it was successful. In gathering pilot responses concerning the use of a masking barrier and determining if a difference exists between a masking barrier and a depression, we are able to draw certain conclusions and make specific recommendations for permanent DFW operations when an EAT is in use.

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End Around Taxiway (EAT) at Dallas/Fort Worth (DFW) International Airport

DOT-FAA-AFS-420-12 **June 2005**

1.0. INTRODUCTION

1.1. PURPOSE

This study is a follow-on study to the Proof-of-Concept Demonstration for the proposed Runway 17R End-Around Taxiway (EAT) at Dallas/Fort Worth International Airport (DFW). For the purposes of this study, the terms End-Around Taxiway and Perimeter Taxiway are interchangeable. Based upon the findings of the previous study (FAA Technical Report #DOT-FAA-AFS-440-6), we determined that there was sufficient evidence, within both the objective and subjective data collected, that it is difficult for pilots to determine whether an aircraft is incurring the runway or safely operating on the respective EAT. The objective data showed that approximately half of the pilots in the incursion condition did not recognize that an incursion had occurred. The subjective data reflects pilot comments and concerns about the difficulty in determining whether an aircraft is incurring the runway or on an EAT. The presence of this condition could make actual incursions more difficult to detect, increase the time it takes the flight crew to react to an incursion, and increase the number of aborted takeoffs as a result. These indicators pointed to the need for specific visual and operational mitigating factors as well as pilot training that addresses EAT operations.

1.2. BACKGROUND

The Dallas/Fort Worth International Airport (DFW) proposes the construction and operation of EAT's for their north/south runways. The key design features of this project are in Attachment 1.

It is significant to note that there are presently no regulatory criteria or standard(s) that specifically dictate EAT design and/or operation, nor are there any present standards that prohibit EAT operations. To address this issue, the FAA is now in the early stages of developing an "End-Around Taxiway National Standard," of which this evaluation will be considered.

Prior to the development of national EAT criteria, site-specific proposals such as DFW, need to be evaluated on a case-by-case basis. Extensive discussion and analysis of the DFW case with personnel from the Dallas/Fort Worth Airport, Commercial Airlines, Airline Pilots Association (ALPA), the National Aeronautics and Space Administration (NASA), the Federal Aviation Administration (FAA) (Flight Standards, Air Traffic, and Airports), the Center for Advanced Aviation System Development/MITRE and others has taken place. The consensus of these experts was that the proposal for DFW EAT operations warranted further risk assessment and safety analysis. This was particularly the case with regard to Human Factors (human performance and limitations) issues. Further, this study primarily concentrated on the RWY 17R departure case.

As previously mentioned, there may be confusion in the minds of the flight crew (individually or collectively) between what might be an EAT aircraft versus a crossing aircraft. It was the consensus that we must minimize the confusion before EAT operations can be put in place. Given that basic premise, a determination was made to mask or hide from view, aircraft that are negotiating the EAT system. Based upon a review of airport ground safety considerations and regulations, we are proposing the construction of a frangible barrier, to be placed past the departure end of the runway (DER) at a distance commensurate with Runway Protection Zone (RPZ), Runway Safety Area (RSA) and Precision Object Free Area (POFA) considerations. Possible design features of the barrier are in Attachment 1.

While this was primarily a Human Factors analysis, designed toward obtaining a specific answer concerning the dimensions of a proposed masking barrier, we also gathered information of a secondary nature. That information included:

- Perceived pilot workload changes
- Primary and Secondary task performance
- Visual acquisition strategies and deficiencies during all phases of the departure with on-going EAT operations in place
- Impacts of the visual scene on pilot performance
- Potential future human performance considerations during taxi operations on the EAT associated with lighting, signage, marking, pilot procedures, and other operating conditions

This document outlines the framework employed for flight simulator preparation/use and methodology for gathering pilot responses concerning the use of a masking barrier. This document will also prescribe the analysis of Human Factors data, and develop conclusions which may lead to recommendations for permanent DFW operations when an EAT is in use.

This analysis is also intended to be considered during the development of a national standard for EAT operations.

It is important to note that the primary focus of this effort was to determine if EAT operations are safe given the dimensions of proposed masking and the difference, if any, between a barrier and a land depression. It is not to gather aircraft-specific performance data. Although not a pre-requisite for this evaluation, performance information (e.g. A/C position, angles, etc.) were recorded and collected by the FAA. This data might potentially be used exclusively for analysis modeling and its use would remain within proprietary constraints of NASA-Ames Research Center and the pilots' respective airlines. Additionally, in-the-cockpit video recording of all crews was obtained. This information might be useful for additional study of pilot head-in versus head-out positioning and point of regard.

Aircraft performance data collection variables included the following:

DISTANCE TO TOUCHDOWN
GROUND SPEED
HORIZONTAL DEVIATION
HEIGHT ABOVE GROUND
CALIBRATED AIRSPEED
ROLL EULER ANGLE
PITCH EULER ANGLE
SIMULATOR TIME
PRESSURE ALTITUDE
VERTICAL SPEED OF A/C
LP ROTOR SPEED
A/C LATITUDE
A/C LONGITUDE
RADIO ALTITUDE
CAP ELEVATOR FOKKER POSITION
F/O ELEVATOR FOKKER POSITION
OUTBOARD ELEVATOR ANGLE
INBOARD ELEVATOR ANGLE
CAP AILERON FOKKER POSITION
F/O AILERON FOKKER POSITION
OUTBOARD AILERON (L/R)
INBOARD AILERON (L/R)
RUDDER PEDAL POSITION
RUDDER ANGLE (UPPER/LOWER)
THROTTLE LEVER ANGLE
HEADING EULER ANGLE
STABLIZER ANGLE
TOTAL ENGINE THRUST
ON GROUND FLAG
EVENT MARKER COUNTER

2.0. HUMAN FACTORS EVALUATION

2.1. GENERAL

The Human Factors (HF – Human Performance and Limitation) elements of EAT operations are centered on the visual scene. This includes aspects of the human visual system, acquisition capabilities, and limitations. We are very interested in analyzing how aircrews develop visual acquisition strategies and how potential limitations (human, environmental and aircraft design) might impact those capabilities and effect normal operations.

Specific to this study, we investigated strategies for dealing with discrimination between aircraft on an EAT and aircraft that may be crossing/incurring the active runway, given certain masking barrier dimensions and depressions of EAT elevation.

2.2. METHODOLOGY

Based upon DFW's airport runway and taxiway structure, EATs are proposed to be constructed at approximately 2,650' past the Departure End of the Runway (DER)(Attachment 1). The masking barrier was simulated to limit the departing crew's visual acquisition of end-around aircraft. In all scenarios, the barrier was placed 1,100' from the DER at a width of 350' on either side of the extended runway centerline (700' total). Various barrier heights and depression depths were used, in an attempt to answer the following three questions:

1. Does masking the EAT aircraft result in improved discrimination between EAT and crossing/incurring aircraft?
2. Is there a difference between masking EAT aircraft with a barrier or masking with a depression?
3. Is there a difference in masking effectiveness between the two tested mask heights?

The variables and scenarios used during the simulation are provided in Table 1.

Following an evaluation of a similar proposed EAT at Hartsfield-Jackson Atlanta International Airport (KATL), the entire evaluation of DFW's proposal was conducted over two separate studies. The first study was conducted through a joint effort with American Airlines and NASA-Ames research center using full-motion, level D simulators in Dallas-Fort Worth and Mountain View, CA, respectively. During that study, the results indicated that a problem of aircraft discrimination existed, prompting a need for further testing. Those further-on studies and subsequent results are explained below.

The masking evaluation of DFW's proposed EAT was divided into two separate phases, each described below:

<u>Phase I - Modeling of various percentages of EAT aircraft masking, using low-level PC-based graphics</u>.

This study employed the use of actual photographs of various runways at DFW from aircraft departure positions and heights with actual aircraft photographs superimposed on the runway photos. The superimposed aircraft were scaled to represent aircraft in various stages of masking and at specified distances from the observer. An example is at Attachment 2.

The simulation used a combination of barrier height and ground depression at the farthest point of the EAT.

NOTE: Phase I was completed on February 11, 2005 at the FAA Southwest Region Headquarters in Fort Worth, TX. Five, FAA, Group IV type-rated pilots were given 38 total scenarios. Each scenario contained either three or four aircraft, in various combinations on either the EAT or crossing the runway.

Findings were as follows:

- Evaluator observations point to a difference between both the barrier/no-barrier and the EAT depression/no depression conditions.
- Pilot comments indicate that the problem of discerning aircraft on either the EAT or a crossing was exacerbated during night conditions.
- There appeared to be a problem in finding and using available monocular cues in depth perception during the no-barrier conditions when either the crossing or EAT aircraft was centered on the runway.
- Some pilots waited until the aircraft reached the near edge of the barrier before making a definitive declaration of whether an aircraft was crossing or on the EAT, while other pilots made their declarations prior to the barrier.
- From an observer standpoint, there did not appear to be a major distinction between the engine-masked barrier height versus the passenger window-masked barrier height.

<u>Phase II - Modeling of various percentages of EAT aircraft masking, using a Level D, full-motion simulator.</u>

Our previous Proof-of-Concept demonstration (Reisweber, 2004) revealed that pilots do, in fact, have a problem discriminating with certainty, whether an aircraft is on the EAT or crossing on any one of the established taxiways. We believed that some form of masking of EAT aircraft might mitigate this problem. In other words, the logical conclusion that we drew from the post-DFW level D simulator Demonstration analysis was that if we masked (hid from view) some portion of the EAT aircraft, the pilot would be better able to recognize, with a higher degree of certainty, the difference between any aircraft that is crossing the runway as an incursion aircraft versus an EAT aircraft. We validated this hypothesis during Phase I of this evaluation. Through the present study, we sought to determine what percentage of the EAT aircraft should be masked or obscured to ensure complete conspicuousness and discrimination of aircraft on the EAT or crossing the runway.

This was partially substantiated by our test of another EAT proposal at Atlanta (Reisweber, 2004), where, through a natural depression at the EAT's location, a large Group IV aircraft is more than 80% obscured or masked. While there actually were no crossing aircraft in that study, pilots could not detect aircraft on the EAT until they were well past rotation speed (Vr) during takeoff and aircraft position was well above the EAT.

We made the inference that pilots confirmed that the aircraft were on the EAT because there were no aborted takeoffs during that simulation, which suggests that pilots did not mistake any of the EAT aircraft for crossing/incurring aircraft.

The present flight simulation study took place in the Level D, FAA certified B-747-400 Flight Simulator, located at the NASA-Ames Research Center in Mountain View, CA. Two, 8-hour data collection sessions were planned, for a total of 16 hours.

The schedule for the simulation is presented below:

Morning Session – March 29, 2005:

First Crew Briefing	0730 - 0800
Session 1 and Debrief	0800 – 0900
Second Crew Briefing	0900 – 0930
Session 2 and Debrief	0930 - 1030
Third Crew Briefing	1030 - 1100
Session 3 and Debrief	1100 - 1230

LUNCH - 1230-1300

Afternoon Session – March 29, 2005:

Fourth Crew Briefing	1300 – 1330
Session 4 and Debrief	1330 - 1430
Fifth Crew Briefing	1430 – 1500
Session 5 and Debrief	1500 - 1630

Morning Session – March 30, 2005:

Sixth Crew Briefing	0730 - 0800
Session 6 and Debrief	0800 – 0900
Seventh Crew Briefing	0900 – 0930
Session 7 and Debrief	0930 - 1030
Eighth Crew Briefing	1030 - 1100
Session 8 and Debrief	1100 - 1230

LUNCH - 1230-1300

Afternoon Session – March 30, 2005:

Ninth Crew Briefing	1300 – 1330
Session 9 and Debrief	1330 - 1430
Tenth Crew Briefing	1430 – 1500
Session 10 and Debrief	1500 – 1630

Five separate flight crews were used during each eight-hour period, resulting in a pilot assessment group of twenty pilots. Participating pilots were drawn from the airline/commercial pilot population. The pilot mix and flight experience varied across age, aircraft type and hours of flight experience. FAA and ALPA pilots were invited to participate as part of the subject pool. Several FAA pilots were present, but did not participate as subjects. Official ALPA pilot representatives were not present. NOTE: Many of the pilot participants were members of ALPA, however, no one officially representing the organization was present. Given the conceptual versus procedural nature of these sessions, it was preferred, but not required, to have pilots who were qualified in-type. As a minimum, we established that having at least one crewmember be qualified in-type for each crew would be sufficient. We fulfilled this criterion for all but two crews. However, all crewmembers were qualified in like heavy aircraft.

Each flight crew (Captain (CP) and First Officer (FO)) conducted 20 scenarios (with the CP and FO alternating Pilot Flying (PF) and Pilot Not Flying (PNF) duties after each run) under various conditions listed in Table 1. Pilots received a thorough pre-flight briefing including an exchange of questions and answers with FAA evaluators. They were informed that the simulator session was solely for Human Factors evaluation and limited to operational procedural data collection and they would not be evaluated in any way with regard to their airmen certificate privileges (Figure 1).

The following conditions and procedures applied:

- The Level D Simulator was set to an eye level equivalent to a B-747.
- Atmospheric conditions were preset to a standard day (15ºC/59ºF and 29.92).
- The simulator was programmed with the first aircraft in each scenario transitioning on the EAT. That aircraft was a Group IV aircraft (in this case, a Boeing 777) negotiating the EAT; the Second Aircraft was either another Boeing 777 aircraft negotiating the EAT or an aircraft Crossing the active runway at taxiway ER (a Boeing 767) (Table 1).
- Landing Lights for crossing aircraft were off.
- When used, the barrier was illuminated during night scenarios.
- All take-offs were at a relatively high gross take-off weight.
- Flight procedures and aircraft configuration were per company policy. When crews were of a heterogeneous company mix, usually the CP made final decisions. NOTE: Some crews were Captain only aborts and some were Captain or FO aborts. In other crew instances, the crews decided before they entered the simulator whether the aborts would be Captain only or whether they would be Captain or FO.
- Air Traffic Control (ATC) communications were simulated by FAA evaluators or local simulation controllers. NOTE: ATC communications remained constant across all

scenarios/crews and were not “free-flowing.” As such, ATC did not intervene during those scenarios if a runway incursion occurred.

- Basic ATIS information was provided to the flight crew prior to each run per Table 1.
- Each run was considered complete when airborne, gear-up and climbing (approximately 1,500’AGL or over the top of the EAT. At this point, the simulator was frozen and re-positioned to RWY 17R in preparation for the next trial.
- EAT lighting was observable and crew comments concerning it were noted
- Crews were instructed to verbally indicate whether the second aircraft within their visual field was a “Crossing Aircraft” or “End-Around Aircraft.” This response was required as-soon-as-possible prior to V1
- Crew responses were made by either the pilot flying (PF) or pilot not-flying (PNF). NOTE: This was a collective crew response.
- Observers noted Airspeed at time of callout by depressing an Event Marker Button that stamped that point on the data stream. In addition, as a backup, observers noted airspeed at the time of “callout” and recorded it manually.
- A very short, informal de-brief to gather valuable comments from the crew’s perspective took place immediately after the crew completed the 20 scenarios (Figure 2).
- This evaluation was not intended to evaluate TERPS, or any other regulation or FAA obstruction or aircraft performance criteria.

2.3. SIMULATION SCENARIOS

Four distinct, independent variables were manipulated during the present study. All other factors were kept constant (ceiling/visibility, air temperature, aircraft weight, etc.). Given the number of variables, we developed a total of 20 counterbalanced scenarios. The methodology followed a within subjects design. That is, all crews flew all 20 scenarios (Table 1), alternating between CP and FO (acting as PF and PNF) for each scenario.

Independent Variables:

Masking Type – No Barrier/Barrier/Depression
Masking Height – No Masking/Engine Tops Masked/Passenger Windows Masked
Environment – Night/Day
Second Aircraft to be Identified - Crossing/EAT
NOTE: The Engine and Passenger window heights were 13' and 20’, respectively, on a B777. However, these actual values would change depending on the type aircraft that is being masked.

The simulation focused on evaluating EAT operations within the constraints of the visual scene as presented to the pilots in the simulator environment.

It was not possible to fully evaluate the pilot's perception of a real world operation in a flight simulator visual scene, given that depth and other important visual cues are not a one-for-one relationship between actual and simulated environments. Specifically, time and simulator constraints did not allow the study to depict the full spectrum of varying fuselage geometries; aircraft sizes; aircraft paint schemes; barrier and depression heights and atmospheric and visibility conditions that affect the visual scene. These items are important and could impact real world operations. Also, we did not fully evaluate the effect that the visual scene had on the pilot's visual scanning or aircraft system monitoring. To accomplish this would have required the use of an expensive (time and money) and intrusive eye tracking system and comparison of baseline simulator operation to an EAT operation in actual visual conditions to determine if there were any significant differences. We are still confident that our scenarios provided a representative sample of visual variables to allow us to make general conclusions from our results.

Flight Simulator Scenarios for proposed DFW EAT DISCRIMINATION TEST

DATE/TIME: **T/O AIRCRAFT: Boeing 747-400** **CREW:**

TABLE 1

Scenario #	Pilot Flying	Ceiling & Visibility (SM)		EAT A/C Type/ Masking Effect (From Ground)	Observer Location on RWY	Incursion A/C Type/ Location	Barrier/ Depression Ratio	Pilot Response (EAT/CROSSING) Remarks: Airspeed
1(16) Crossing	CP/FO	12K SCT UNL Vis		Boeing 777/ None	Up to V1	Boeing 767 Twy ER	N/A	EAT Crossing
2(9) End-Around	CP/FO	12K SCT UNL Vis		Boeing 777/ Engine Top	Up to V1		No Barrier – Depression	EAT Crossing
3(12) Crossing	CP/FO	12K SCT UNL Vis		Boeing 777/ Engine Top	Up to V1	Boeing 767 Twy ER	No Depression – Barrier	EAT Crossing
4(20) Crossing	CP/FO	12K SCT UNL Vis		Boeing 777/ PAX Windows	Up to V1	Boeing 767 Twy ER	No Barrier – Depression	EAT Crossing
5(3) End-Around	CP/FO	12K SCT UNL Vis		Boeing 777/ PAX Windows	Up to V1		No Depression – Barrier	EAT Crossing
6(6) End-Around	CP/FO	12K SCT UNL Vis		Boeing 777/ None	Up to V1		N/A	EAT Crossing
7(14) Crossing	CP/FO	12K SCT UNL Vis		Boeing 777/ Engine Top	Up to V1	Boeing 767 Twy ER	No Barrier – Depression	EAT Crossing
8(5) End-Around	CP/FO	12K SCT UNL Vis		Boeing 777/ PAX Windows	Up to V1		No Barrier – Depression	EAT Crossing
9(13) Crossing	CP/FO	12K SCT UNL Vis		Boeing 777/ PAX Windows	Up to V1	Boeing 767 Twy ER	No Depression –Barrier	EAT Crossing
10(17) Crossing	CP/FO	12K SCT UNL Vis		Boeing 777/ Engine Top	Up to V1	Boeing 767 Twy ER	No Depression –Barrier	EAT Crossing

TABLE 1 (continued)

Scenario #	Pilot Flying	Ceiling & Visibility (SM)		EAT A/C Type/ Masking Effect (From Ground)	Observer Location on RWY	Incursion A/C Type/ Location	Barrier/ Depression Ratio	Pilot Response (EAT/CROSSING) Remarks: Airspeed
11(4) End-Around	CP/FO	12K SCT UNL Vis		Boeing 777/ Engine Top	Up to V1		No Barrier – Depression	EAT Crossing ☐ ☐
12(8) End-Around	CP/FO	12K SCT UNL Vis		Boeing 777/ PAX Windows	Up to V1		No Depression – Barrier	EAT Crossing ☐ ☐
13(10) End-Around	CP/FO	12K SCT UNL Vis		Boeing 777/ PAX Windows	Up to V1		No Barrier – Depression	EAT Crossing ☐ ☐
14(11) Crossing	CP/FO	12K SCT UNL Vis		Boeing 777/ None	Up to V1	Boeing 767 Twy ER	N/A	EAT Crossing ☐ ☐
15(18) Crossing	CP/FO	12K SCT UNL Vis		Boeing 777/ PAX Windows	Up to V1	Boeing 767 Twy ER	No Depression – Barrier	EAT Crossing ☐ ☐
16(7) End-Around	CP/FO	12K SCT UNL Vis		Boeing 777/ Engine Top	Up to V1		No Depression – Barrier	EAT Crossing ☐ ☐
17(15) Crossing	CP/FO	12K SCT UNL Vis		Boeing 777/ PAX Windows	Up to V1	Boeing 767 Twy ER	No Barrier – Depression	EAT Crossing ☐ ☐
18(1) End-Around	CP/FO	12K SCT UNL Vis		Boeing 777/ None	Up to V1		N/A	EAT Crossing ☐ ☐
19(19) Crossing	CP/FO	12K SCT UNL Vis		Boeing 777/ Engine Top	Up to V1	Boeing 767 Twy ER	No Barrier – Depression	EAT Crossing ☐ ☐
20(2) End-Around	CP/FO	12K SCT UNL Vis		Boeing 777/ Engine Top	Up to V1		No Depression – Barrier	EAT Crossing ☐ ☐

PILOT BRIEFING

Good - morning/afternoon/evening, I am _______________, from the FAA Flight Operations Simulation and Analysis Branch, Oklahoma City, OK. I will be serving as the test director for this simulator period.

With greater emphasis on improving efficiency and safety within the National Airspace Systems, the FAA is evaluating several flight procedures that may result in enhanced safety at many of our more congested airports. One such procedure involves the use of an End-Around or Perimeter Taxiway System.

Today you will simulate departing RWY 17R at Dallas/Forth Worth International Airport (DFW) with aircraft operating on or near an End-Around Taxiway on the RWY 17 C/R Parallel Complex. Your initial position will be on RWY 17R, ready for takeoff. Please fly the procedure as your company flight procedures direct.

Weight and fuel will be frozen at close to the maximum takeoff weight. Altimeter setting will be 29.92" Hg and the surface temperature will be set for a standard day. All checklists are presumed to be complete. You should verify that the aircraft configuration agrees with these conditions. ATIS information will be provided before each run. The visual scene selected for this evaluation will remain relatively constant.

This IS NOT an Airman examination. We are here to evaluate the safety aspects of this procedure. You may observe us taking notes or discussing various issues, this is in regard to the End-Around Taxiway operations, specifically, and will in no way evaluate any airmen certification criteria.

You will be given twenty scenarios, all of which will be takeoffs. During each scenario, you might see a Barrier Screen (masking the end-around aircraft), an aircraft that is depressed on the End-Around Taxiway due to a drop in terrain on the End-Around Taxiway or no barrier or depression. After receiving clearance to takeoff, you will see aircraft negotiating the End-Around Taxiway or crossing to your front. The first aircraft of each scenario will be on the End Around Taxiway for that respective set of conditions. As that aircraft passes the centerline, out of your field of view, a second aircraft will pass to your front. As soon as you can visually identify whether that second aircraft is on the EAT or Crossing Runway 17R (i.e. Incursion), call out "End – Around" or "Crossing" and take the appropriate action as you deem necessary at that point. We ask that you make your decision "callout" prior to V1, if possible.

NOTE: Each scenario's data timestamp and movement of other aircraft in the scene are based upon throttle movement. So, please insure that your parking brake is not set and engage "auto throttles" as soon as possible after you initiate "throttles up."

It's important to note that we are looking for a collective crew response. That is, either the pilot flying or pilot not-flying can respond in each scenario.

Following the completion of all scenarios, we will conduct a short de-briefing to collect your thoughts, perceptions and recommendations.

Thank you for participating in this study and do you have any questions?

Figure 1

DATE:____________CREW #:_____________

Post-Simulation De-Brief

1. Did you have any problems discriminating between aircraft that were on the EAT and aircraft that were crossing at any point along the runway?

____
____
____

2. What cues were you using to discriminate between EAT and Crossing Aircraft when no barrier was present?____
____
____

3. What cues were you using to discriminate between EAT and Crossing Aircraft when a barrier was present?

____
____
____

4. Was there a difference between night and day in discriminating between aircraft that were on the EAT and aircraft that were crossing at any point along the runway?

____
____
____

5. Do you have any suggestions for this procedure in the future?

____
____
____

6. Do you feel more or less comfortable in your ability to discriminate between EAT and Crossing Aircraft with a barrier present?

____
____
____

7. Provide comments on the flight simulator fidelity. How closely representative is it of real world flight operations?

____
____

2.4. EXPERIMENTAL RESULTS

2.4.1. Observed Airspeed at Callout

During each run, the cockpit observers noted the airspeed when the crew first called out the second aircraft type (EAT or Crossing). On many trials there were multiple observers. The resulting data were consolidated between the observers and discrepancies were resolved. Greater airspeeds indicate that the crews were farther into the departure roll when the callout occurred.

Within the Masking Type variable, the mean indicated airspeed at "callout" was greatest during the no barrier/no depression condition, followed by the two depression conditions. The callout airspeed was least in the two barrier conditions. The barrier conditions yielded significantly lower airspeeds than the depression conditions, while the depression conditions were not significantly different from the no barrier/no depression condition. Within the Masking Height variable, there were no significant differences between the engine masking and passenger window masking (Figure 3). Therefore, callouts were made sooner in the Barrier Conditions versus the No Barrier or Depression Conditions. These results were generally non-specific to either the EAT or Crossing variable conditions, although callouts were made slightly sooner in the lower engine-masking barrier condition when the "callout" aircraft was on the EAT. That is, the absolute difference between the EAT and Crossing scenario conditions was close in magnitude (Figure 4).

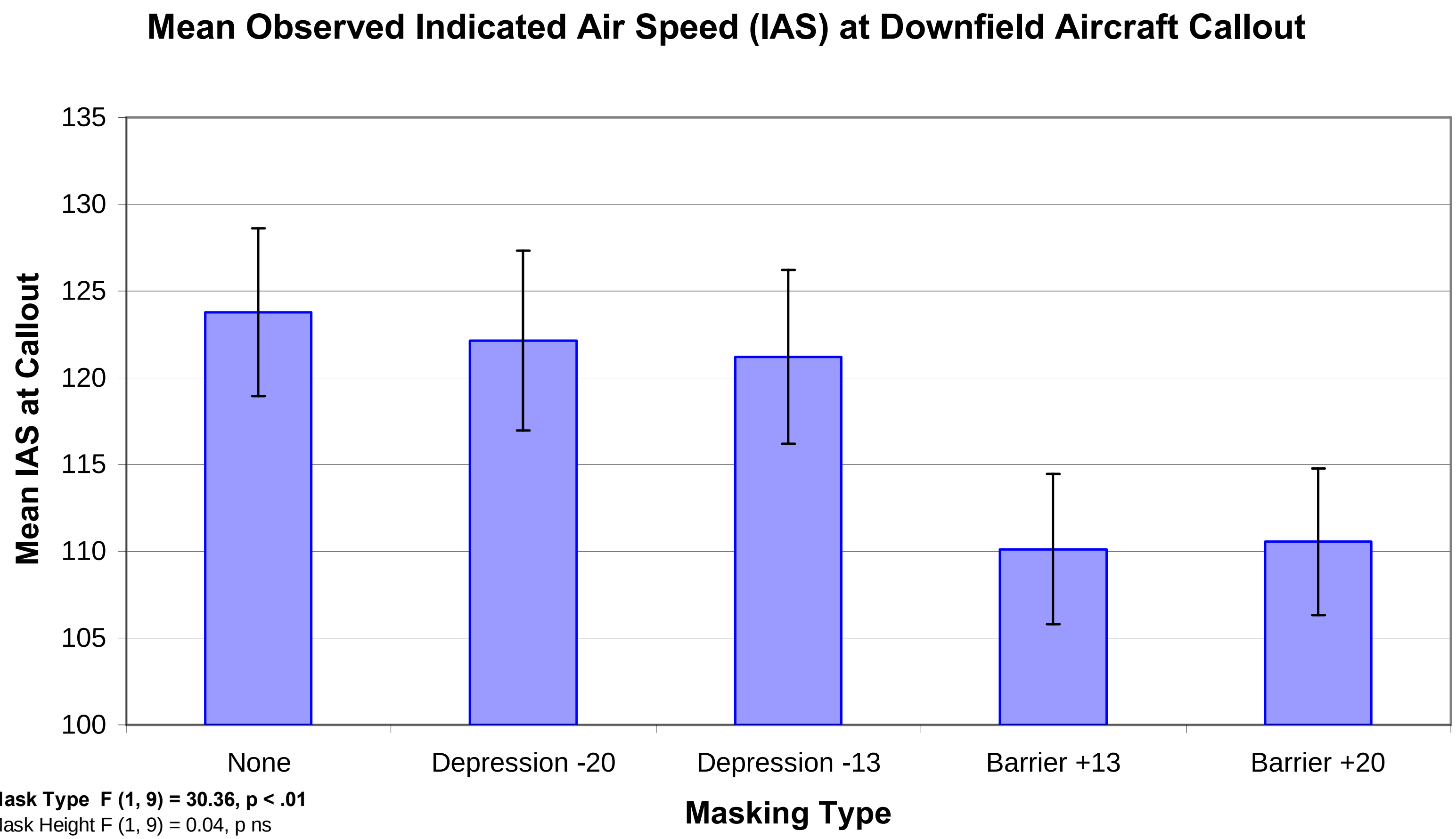
Within the Crossing versus EAT variable scenarios, "callouts" were made sooner in crossing conditions. However, in the next section it is clear that pilots were also less accurate when calling out the Crossing aircraft. This suggests that a speed accuracy tradeoff exists when pilots try to discriminate between Crossing and EAT aircraft.

There were no significant differences in "callout" times between Day and Night conditions.

2.4.2. Callout Errors

During each run, the cockpit observers noted the response when the crew first called out the second aircraft type (EAT or Crossing). This response was compared to the actual aircraft that was presented on each trial. If the crew called out EAT and the aircraft was actually a crossing, this was recorded as an error. Similarly if they called out Crossing and the actual aircraft was an EAT this was also recorded as an error. The following describes the error data analysis.

Within the Masking Type variable, the frequency of errors was greatest during the no barrier/no depression condition, followed by the two depression conditions. The frequency of errors was least in the two barrier conditions. Within the Masking Height variable, the frequency of errors was similar within the respective conditions. The Crossing aircraft were generally called out faster than the EAT aircraft, but had far more errors suggesting a speed accuracy tradeoff.



Mask Type F (1, 9) = 30.36, p < .01
Mask Height F (1, 9) = 0.04, p ns
Interaction Type x Height F (1, 9) = 0.00, p ns

Figure 3

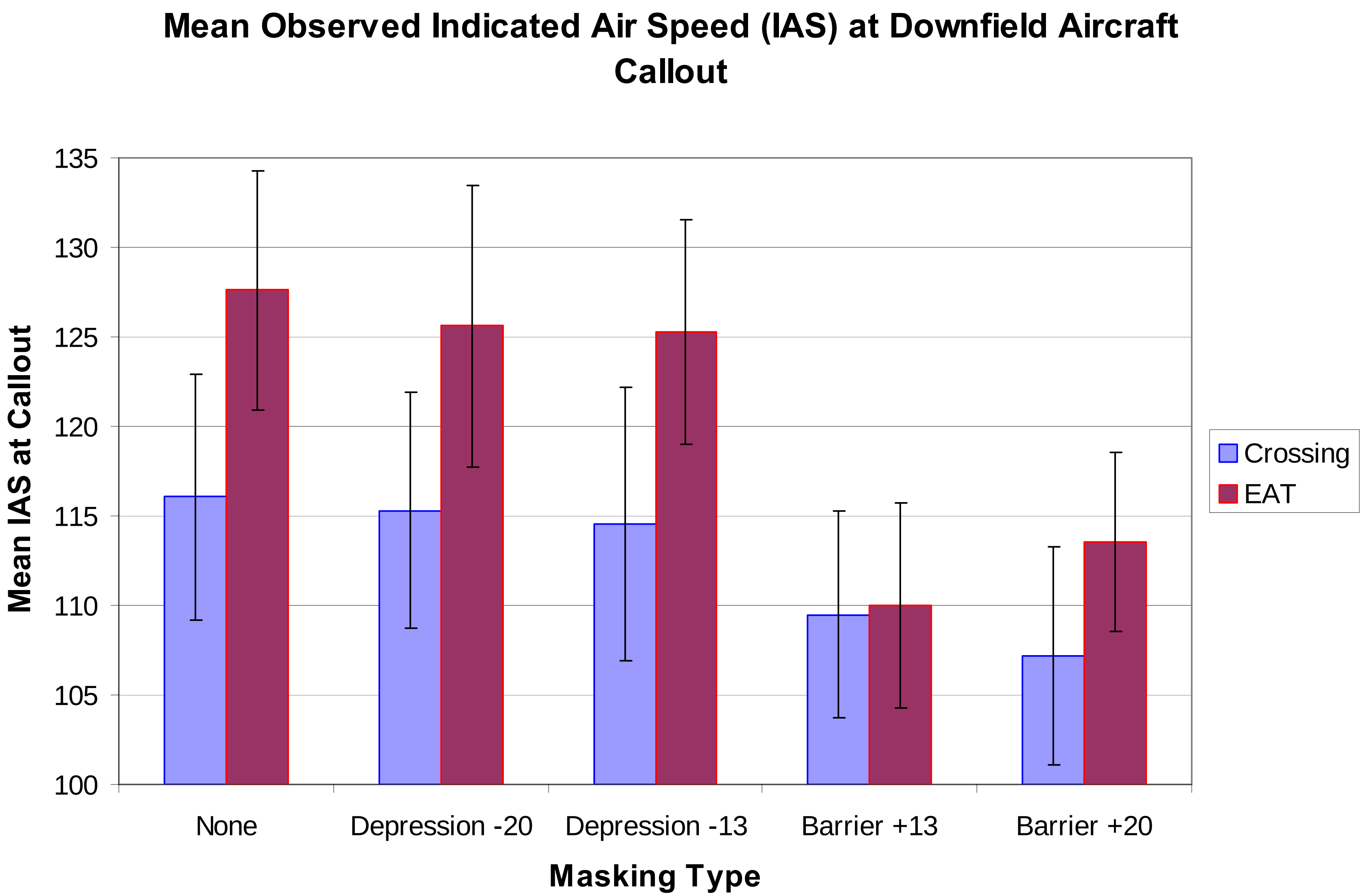
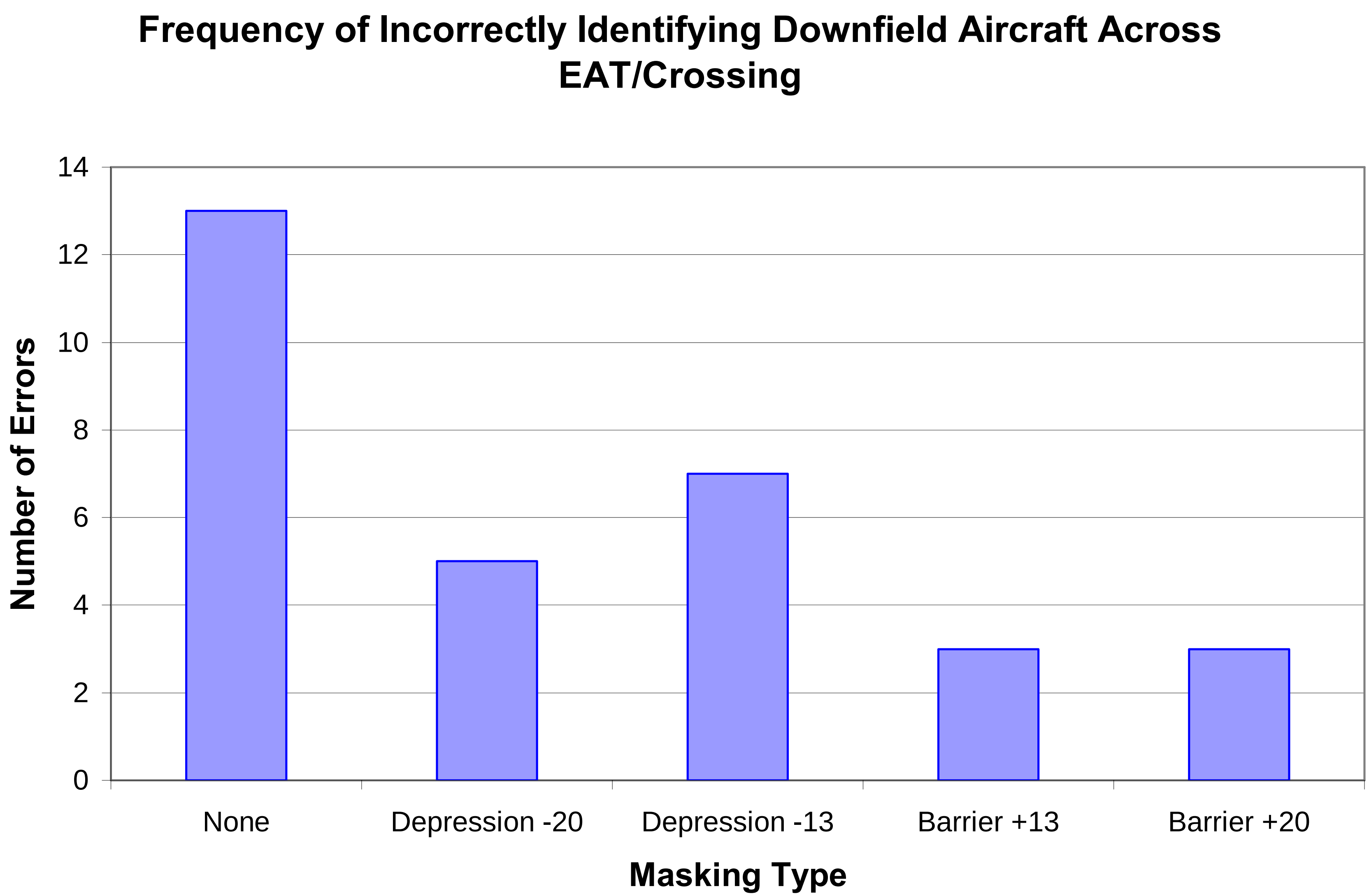

Mean Observed Indicated Air Speed (IAS) at Downfield Aircraft Callout
135
130
125
120
115
110
105
100
Mean IAS at Callout
None
Depression -20
Depression -13
Barrier +13
Barrier +20
Masking Type
Crossing
EAT

Figure 4



Callout Errors x Mask Type vs Height χ^2 (4, N = 27) = 11.10, p < .03

Figure 5

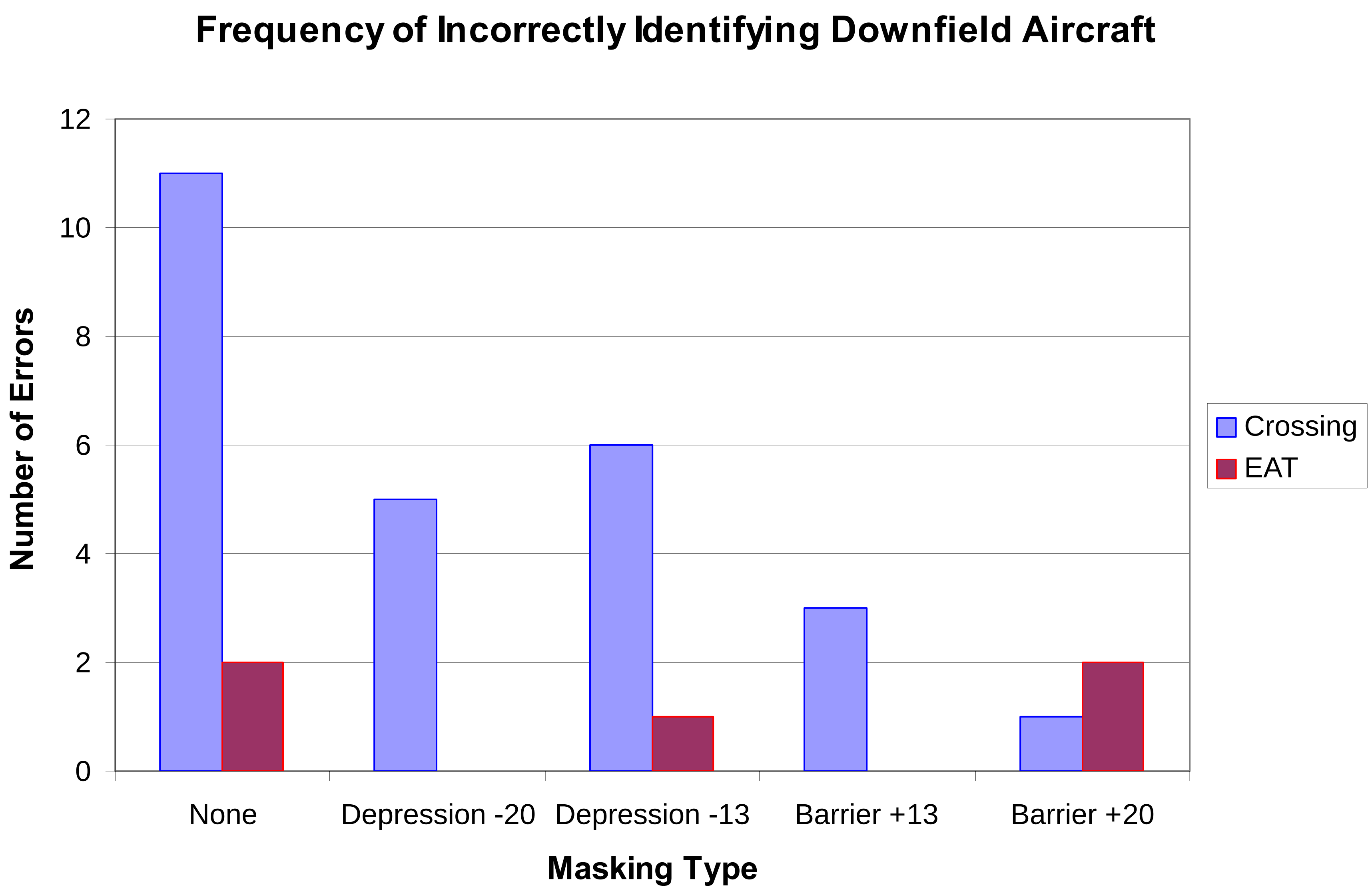
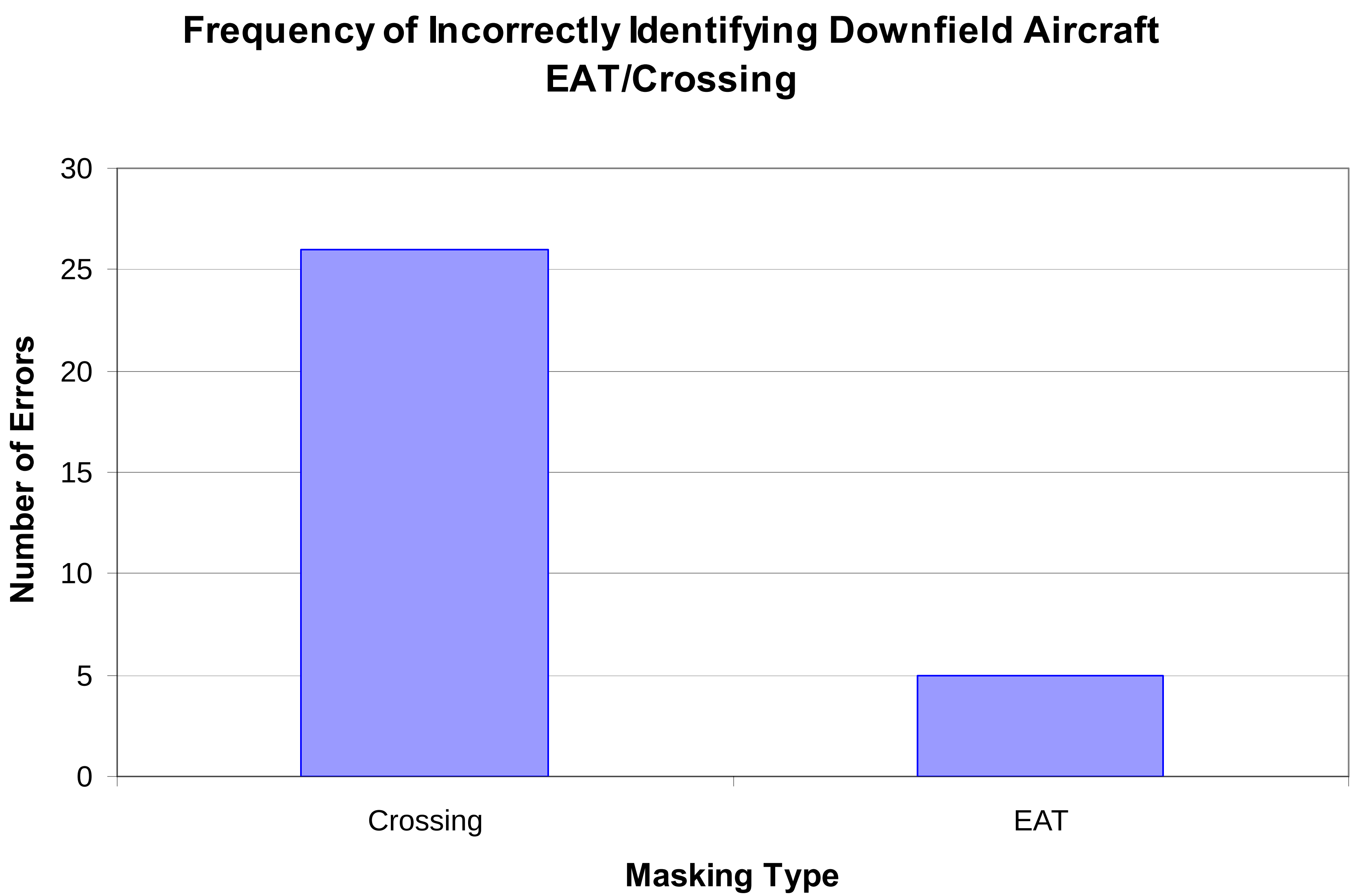

Frequency of Incorrectly Identifying Downfield Aircraft
Number of Errors
12
10
8
6
4
2
0
None
Depression -20
Depression -13
Barrier +13
Barrier +20
Masking Type
Crossing
EAT

Figure 6



EAT vs Crossing - Errors $\chi 2$ (1, N = 30) = 14.23, p < .01

Figure 7

2.5. OBJECTIVE (IN-THE-COCKPIT) OBSERVATIONS

Objective crew performance measures were accomplished through simple observation of pilot/crew performance. Observers, which included pilots who were familiar with commercial aircraft pilot procedures and techniques, were unobtrusively positioned directly behind the pilot stations in the simulator. All flight scenarios were carefully scripted. During those periods in a given departure sequence when a pilot/crew would perform a task out of the norm, both primary and secondary task completion were monitored. That is to say, during those times, pilots might have been required to do more things or different things within the scope of their duties to safely maneuver the aircraft. As such, mental or physical workload might have increased; tasks may have been perceived as more difficult; reactions to external stimuli might have changed; or task shedding may have taken place. Such changes were observed and recorded. NOTE: Visual scan patterns, and instrument/system monitoring were not measured

For the purposes of this study, primary tasks were those that included the departure sequence when EAT operations were ongoing (i.e., visually scanning the DER, visually acquiring aircraft that were either operating on the EAT or crossing at the end of the runway, taking appropriate action and making a “callout” indicating “End-Around” or “Crossing”). Secondary tasks included those measures that occur during normal flight operations (i.e., properly configuring the airplane, communications calls, crew cockpit coordination, checklist completion items).

Generally, pilots had no difficulty performing departure procedures with simultaneous EAT operations in effect. There did not appear to be any appreciable increase in physical demands based upon the EAT scenario. During those times when other large aircraft were operating on the EAT, pilots might have been required to accomplish more or different actions within the scope of their duties to safely maneuver the aircraft (e.g., visual acquisition strategies, scanning techniques, crew cockpit coordination). The pilots performed well within the scope of their training and experience in order to safely maneuver the airplane. No appreciable primary or secondary task shedding was observed.

2.6. PILOT COMMENTS/DEBRIEFING REMARKS

After each crew completed all scenarios, we conducted a short debriefing to gather crew comments, concerns and recommendations. Predominant and frequent crew comments are listed below:

- The Barrier was the best visible cue available in making a “callout” decision

- Aircraft taxiing in the Depression Condition were not easy to discriminate

- Pilots indicated that during EAT operations they tended to devote more “heads-out” time than during a normal departure without EAT operations and some noted that they monitored critical systems less than they normally would have during the takeoff roll.

The task used during the simulation may have led to more "heads-out" time than would exist during normal line operations, however, there could be some operational impact on critical system monitoring as a result of EAT operations

- When a barrier was present, the Night Condition provided better discernment for making a decision than the Day Condition.

- Since the Barrier was indicated as an effective visual cue and since pilots are making decisions based upon the moment that an aircraft (EAT or Crossing non-specific) passes in front of or behind the barrier – blocking it or not blocking it - pilots recommended making the barrier as wide as possible.

- Obscuration or Flickering of runway end Lights from a passing aircraft could be an effective visual cue, especially at night. NOTE: Simulator fidelity did not fully provide a real-life representation of this.

- Although the simulation was designed with a larger aircraft on the EAT than the one that was Crossing, thereby giving a similar retinal image size to the pilots, the pilots indicated that they used relative size of one aircraft to the other as a good cue for discriminating between EAT and Crossing aircraft.

- Although crewmembers stated that the simulation fidelity was very representative, they were not specifically asked for a breakdown between aircraft performance fidelity and visual scene fidelity. FAA evaluators and simulation participants (pilot and operational personnel) agree that aircraft performance fidelity is extremely high, while visual scene fidelity was less than optimal and is not equivalent to the real-world.

- When queried about any previous experience with, or knowledge of EAT operations, on the line, pilots almost universally indicated only a passing knowledge of the concept at most. Most of the pilots had no experience with the concept. The pilot viewpoints on EAT operations were perceived to be unbiased prior to this demonstration.

3.0. CONCLUSION

3.1. HUMAN FACTORS

From a human performance and limitation perspective, there is no appreciable increase in physical workload that would lead to a compromise in current levels of safety. Pilots aptly handled the aircraft during the departure phase of this simulation. However, training for EAT operations should emphasize the importance of rigorous inside and outside the cockpit procedures, scanning and monitoring techniques during departures.

The data indicates that some form of masking feature optimizes a pilot's ability to discriminate between an aircraft that is on the EAT versus an aircraft crossing at a distance out to his/her front. This study evaluated both an above-ground barrier and a depression in elevation of the EAT. The barrier yielded the best performance in terms of accuracy and speed of discrimination between EAT and crossing aircraft. A depression, while not optimal, does increase performance better than no barrier or no depression at all.

We evaluated the difference in masking effect between the Top of Engines and the Top of Passenger Windows conditions. Our analysis of the results indicated that there is no significant difference between either of those, within the barrier or depression variable, respectively. In other words, the lower of the masking conditions (in this case, covering the engines at 13 feet) is sufficient to provide a masking effect that will enhance aircraft discrimination.

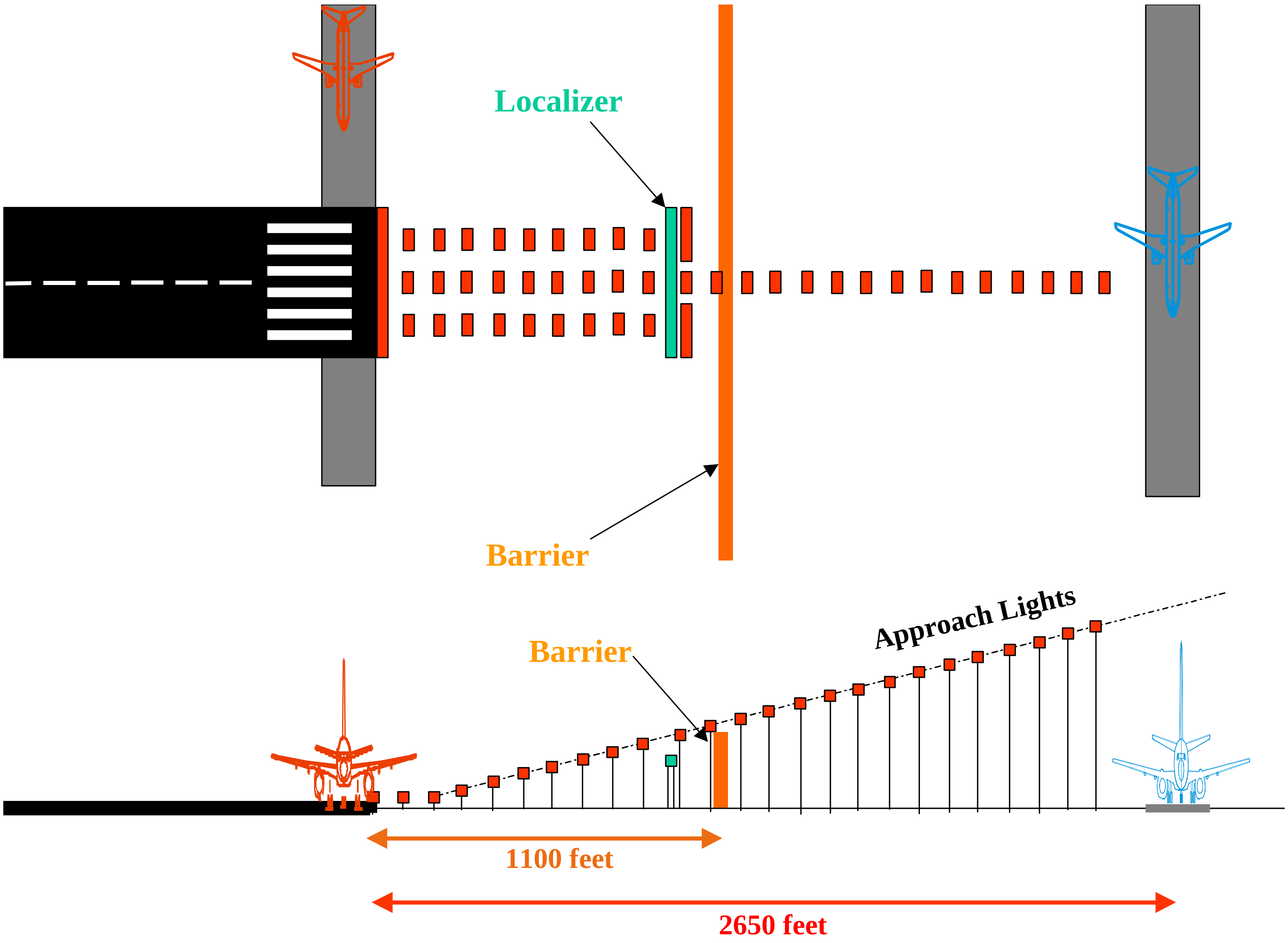
Pilot responses and comments indicate a high degree of certainty in making a decision as soon as an EAT or Crossing aircraft breaches the widest lateral limits of the barrier. This suggests that as width of the barrier increases, response times would be faster.

3.2. SUMMARY

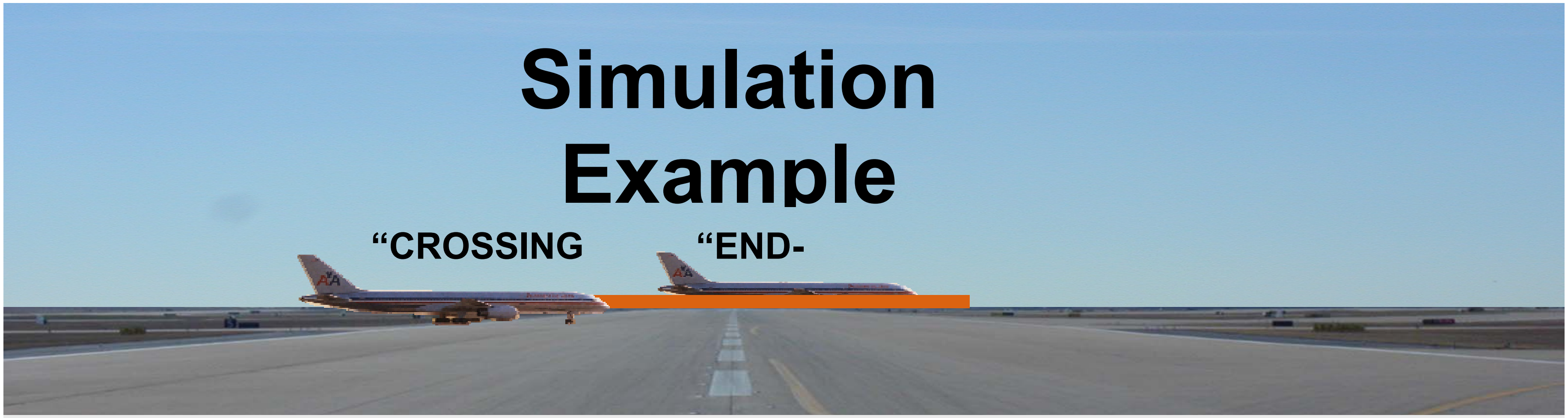
This evaluation was conducted in accordance with the approved plan. In keeping with the stated purpose of evaluating specific visual and operational mitigating factors, it was successful. In gathering pilot responses concerning the use of a masking barrier and determining if a difference exists between a masking barrier and a depression, we are able to draw certain conclusions and make specific recommendations for permanent DFW operations when an EAT is in use.

Further investigation may be needed to: 1) identify crew training requirements; and 2) identify and establish EAT-specific operational procedures.

ATTACHMENT 1



ATTACHMENT 2



Pilot Task: **Positively identify** the aircraft location as quickly as possible, and **state** either;

“**CROSSING**” (crossing the runway) or,

“**END-AROUND**” (aircraft on the EAT)