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Proof–of-Concept Demonstrations for the Proposed Runway 17R End Around Taxiway (EAT) at Dallas/Fort Worth International Airport (DFW)

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12. Abstract

The Dallas/Forth Worth International Airport (DFW) proposes the construction and operation of end-around taxiways (EAT) for runways in both east and west traffic. To address this specific request, the FAA performed a proof-of-concept demonstration in flight simulators at the American Airlines Flight Academy and the NASA-Ames Research Center. The intention was to evaluate the visual scene from a HF standpoint and potentially assist in the development, application, and approval of EAT procedures for aircraft departing active runways at DFW while simultaneous EAT operations are being conducted at the approach ends of those runways. 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. There are, however, indications in both the objective and subjective data collected that it is not easy for pilots to determine whether an aircraft is incurring the runway or safely operating on the EAT. A Collision Risk Model (CRM) analysis indicates that aircraft with tail heights of 55 feet or below presented acceptable levels of risk for unabated taxiing on the EAT and from a Terminal Instrument Procedures (TERPS) standpoint, there are no penetrations of the 40:1 departure surface for all departures. Operationally, EAT implementation requires the development of airfield and flight operational procedures to ensure that the appropriate level of safety is maintained while promoting capacity goals.

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EXECUTIVE SUMMARY

The Dallas/Fort Worth International Airport (DFW) proposes the construction and operation of end-around taxiways (EATs) for runways in both east and west traffic. There are no regulatory criteria or standards that dictate EAT design and/or operation, nor are there any standards that prohibit EAT operations. To address this issue, the FAA is now in the early stages of developing an EAT national standard.

To address this specific EAT request, the FAA performed a proof-of-concept demonstration in flight simulators to gather Human Factors (HF) and operational information to potentially assist in the development, application, and approval of EAT procedures for aircraft departing active runways at DFW while simultaneous EAT operations are being conducted at the approach ends of those runways. Terminal Instrument Procedures (TERPS) and Collision Risk Model (CRM) analyses of the proposal were also conducted and are included in this report.

This proof-of-concept demonstration was conducted in flight simulators in accordance with the approved plan. In keeping with the stated purpose of evaluating EAT procedures for aircraft departing Runway 17 R at DFW, this demonstration was successful in meeting the intended purpose. The intention to evaluate the visual scene from a HF standpoint was accomplished through elicited subjective responses and comments from aircrews, as well as objective observation of crew performance during closely scripted scenarios. Pilot comments varied slightly across all crews. Several anomalies that seemed to validate some of our pre-demonstration concerns were observed and recorded. For instance, a portion of intentionally-induced aircraft incursions were not detected by the flight crews during various phases of the departure scenarios.

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. There are, however, indications in both the objective and subjective data collected that it is not easy 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 point to the need for specific visual and operational mitigators as well as pilot training that addresses EAT operations.

This was a limited HF evaluation of the proof of concept. Due to the limited resources available (simulation time and qualified pilots), a baseline incursion detection scenario was not conducted. Performing a more in-depth study is not warranted at this time and would not be expected to yield significantly different results.

From a CRM perspective, the results in every scenario indicated that aircraft with tail heights of 55 feet or below presented acceptable levels of risk for unabated taxiing on the EAT, and aircraft with taller tail heights should be controlled so that no over-flights occur.

From an operational perspective, the implementation of EATs requires the development of airfield and flight operational procedures to ensure that the appropriate level of safety is maintained while promoting capacity goals. All operational issues have been identified, and feasible recommendations and mitigations have been suggested.

A TERPS departure evaluation was performed for aircraft with tail heights of 45 feet and 55 feet for the following runways: Runway 36 Left/Right, 18 Left/Right, 35 Center/Left, and 17 Center/Right. It was determined that for all departures, given either tail height, no penetration of the 40:1 departure surface takes place.

EAT operations may very well increase safety levels for various reasons. Pilot crews felt this operation might increase safety through the reduction of runway crossings and reduced aircraft/Air Traffic Control (ATC) communications. Further, there do not appear to be any HF, CRM, Operational, or TERPS-specific issues that cannot be overcome through mitigation strategies.

However, the proposal for an EAT system to be put in place at DFW should not be approved to move forward in its current form. The data from this demonstration confirms that, as suspected, there is an increased risk of an incident because of the potential lag in acquiring and confirming an incursion is present. Not only did several participating crews fail to identify an incursion, but more than half indicated that a potential problem existed with operations conducted in the current proposal.

Further investigation may be needed to: 1) identify crew training requirements; 2) develop mitigation strategies to increase the conspicuity of aircraft on the EAT or crossing the centerline, thereby preventing pilots from mistaking an incursion aircraft for an EAT aircraft; and 3) identify and establish EAT-specific operational procedures. Conclusions drawn from this data, analysis, and demonstration cannot be broadly generalized to other runways or other locations.

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1.0. INTRODUCTION

1.1. PURPOSE

The purpose of this proof-of-concept demonstration was to gather Human Factors (HF) and operational information, potentially leading to the development, application and approval of End-Around Taxiway (EAT) procedures for aircraft departing active runways at Dallas/Fort Worth International Airport (DFW) while simultaneous EAT operations are being conducted at the approach ends of those runways. Terminal Instrument Procedures (TERPS) and Collision Risk Model (CRM) analyses of the proposal were also conducted and are included in this report.

1.2. BACKGROUND

DFW proposes the construction and operation of EATs for runways in both east and west traffic (Attachment 1). There are no regulatory criteria or standards that dictate EAT design and/or operation, nor are there any standards that prohibit EAT operations. To address this issue, the FAA is now in the early stages of developing an EAT national standard.

Prior to the development of national EAT criteria, site-specific proposals, such as DFW, must be evaluated on a case-by-case basis. Extensive discussion and analysis of the DFW case with DFW, American Airlines (AA), Airline Pilots Association (ALPA), NASA, FAA (Flight Standards, Air Traffic, Airports), the Center for Advanced Aviation System Development/MITRE, and others reflected that this unique proposal for DFW EAT operations warranted further risk assessment and safety analysis, particularly regarding HF (human performance and limitations) issues.

The demonstration was coordinated at, and in conjunction with, both AA and National Aeronautics and Space Administration (NASA) Ames. Attachments 2 & 3 contain a chronology of events and background information for demonstrations conducted at both the American Airlines and NASA-Ames facilities, respectively. The results of this demonstration are intended to also contribute to the development of a national standard for EAT operations.

2.0. HUMAN FACTORS EVALUATION

2.1. GENERAL

This proof-of-concept demonstration was conducted in accordance with the approved plan. In keeping with the stated purpose of evaluating EAT procedures for aircraft departing Runway 17 R at DFW, this demonstration was successful in meeting the intended purpose. The intention to evaluate the visual scene from a HF standpoint was accomplished through elicited subjective responses and comments from aircrews, as well as objective observation of crew performance during closely scripted scenarios.

Pilot comments varied slightly across all crews. We did observe and record a few anomalies that seemed to validate some of our pre-demonstration concerns. For instance, a portion of the intentionally-induced aircraft incursions were not detected by the flight crews during various phases of the departure scenarios. The data reduction and analysis describes this finding in detail.

The demonstration 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; and atmospheric and visibility conditions that affect the visual scene. These items are important and could impact real world operations. Nor did it fully evaluate the effect of the visual scene on visual scan 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 a baseline simulator operation to an EAT operation in actual visual conditions to determine if there were any significant differences. This was a limited human factors evaluation of the proof of concept, seeking to uncover macro issues that may manifest themselves as a result of flying specific and limited scenarios in a simulator.

2.2. SIMULATION SCENARIOS

Each crew flew nine distinct scenarios per the approved plan (Tables 1 & 2), alternating between Captain and First Officer for each scenario. After completing the nine-scenario set, each crew conducted the same full set again (assuming time was available), alternating in different order.

2.3. SUBJECTIVE QUESTIONNAIRE

After each scenario/run, each crewmember (regardless of pilot-flying (PF) or pilot-not-flying (PNF)) was given a six-question, check-the-block, subjective questionnaire (Figure 1). It was stressed that each questionnaire was designed to capture pilot reaction to that particular stand-alone scenario.

Following the simulator session, both the Captain and First Officer were given a final post-simulation questionnaire (Figure 2) to gather their overall view of the operation and encompassing all scenarios/runs. Upon completion of the final questionnaire, the crew and evaluators/observers conducted a verbal post-simulation de-brief (Figure 3).

All evaluators and observers briefed crews from a scripted briefing sheet and de-briefed crews in the same manner in order to preserve data/test continuity and integrity.

Flight Simulator Scenarios for proposed DFW RWY 17R EAT Operations – American Airlines

DATE/TIME: AIRCRAFT TYPE: Boeing 767-300 **CREW:**

Scenario #	Pilot Flying	Wind (Knots)	Ceiling (Feet AGL)	Visibility (SM/RVR)	Day/ Night	Conditions (Weight/Temp)	Operational Weight (LBS)	Remarks
1 Takeoff	CP/FO	215/15	1000’	3	Day	NORMAL/90º	**767-300:**	
2 Takeoff	CP/FO	125/15	1000’	3	Night	MAXIMUM/90º	**767-300:**	
3 Takeoff	CP/FO	125/15	400’	6000	Day	NORMAL/100º	**767-300:**	
4 Takeoff w/Incursion	CP/FO	215/15	400’	6000	Night	MAXIMUM/90º	**767-300:**	**Incursion – Boeing 757**
5 Takeoff	CP/FO	215/15	400’	6000	Day	MAXIMUM/100º	**767-300:**	**Engine Out/Abort ****
6 Takeoff	CP/FO	125/15	1000’	3	Day	MAXIMUM/100º	**767-300:**	
7 Takeoff w/Incursion	CP/FO	215/15	400’	6000	Night	MAXIMUM/90º	**767-300:**	**Incursion – Boeing 757**
8 Landing	CP/FO	125/15	1000’	3	Day	MAXIMUM/100º	**767-300:**	**RWY 17C**
9 Landing	CP/FO	215/15	1000’	3	Night	MAXIMUM/90º	**767-300:**	**RWY 17C**

** Engine-out or abort not required and only authorized with pilot qualified in-type

TABLE 1

Flight Simulator Scenarios for proposed DFW RWY 17R EAT Operations- NASA Ames

DATE/TIME: AIRCRAFT TYPE: Boeing 747-400 CREW:

Scenario #	Pilot Flying	Wind (Knots)	Ceiling (Feet AGL)	Visibility (SM/RVR)	Day/ Night	Conditions (Weight/Temp)	Operational Weight (LBS)	Remarks
1 Takeoff	CP/FO	215/15	1000’	3	Day	NORMAL/90º	**747-400:**	
2 Takeoff	CP/FO	125/15	1000’	3	Night	MAXIMUM/90º	**747-400:**	
3 Takeoff	CP/FO	125/15	400’	6000	Day	NORMAL/100º	**747-400:**	
4 Takeoff w/Incursion	CP/FO	215/15	400’	6000	Night	MAXIMUM/90º	**747-400:**	**Incursion – ERJ-145**
5 Takeoff	CP/FO	215/15	400’	6000	Day	MAXIMUM/100º	**747-400:**	**Engine Out/Abort ****
6 Takeoff	CP/FO	125/15	1000’	3	Day	MAXIMUM/100º	**747-400:**	
7 Takeoff w/Incursion	CP/FO	215/15	400’	6000	Night	MAXIMUM/90º	**747-400:**	**Incursion – RJ-145**
8 Landing	CP/FO	125/15	1000’	3	Day	MAXIMUM/100º	**747-400:**	**RWY 17C**
9 Landing	CP/FO	215/15	1000’	3	Night	MAXIMUM/90º	**747-400:**	**RWY 17C**

** Engine-out or abort not required and only authorized with pilot qualified in-type

TABLE 2

DATE:____________CREW #:_____________SCENARIO:_______PF/PNF

Post-Run Questionnaire

1. In general, compared to departure procedures that your company normally performs, characterize the overall procedure flown in the test.

Easy Moderate Difficult

1 2 3 4 5 6 7 8 9

2. Rate your level of comfort while departing when EAT operations are in effect.

Very Comfortable Moderately Comfortable Uncomfortable

1 2 3 4 5 6 7 8 9

3. Rate your level of comfort before V1 when an aircraft is on the End-Around Taxiway but you do not have visual acquisition of it.

Very Comfortable Moderately Comfortable Uncomfortable

1 2 3 4 5 6 7 8 9

4. Rate your level of comfort when over-flying an aircraft on the End-Around Taxiway

Very Comfortable Moderately Comfortable Uncomfortable

1 2 3 4 5 6 7 8 9

5. Rate your perceived level of **individual workload** for this procedure from the standpoint of mental demand (e.g. thinking, deciding, calculating, remembering, looking, searching, etc.).

Low Moderate High

1 2 3 4 5 6 7 8 9

6. Rate the level of **crew workload** for this procedure from the standpoint of mental demand (e.g. thinking, deciding, calculating, remembering, looking, searching, etc.).

Low Moderate High

1 2 3 4 5 6 7 8 9

FIGURE 1

DATE:____________CREW #:_____________ PF/PNF

Post-Simulation Questionnaire

1. In general, compared to other departure procedures that your company performs, characterize the overall procedure flown in the test.

Easy Moderate Difficult

1 2 3 4 5 6 7 8 9

2. Rate your overall level of comfort with this procedure.

Very Comfortable Moderately Comfortable Uncomfortable

1 2 3 4 5 6 7 8 9

3. Rate your perceived level of **individual workload** for this procedure from the standpoint of mental demand (e.g. thinking, deciding, calculating, remembering, looking, searching, etc.).

Low Moderate High

1 2 3 4 5 6 7 8 9

4. Rate the level of **crew workload** for this procedure from the standpoint of mental demand (e.g. thinking, deciding, calculating, remembering, looking, searching, etc.).

Low Moderate High

1 2 3 4 5 6 7 8 9

5. Compared to other departure procedures, rate the overall level of effort required to perform this one.

Lower No Different Higher

1 2 3 4 5 6 7 8 9

6. Rate the realism of the aircraft flight simulator versus the actual aircraft (e.g. control feel, power response, landing characteristics, visual display).

Not Realistic Realistic Extremely Realistic

1 2 3 4 5 6 7 8 9

FIGURE 2

DATE:____________CREW #:_____________ PF/PNF

Post-Simulation De-Brief

1. Overall, did you feel comfortable with this procedure (i.e. as the departing aircraft with an aircraft on the
End-Around Taxiway or as the EAT aircraft)? ______________ Why? Why Not? Which phase(s) was more
critical?____
____
____

2. What additional mental or physical requirements, if any, were imposed on you during this procedure?
____
____

3. Which phase of the procedure was more difficult? _____________ Why?
____
____

4. Provide comments on the flight simulator fidelity. How closely representative is it of real world flying?
____
____

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

6. Have you ever been to Miami or any other location where End-Around Taxiway or similar operations are in effect? ____
Where?____
What were your impressions? ____
____

7. Did you have any problems discriminating between aircraft that were on the EAT and aircraft that were holding short at the end of the
runway?____
____
____

8. Is it your sense that over time you might become complacent when EAT operations are in effect (e.g. you might assume that an aircraft is on the EAT when it might actually be holding short of the active?
____
____

FIGURE 3

2.4. SUBJECTIVE QUESTIONNAIRE RESPONSES

As shown in Tables 3 & 4, 128 separate departure and 30 separate approach scenarios, using ten different crews, were conducted. The crews were a mix of instructor pilots and line pilots. All crewmembers were current or former (recently retired) captains. After each run, both the PF and PNF were given a six-question subjective questionnaire (316 total questionnaires). The numbers in Tables 3 & 4 represent total number of responses by specific question. They are broken down by responses from both the PF and PNF.

Question 1 dealt with a comparative analysis between departures while EAT operations are on-going and other departure procedures that the crewmember has flown. Of the total responses in the AA analysis, 84PF/80PNF% (yellow shaded area) indicated that this procedure was comparatively “Easy.” Of the total responses in the NASA Ames analysis, 90PF/77PNF% considered this procedure to be comparatively “Easy.” The remaining percentage of responses occurred almost exclusively in the moderately difficult range of responses. As pilots became more experienced and familiar with EAT operations in the simulators, pilot perception of difficulty did not change. Figures 4 & 10 graphically depict the responses for Question 1 for the AA and NASA Ames studies, respectively.

Questions 2 through 4 (pink shaded area) were intended to derive information concerning crewmember comfort level. Of the total responses to Question 2 in the AA evaluation, 77PF/75PNF% indicated moderate to high levels of comfort with EAT operations (Figure 5). Of the AA responses to Question 3, 72PF/77PNF% indicated that at V_1, with no visual acquisition of an aircraft on an EAT; comfort levels are moderate to high (Figure 6). Of the AA responses to Question 4, 73PF/75PNF% indicated moderate to high levels of comfort when over-flying another aircraft (Figure 7). Results across the same questions in the NASA Ames study resulted in 55PF/47PNF%, 53PF/37PNF%, and 58PF/54PNF%, respectively (Figures 11-13).

The remaining percentage of responses occurred almost exclusively in the moderately comfortable range of responses. Pilot de-brief comments indicated an increase in comfort levels with increased experience and familiarity with EAT operations in the simulator although subjective responses did not support this trend. It is also unclear why the pilots from the NASA Ames simulation generally indicated lower comfort levels. Comfort scores remained constant within the pilot population from the beginning of the simulation through all departure scenarios. However, pilot comments, as well as subjective ratings, generally indicated that the approach and landing scenarios were the less comfortable phases of the simulation. Since these two scenarios were flown during the same period as the departures, pilots commented on them in comparison with the entire scenario set.

Questions 5 and 6 (gray shaded area) queried crewmembers about their perceived levels of individual and crew workload (i.e., any change in level of workload that can specifically be attributed to EAT operations).

Of the AA pilot responses, 75PF/76PNF% and 76PF/79PNF% respectively indicated that both individual and crew workload levels were changed somewhat (Figures 8 & 9). Of the NASA Ames pilot responses, 43PF/44PNF% and 47PF/40PNF% indicated a higher level of perceived workload (Figures 14 & 15). Of the remaining percentages, pilots indicated a moderate level of increased individual and crew workload. As with the comfort level ratings, the NASA Ames pilots rated the EAT operations produced a higher perceived level of workload than the AA pilots.

END-AROUND TAXIWAY
RWY 17R AT DFW – 25-26 AUG 04 – American Airlines

EASY
VERY COMFORTABLE
LOW WORKLOAD

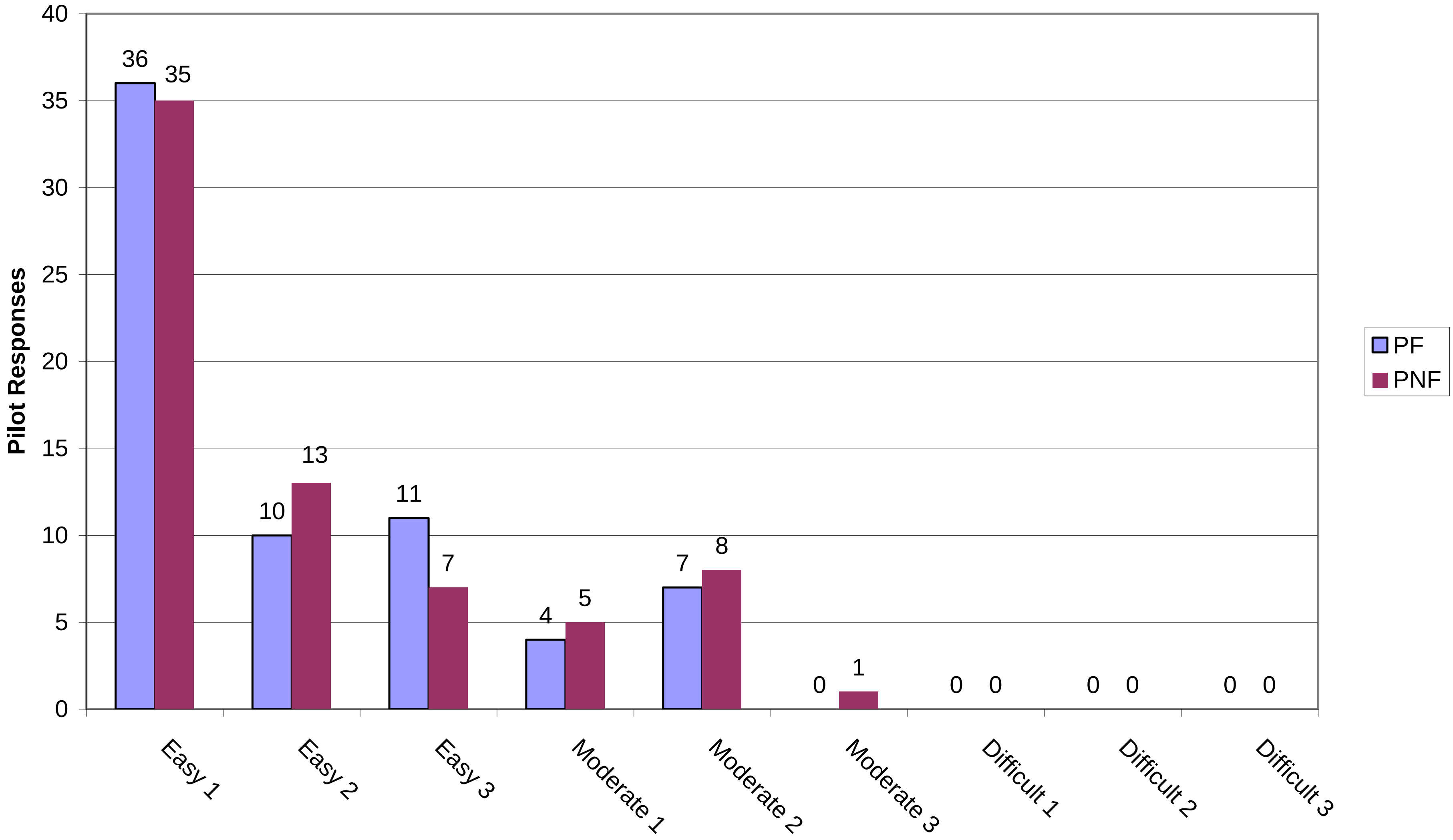
(Question 1)
(Questions 2, 3, 4)
(Questions 5 & 6)

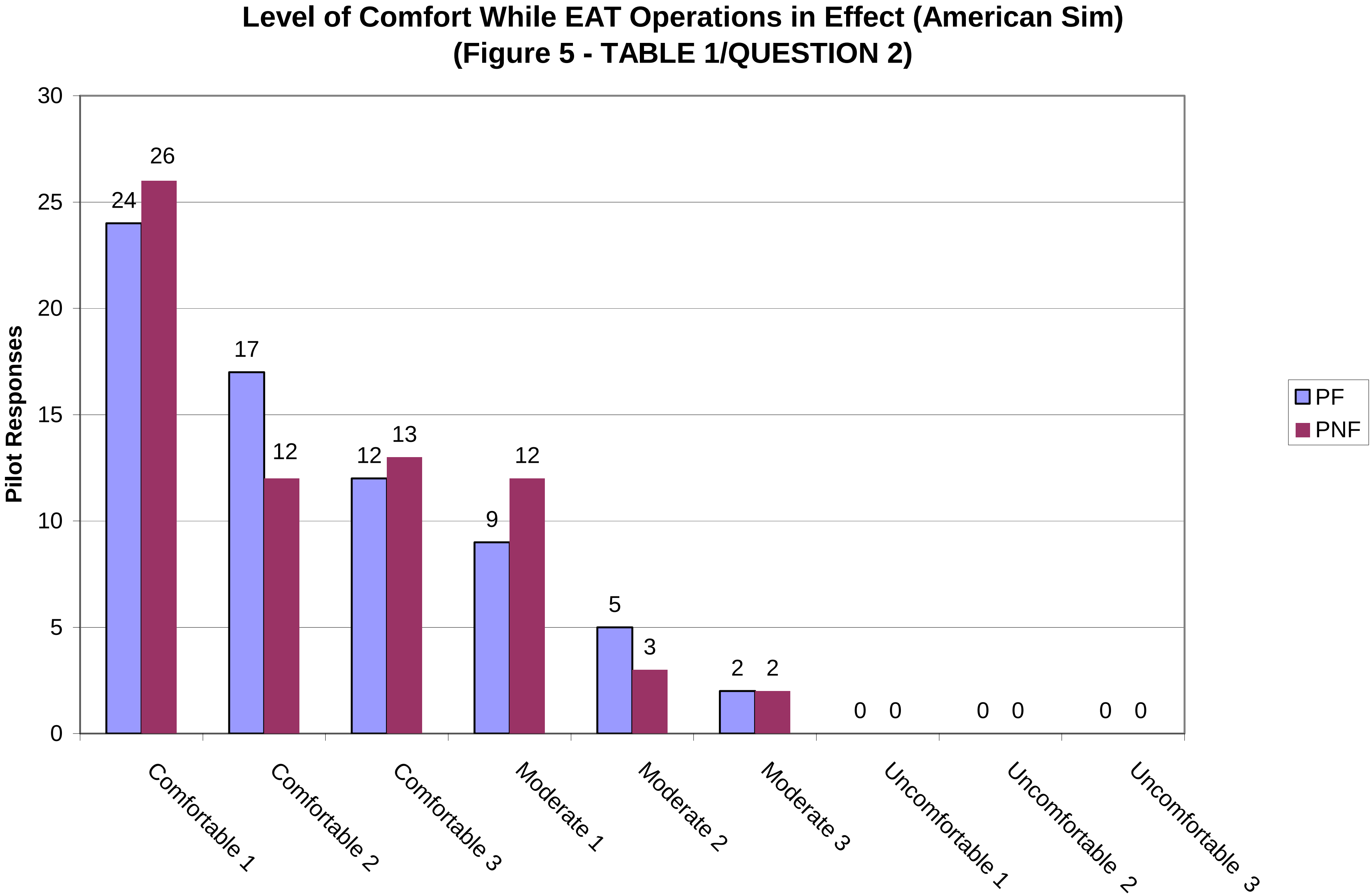
DIFFICULT
UNCOMFORTABLE
HIGH WORKLOAD

Question / Response	1(84/80%) Versus Other Approaches		2(77/75%) Comfort During Depart.		3(72/77%) Comfort Before V1		4(73/75%) Comfort W/Overflight		5(75/76%) Individual Workload		6(76/79%) Crew Workload	
1 PF PNF	36	35	24	26	24	27	25	28	21	23	15	26
2 PF PNF	10	13	17	12	15	9	18	12	19	18	13	15
3 PF PNF	11	7	12	13	7	13	10	16	19	18	25	20
4 PF PNF	4	5	9	12	13	11	15	13	10	14	9	10
5 PF PNF	7	8	5	3	1	3	1	3	3	2	3	6
6 PF PNF		1	2	2	4	1	3	2	4	1	4	
7 PF PNF							1	1	3	2	1	
8 PF PNF												
9 PF PNF												

TABLE 3

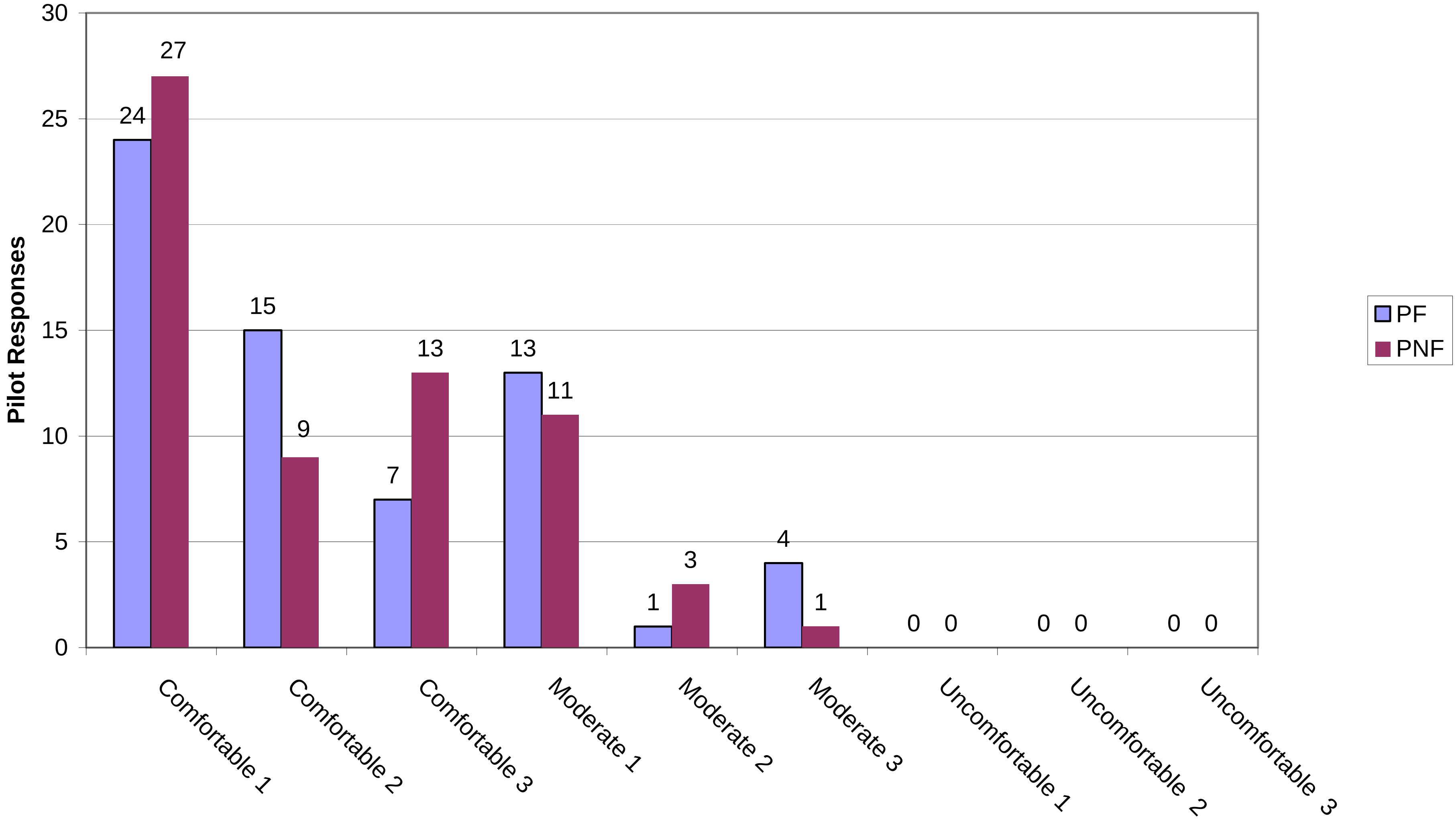
Compare EAT Procedure to Normal Procedure (American Sim)
(Figure 4 - TABLE 1/QUESTION 1)



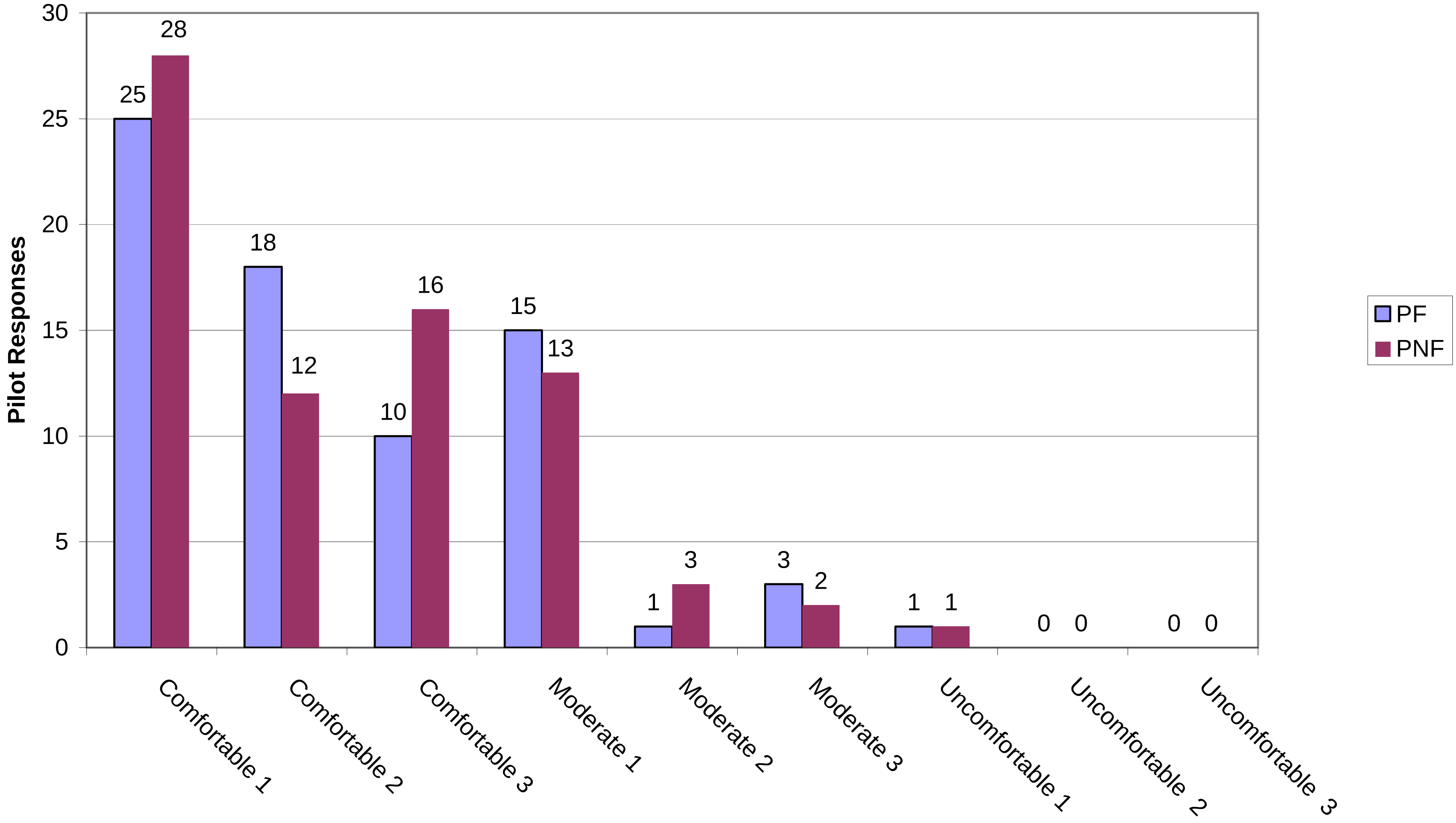

Level of Comfort While EAT Operations in Effect (American Sim)
(Figure 5 - TABLE 1/QUESTION 2)
Pilot Responses
30
25
20
15
10
5
0
24
26
17
12
12
13
9
12
5
3
2
2
0
0
0
0
0
0
Comfortable 1
Comfortable 2
Comfortable 3
Moderate 1
Moderate 2
Moderate 3
Uncomfortable 1
Uncomfortable 2
Uncomfortable 3
PF
PNF

END-AROUND TAXIWAY
RWY 17R AT DFW – 25-26 AUG 04 – American Airlines

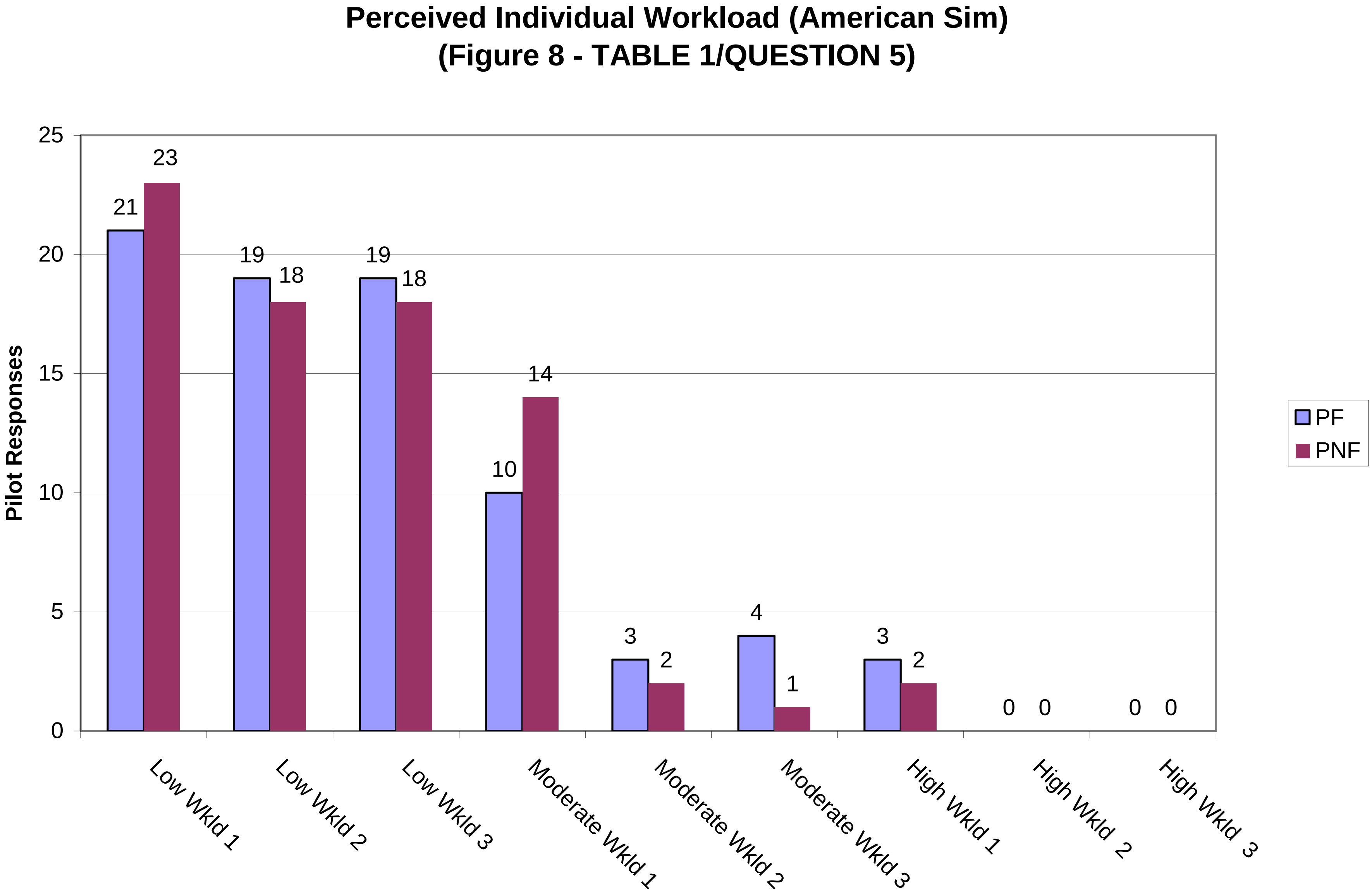
Level of Comfort Before Reaching V1 (American Sim)
(Figure 6 - TABLE 1/QUESTION 3)



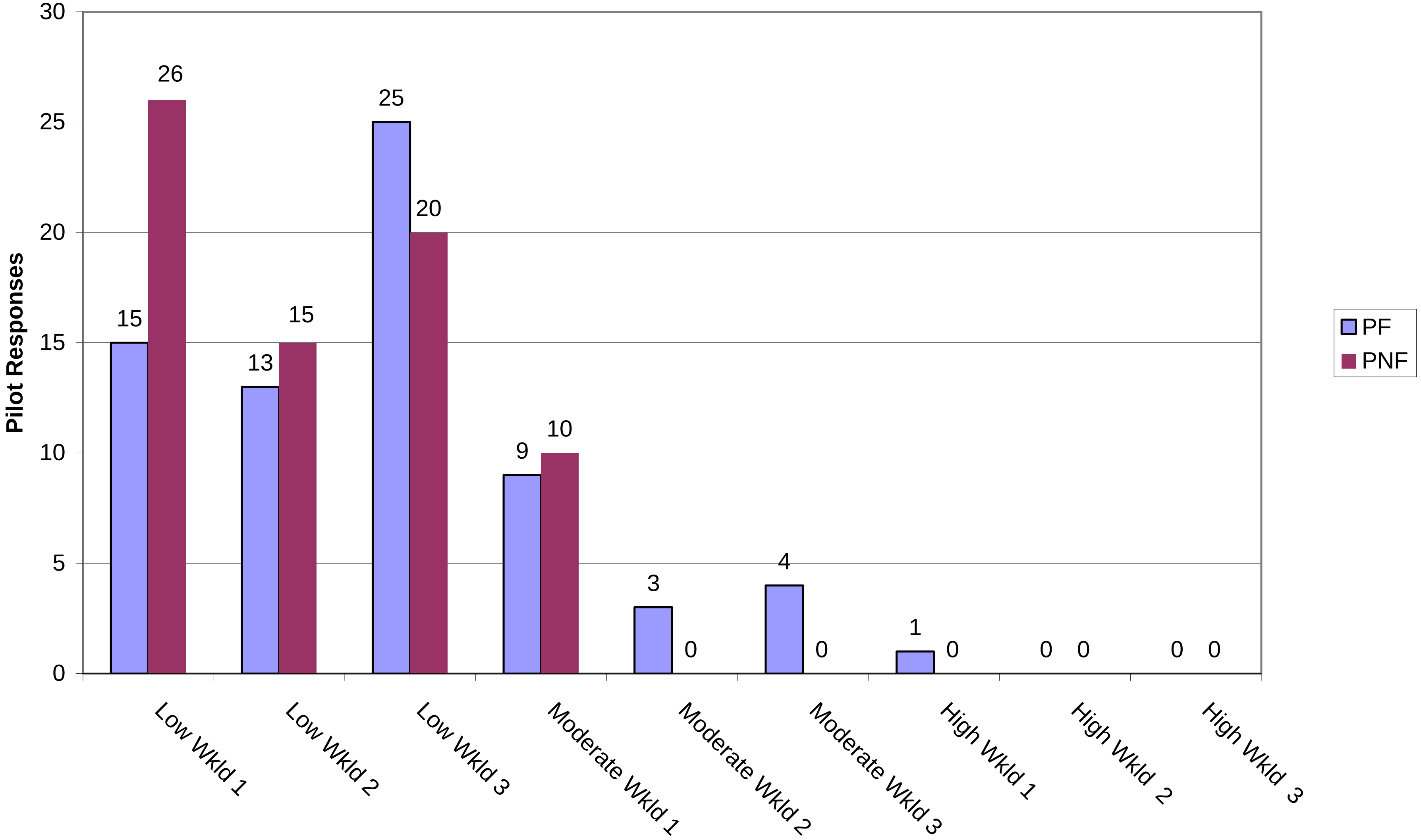
Level of Comfort While Overflying Another Aircraft on EAT (American Sim) (Figure 7 - TABLE 1/QUESTION 4)



END-AROUND TAXIWAY
RWY 17R AT DFW – 25-26 AUG 04 – American Airlines



Perceived Crew Workload (American Sim)
(Figure 9 - TABLE 1/QUESTION 6)



END-AROUND TAXIWAY
RWY 17R AT DFW – 23,31 AUG 04 – NASA-Ames

EASY
VERY COMFORTABLE
LOW WORKLOAD

(Question 1)
(Questions 2, 3, 4)
(Questions 5 & 6)

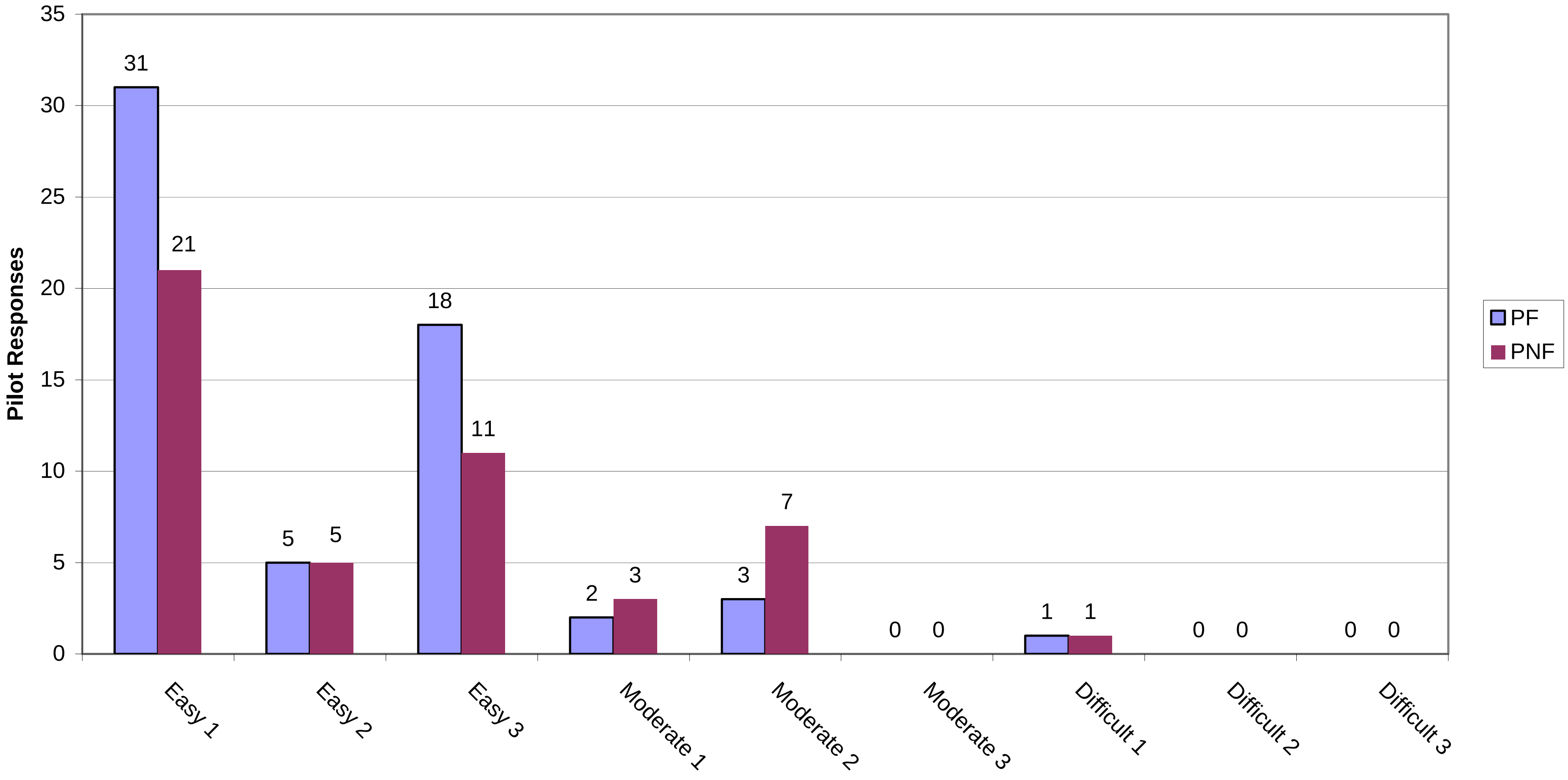
DIFFICULT
UNCOMFORTABLE
HIGH WORKLOAD

Question / Response	1(90/77%) Versus Other Approaches		2(55/47%) Comfort During Depart.		3(53/37%) Comfort Before V1		4(58/54%) Comfort W/Overflight		5(43/44%) Individual Workload		6(47/40%) Crew Workload	
1 PF PNF	31	21	23	13	21	12	21	12	21	16	22	16
2 PF PNF	5	5	1	2	3	3	3	4	2	2	2	2
3 PF PNF	18	11	7	6	4	1	11	11	3	4	6	3
4 PF PNF	2	3	18	14	12	15	12	11	11	7	13	10
5 PF PNF	3	7	5	10	6	4	9	5	17	11	12	12
6 PF PNF			2		6	7	3	5	6	5	8	5
7 PF PNF	1	1			1	1		1	1	5		4
8 PF PNF							1	1	1		1	1
9 PF PNF												

TABLE 4

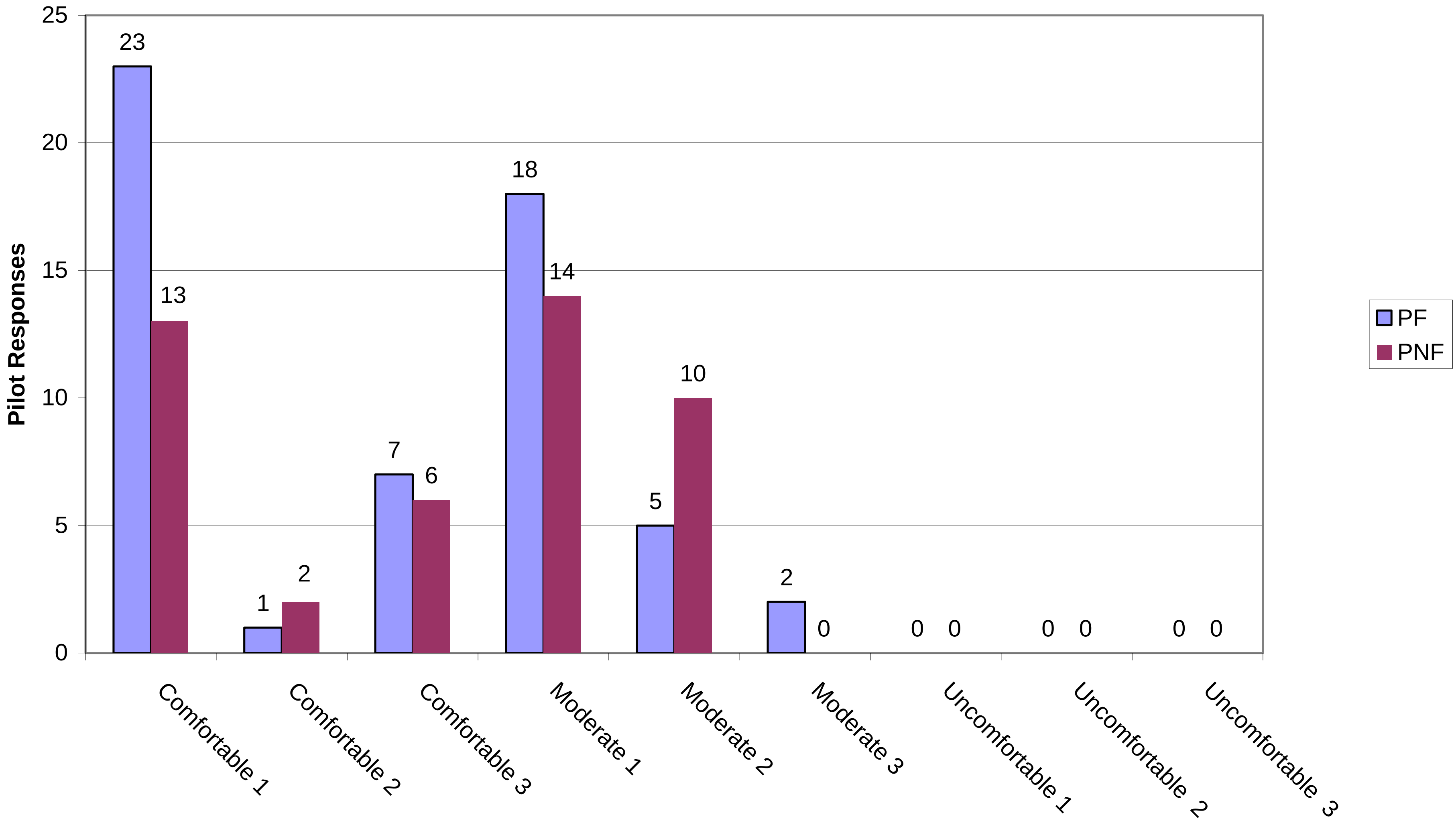
END-AROUND TAXIWAY
RWY 17R AT DFW – 23,31 AUG 04 – NASA-Ames

Compare EAT Procedure to Normal Procedure (NASA Sim)
(Figure 10 - TABLE 2/QUESTION 1)



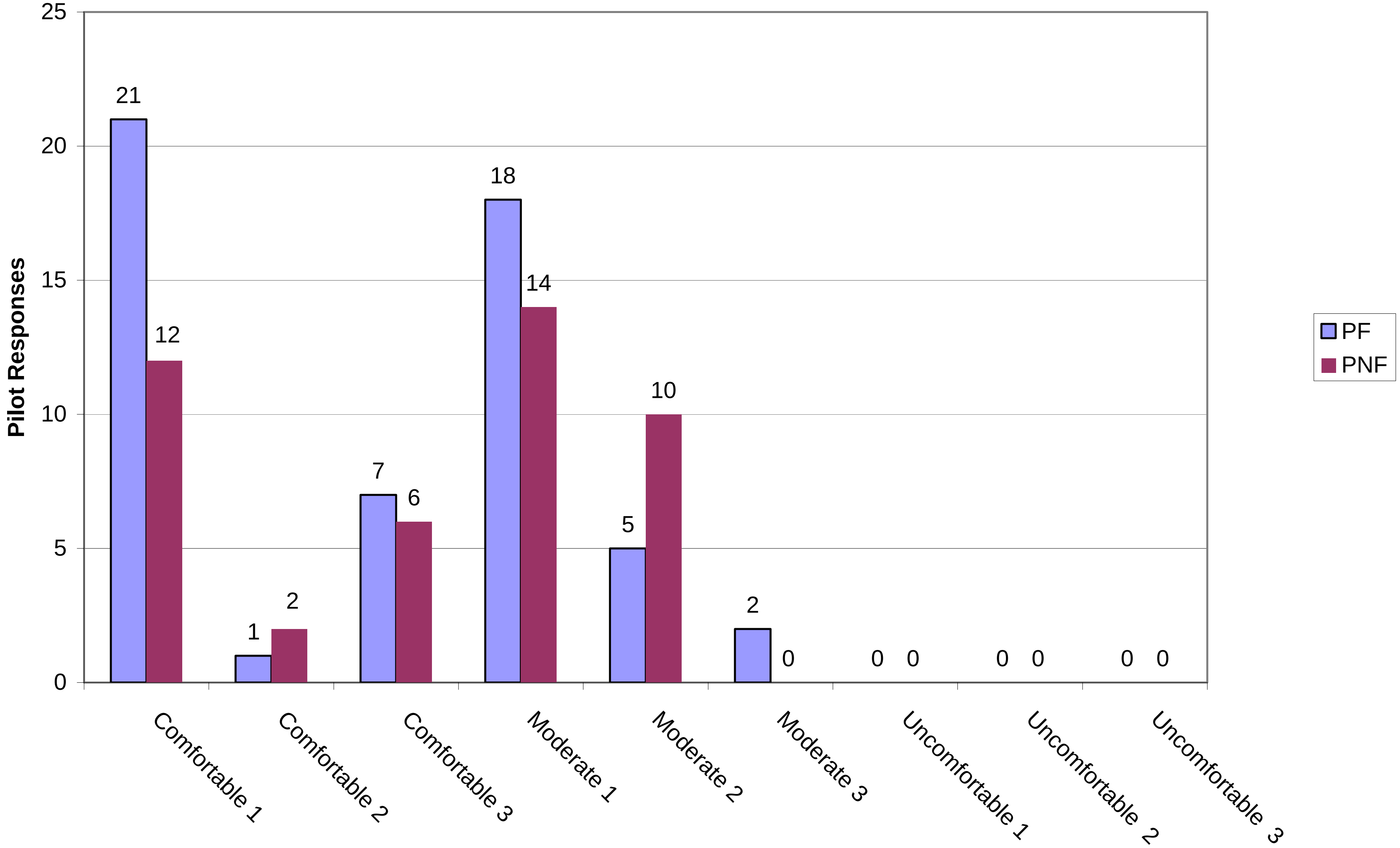
END-AROUND TAXIWAY
RWY 17R AT DFW – 23,31 AUG 04 – NASA-Ames

Level of Comfort While EAT Operations in Effect (NASA Sim)
(Figure 11 - TABLE 2/QUESTION 2)

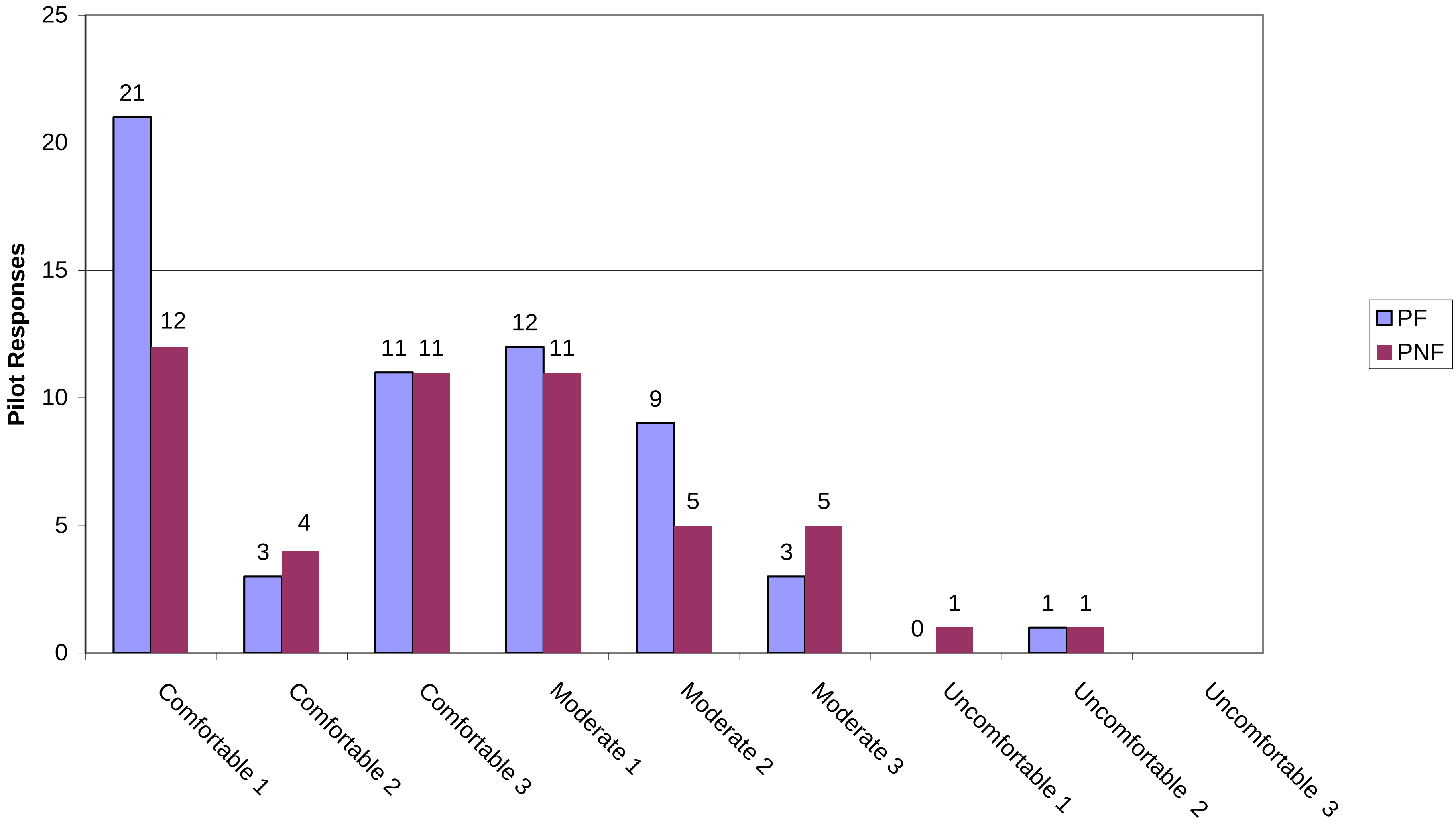


END-AROUND TAXIWAY
RWY 17R AT DFW – 23,31 AUG 04 – NASA-Ames

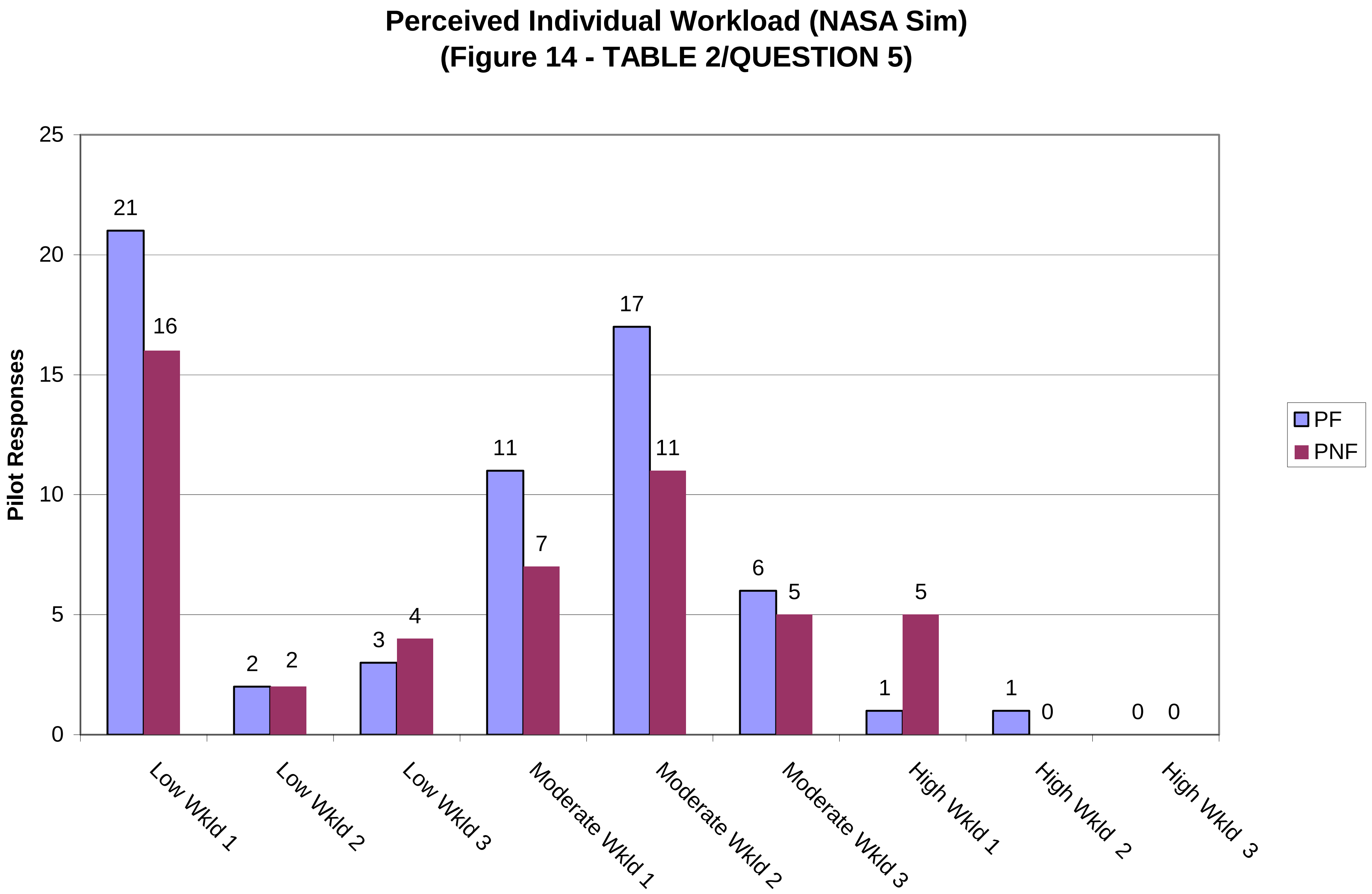
Level of Comfort Before Reaching V1 (NASA Sim)
(Figure 12 - TABLE 2/QUESTION 3)



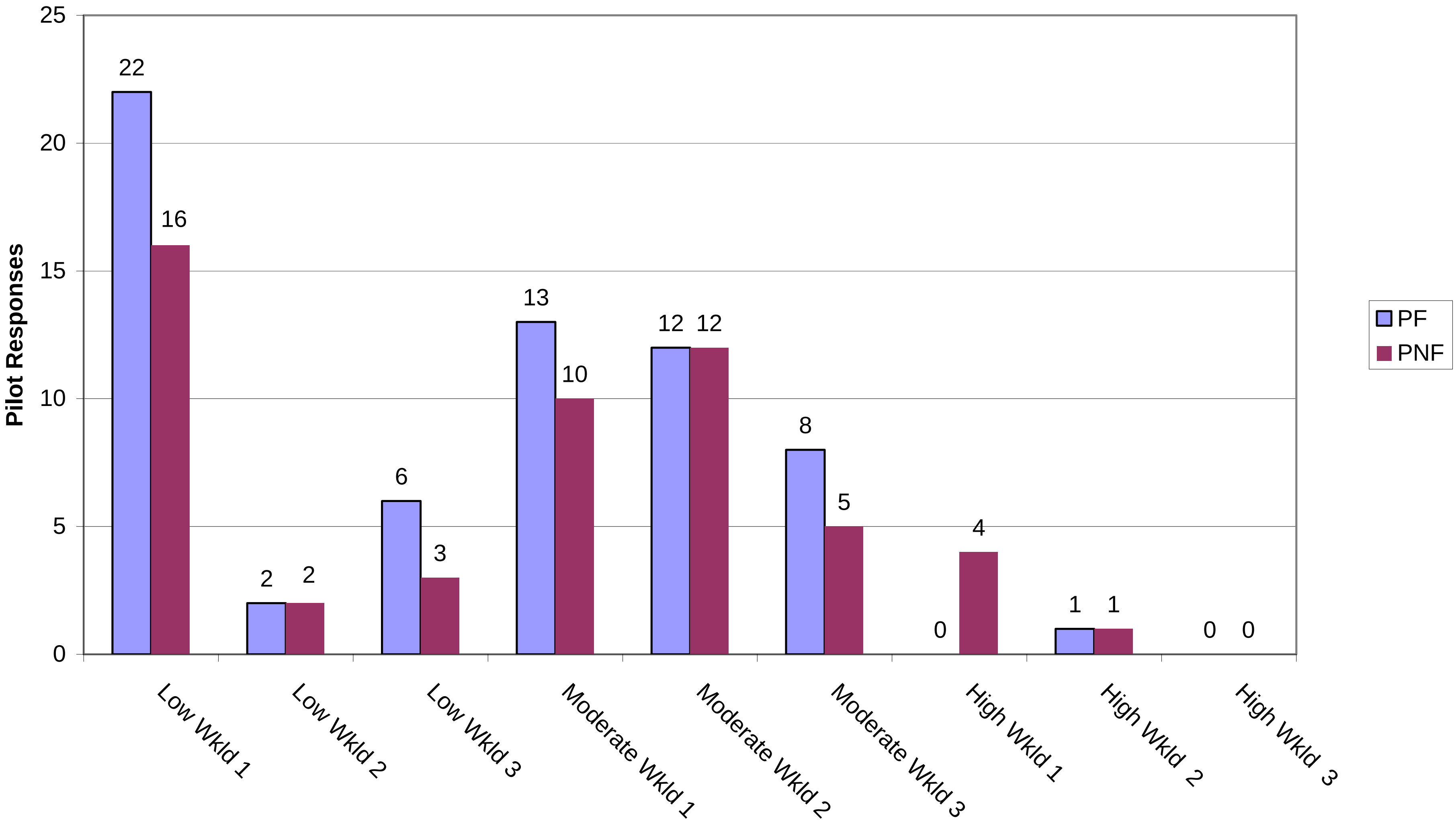
Level of Comfort While Overflying Another Aircraft on EAT (NASA Sim)
(Figure 13 - TABLE 2/QUESTION 4)



END-AROUND TAXIWAY
RWY 17R AT DFW – 23,31 AUG 04 – NASA-Ames



END-AROUND TAXIWAY
RWY 17R AT DFW – 23,31 AUG 04 – NASA-Ames



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 simulators. All flight scenarios were carefully scripted. During those periods in a given flight 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: Reaction times, visual scan patterns, and instrument/system monitoring were not measured

For the purposes of this demonstration, primary tasks were those that included the departure sequence when EAT operations were ongoing (i.e., visually scanning the departure end of the runway, visually acquiring aircraft that were either operating on the EAT or crossing at the end of the runway, and taking appropriate action). 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 whatsoever with physically 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). With the exception of the one engine-out scenario, pilots performed well within the scope of their training and experience in order to safely maneuver the airplane. No primary or secondary task shedding was observed.

During departure operations, pilots were only minimally distracted by aircraft on any part of the EAT. Both the PF and PNF remained on task during departures. Typically, both indicated that they could not see the aircraft on the EAT once the aircraft had rotated. This is probably attributed to aircraft attitude and pitch configuration precluding visual acquisition at the position on the runway when the aircraft is past rotation and climbing. The pilot simply cannot see anything at that point in the flight profile because of the cockpit cutoff angle after V_1. Occasionally, the PNF was observed leaning forward to gain visual acquisition of EAT aircraft. Those crewmembers indicated this was done more out of curiosity than out of operational necessity, and this behavior would likely subside as they gained operational exposure and experience with these procedures.

Approximately half of all scenario-induced incursions were unnoticed by the crews. While some crews recognized all incursions, others did not recognize any of the four incursions presented to each crew. The incursion timing varied, with some incursions occurring early in the takeoff roll and other incursions occurring later, near V_1 speeds. Within the subset of incursions that occurred at or near V_1, several crews were able to recognize that an aircraft was incurring in front of them, but consciously made the decision to continue with the takeoff sequence rather than abort. They indicated that their decision was based upon the intruder's location, their own airspeed and heavy aircraft weight at the time when they were able to determine that the crossing aircraft was an incursion rather than an aircraft on the EAT. The pilots indicated that discriminating between EAT aircraft and incursion aircraft was very difficult, and the objective observations and de-briefing comments support this finding

Although not a primary goal in this demonstration, the 30 approach scenarios flown by the ten flight crews to runway 17R/35L did indicate the need for further testing if the airport operator requests such an operation. This should also include an evaluation of the EAT during low visibility conditions for taxiing aircraft to determine if any specific operational procedure, lighting, marking, signage, etc., will be needed.

2.6. PILOT COMMENTS/DEBRIEFING REMARKS

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

-Several crew members stated there was more confusion during night departures between EAT aircraft and crossing aircraft, as depth perception, based upon aircraft lighting, is significantly degraded.

-There was no appreciable increase in mental or physical workload during departures when EAT operations were in effect, whether they had visual acquisition of an EAT aircraft or not.

-Any aircraft holding short of the runway were more of a potential distraction than an EAT aircraft.

-Comfort levels increased with more flights flown.

-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 a one-to-one relationship and is not equivalent to the real-world.

-Several crews indicated they would expect that under “good” visibility conditions, in the “real” world, visual acquisition and contrast of EAT aircraft and crossing aircraft would likely be better than in the simulator.

-Pilots generally commented that vigilance levels would remain constant whether EAT operations were in effect or not. In other words, pilots felt that they would not become complacent over time when they have become accustomed to conducting departure operations with on-going EAT operations. This is directly related to experience, training, and operational procedures in place. Pilots feel they are always on the alert for runway incursions.

-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 neither experience with nor knowledge of the concept. The pilot viewpoints on EAT operations were perceived to be unbiased prior to this demonstration.

3.0. COLLISION RISK MODEL ANALYSES

Earlier CRM analyses indicated that taxiing aircraft could safely be moved on an EAT while an aircraft was on an Instrument Landing System (ILS) approach, if the taxiway was of sufficient distance beyond the runway threshold. The distance required is dependent on the tail heights of the taxiing aircraft. These analyses suggest that with a threshold crossing height of 50 feet or more, aircraft with tail heights of 46 feet or less could safely taxi on an EAT at 2,240 feet or more from runway threshold; aircraft with tail heights of 55 feet or less could taxi safely at 2,600 feet or more from threshold; aircraft with tail heights of 65 feet or less could taxi safely at 3,000 feet or more from threshold; and aircraft with tail heights of 80 feet or less could taxi safely at 3,600 feet or more from the threshold. Some additional advantage can be gained if the EAT is sloped down away from the threshold, so the taxiway elevation is lower than the runway threshold elevation. It should be noted that these distances are consistent with a plane whose origin is 400 feet beyond threshold with a slope of 40:1. This is more restrictive than the 34:1 ILS W Obstacle Clearance Surface, because a collision of an approaching aircraft with a taxiing aircraft would be a catastrophic event and, therefore, requires a reduced likelihood of occurrence.

DFW is proposing to build EATs beyond eight different runway ends. These taxiways are each designed to be 2,650 feet beyond their respective runway thresholds. Additionally, their elevations are designed to be close to corresponding runway threshold elevations. Their intended use is for aircraft with tail heights of 46 feet or less to taxi unabated on these end-around taxiways regardless of over-flights of approaching or departing aircraft. Also, it is intended that the movement of taxiing aircraft with tail heights greater than 46 feet be controlled, so over-flights of approaching or departing aircraft do not occur.

Specifically, the DFW proposed EATs were examined using CRM analyses. All eight runways involved presented acceptable levels of risk for EAT operations as proposed during ILS CAT I or CAT II operations. Each end-around scenario was modeled by placing 46 feet, 55 feet, and 65 feet tail height aircraft upon both the parallel taxiways leading out to the EATs and the EATs themselves. The results in every scenario indicated that aircraft with tail heights of 55 feet or below presented acceptable levels of risk for unabated taxiing on the EATs, and aircraft with taller tail heights should be controlled so that no over-flights occur. Appendix A contains the obstacle databases and CRM summary results for each runway. Please note that the databases only include tails of taxiing aircraft distributed at approximately 300 feet intervals and do not include any other obstacles. If there are other existing or proposed significant obstacles, then the validity of these CRM analyses may be in question. Additionally, the CRM does not examine the visual segment of approaching aircraft, nor does it examine departures. The impacts of these issues are not considered in these CRM analyses.

4.0. OPERATIONAL CONCERNS AND RECOMMENDATIONS

The implementation of EATs requires the development of airfield and flight operational procedures to ensure that the appropriate level of safety is maintained while promoting capacity goals.

The following issues have been identified, and recommendations are suggested:

4.1. AIRFIELD PROCEDURES AND EQUIPMENT CONSIDERATIONS

Signage, Marking: EATs need to be evaluated and a national policy established to standardize naming conventions, holding lines (for metering purposes), runway safety area/obstacle free zone boundary signs, etc.

<u>Contaminated taxiway operations</u>: Policy needs to be established on the use of EATs when contaminated by snow, ice, or other potentially hazardous conditions. Specifically, evaluation needs to be made of the requirement for lighting, marking, and/or signage to ensure safe operations away from other airfield reference points (other taxiways, terminals, and runways).

<u>Foreign Objects and Debris (FOD)</u>: The airport should evaluate and develop policy for inspecting and clearing EATs of FOD, especially as related to the affect of takeoff operations' jet blast movement of debris onto EAT surfaces.

<u>Evaluation of the effect of the presence of aircraft beyond the localizer antenna during CAT I/II/III operations</u>: FAA should flight check ILS procedures with representative aircraft on the EAT to ensure required signal attributes remain intact during EAT operations.

Crash/Fire Rescue (CFR): Existing CFR plans should be evaluated for response procedures for the additional taxiway surfaces and management of the movement of CFR assets during EAT operations.

Visual aid development: In order to avoid unnecessary takeoff aborts, a standard obscuring, frangible barrier design should be developed to allow the takeoff aircraft crew's easy determination of crossing aircraft position on the EAT or conventional runway crossing taxiway. This concept is similar to the approach light obscuring panels developed at certain airports to reduce misidentification of the light structure as an aircraft by pilots of opposite direction departing aircraft.

Runway length and taxiway considerations: In a July 12, 2004 decision document, the Airport Obstructions Standards Committee cited a July 2004 analysis based on 22 years of incident/accident data that showed an acceptable risk level (0.6×10^{-7}) associated with allowing taxiing aircraft in the Runway Protection Zone of runways with length of 9,000 feet or more, as long as the taxiing operations remain outside the 1,000-feet x 500-feet Runway Safety Area. EAT operations should conform to this standard and should be limited to departures only.

4.2. AIR TRAFFIC PROCEDURE CONSIDERATIONS

Radio Phraseology: Standard radio phraseology should be developed for EAT operations and incorporated into the Aeronautical Information manual (AIM) and Aeronautical Information Publication (AIP).

Radio Frequency to be used: Policy needs to be established on the standard radio frequency to be used in EAT operations (ground or tower).

Use of surveillance aids during low visibility EAT operations: Policy should be developed on the use of Airport Surveillance Detection Equipment (ASDE), multi-lateration, remote cameras and other technologies to support safe control of traffic on EATs during low visibility operations.

Automatic Terminal Information Service (ATIS): Policy and standardized phraseology should be developed on the use of ATIS to indicate EAT operations in effect. This information should be published in the AIM and AIP.

Airport/Facility Directory (A/FD): Policy and standardized terminology should be developed for the A/FD to indicate that EAT operations may be in effect at specific airports.

Mixing of aircraft on the EAT: A policy should be developed as to mixing EAT and other runway crossing taxiway usage, including policies on the use of EATs by uni- or bi-directional traffic flows.

4.3. OPERATIONAL PROCEDURE CONSIDERATIONS

Operators intending to use EATs should ensure that flight crews are familiar with EAT operations, procedures, lighting/marking/signage, phraseology, and the affect of EAT operations on aircraft systems (brake usage, including heat monitoring and control; power required for uphill operations; speed control in downhill operations; limitations on thrust reverser usage).

Specifically, operators should ensure that flight crews are aware of the need to scan the EAT (as much as possible, given visibility and geometry limitations) to avoid nose-to-nose encounters on the EAT, and to scan the departure path to avoid unnecessary taxi directly beneath over-flying aircraft, if possible. Operators of smaller aircraft need to consider EAT operations from the standpoint of jet blast issues.

Standard policy should be developed on the use of aircraft and vehicle lights using EATs and conventional taxiways to ensure easy determination of route and intent of operation by other aircraft, vehicles and Air Traffic Control (ATC).

Standard policy should be developed on the use of EATs during Surface Movement and Guidance Control System (SMGCS) operations, especially any metering requirements for larger group aircraft.

Obviously, these considerations have great inter-operability between airfield procedures and equipment, ATC procedures and operational procedures. Solutions for each issue must be integrated between the airfield, air traffic, and operational community to ensure successful resolution.

4.4. TAKEOFF PERFORMANCE CONSIDERATIONS

An additional issue remains concerning the affect of aircraft taxiing on EATs to the allowable takeoff weight for departing aircraft. At issue is the affect of a taxiing aircraft on the EAT against regulatory requirements, specifically, the aircraft certification requirements of 14 CFR 25.111, .121 and 121.189. These regulations are attached in Appendix B.

FAR 25 generally requires that turbojet transport airplanes achieve a height of 35 feet at the end of the runway, followed by a climb of at least 2.4% net climb gradient to at least 400 feet, followed by a reduced climb gradient of 1.2% to 1,500 feet above the departure end of runway (DER). The 2.4% requirement applies to two engine airplanes, while higher gradients are required for three and four engine airplanes. These climb requirements are based on an engine failure at V_1, a speed that is achieved while the aircraft is still on the runway, just prior to or coincident with rotation. FAR 25 subpart B contains these standards.

The pertinent operational performance requirements for this discussion are specified in 14 CFR 121 Subpart I. This subpart requires that an operator meet any airplane flight manual (AFM) limitations, as well as specific performance requirements based on phase of flight. In addition to meeting the AFM takeoff weight requirements (which are limited by the performance required by 14 CFR 25), 121.189 generally requires a 35-foot clearance of obstacles after takeoff, using the net climb gradient as described in FAR 25. Of interest is that for nearly all transport category turbojets (SR 422A and subsequent), no additive factor is required (no additional buffer provided based on distance traveled from the DER). Hence, with no obstacles present, such a departure from a theoretical airport in the Bonneville Salt Flats, once the aircraft has reached 35 feet at the end of the runway, 121.189 would require no net climb gradient other than the AFM requirement, which is tied to FAR 25.121 (yielding 2.4% for two engine airplanes). Essentially, to determine the required climb gradient, one would evaluate the FAR 25.111 and .121 second segment climb, and the 121.189 35 foot obstacle clearance requirement and select the most restrictive.

For an obstruction 45 feet above the DER elevation, the “break point” is 1,875 feet from the DER. For distances below 1,875 feet, the 121.189 (d)(2) requirement is more restrictive. For distances of 1,875 feet or greater, the FAR 25.111 and .121 requirements control.

The slides provided in Appendix C describe this interrelationship.

Note also that under wet runway circumstances, 14 CFR 25.113 allows performance planners may use a 15 foot screen height in lieu of the 35 foot DER height described to permit a wider range of options to continue the takeoff in the event of an engine failure rather than conduct an abort on a wet runway.

The effect of this reduction in screen height is to anchor the climb path at the DER at 15 rather than 35 feet. Such a reduction will impact the required climb gradient to meet the 121.189 (d) (2) 35 feet clearance by moving the “break point” to 2,708 feet from the DER.

From an operational point of view, the current declared distance standard marking, and particularly the distance remaining markers, does not indicate to the pilot their position along the takeoff run available (TORA) or the takeoff distance available (TODA). It just indicates the end of useable pavement, which may include the safety area. This may be acceptable when an operator with established airport-specific performance data regularly uses a particular runway, but there may be a negative impact on critical decision making by crews of supplemental or non-scheduled operators who rarely use the airport in question. Crews determining performance based on using the observed distance-to-go markings on a declared distance runway will not come up with an accurate assessment.

5.0. TERMINAL INSTRUMENT PROCEDURES (TERPS) ANALYSIS

This analysis was from a Flight Standards perspective with particular attention given to the provisions of FAA Order 8260.3B (TERPS).

A TERPS departure evaluation was performed for aircraft with tail heights of 45 feet and 55 feet for the following runways: Runway 36 Left/Right, 18 Left/Right, 35 Center/Left, and 17 Center/Right. It was determined that for all departures, given either tail height, no penetration of the 40:1 departure surface takes place.

6.0. CONCLUSIONS

6.1. HUMAN FACTORS

The DFW proposal for an EAT system would certainly reduce the frequency of runway crossings when EATs, rather than crossing taxiways are used. It may also significantly reduce the amount of communications between ATC and aircraft on the ground. Furthermore, 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.

There are, however, indications in both the objective and subjective data collected that it is not easy 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 point to the need for specific visual and operational mitigators as well as pilot training that addresses EAT operations.

This was a limited HF evaluation of a proof of concept. Due to the limited resources available (simulation time and qualified pilots), a baseline incursion detection scenario was not conducted. Performing a more in-depth study is not warranted at this time and would not be expected to yield significantly different results. Conclusions drawn from this data, analysis, and demonstration cannot be broadly generalized to other runways or other locations.

6.2. CRM

All eight runways at DFW presented acceptable levels of risk for EAT operations as proposed during ILS CAT I or CAT II operations. The results in every scenario indicated that aircraft with tail heights of 55 feet or below presented acceptable levels of risk for unabated taxiing on the EAT, and aircraft with taller tail heights should be controlled so that no over-flights occur.

6.3. OPERATIONS

The implementation of EAT requires the development of airfield and flight operational procedures to ensure that the appropriate level of safety is maintained while promoting capacity goals. All operational issues have been identified, and feasible recommendations and mitigations have been suggested.

6.4. TERPS

A TERPS departure evaluation was performed for aircraft with tail heights of 45 feet and 55 feet for the following runways: Runway 36 Left/Right, 18 Left/Right, 35 Center/Left, and 17 Center/Right. It was determined that for all departures, given either tail height, no penetration of the 40:1 departure surface takes place.

6.5. SUMMARY

EAT operations may very well increase safety levels for the reasons that have been mentioned. Pilot crews felt that this operation might increase safety through the reduction of runway crossings and reduced aircraft/ATC communications. Further, there do not appear to be any HF, CRM, Operational, or TERPS-specific issues that cannot be overcome through mitigation strategies.

However, the proposal for an EAT system to be put in place at DFW should not be approved to move forward in its current form. The data from this demonstration confirms that, as suspected, there is an increased risk of an incident because of the potential lag in acquiring and confirming that an incursion is present. Not only did several participating crews fail to identify an incursion, more than half indicated that a potential problem existed with operations conducted in the current proposal.

Further investigation may be needed to: 1) identify crew training requirements; 2) develop mitigation strategies that may increase the conspicuity of aircraft on the EAT or crossing the centerline, thereby preventing pilots from mistaking an incursion aircraft for an EAT aircraft; and 3) identify and establish EAT-specific operational procedures.

APPENDIX A. DFW END AROUND TAXIWAY COLLISION RISK MODEL ANALYSES

Runway 17 C

Obstacle Data Base

OBS No.	x dist	y dist	z dist
01	0	-600	47, 56, 66
02	300	-600	47, 56, 66
03	600	-600	47, 56, 66
04	900	-600	47, 56, 66
05	1200	-600	47, 56, 66
06	1500	-600	47, 56, 66
07	1800	-600	47, 56, 66
08	2100	-600	47, 56, 66
09	2400	-600	47, 56, 66
10	2650	-600	47, 56, 66
11	2650	-300	47, 56, 66
12	2650	0	47, 56, 66
13	2650	116	47, 56, 66
14	2422	383	47, 56, 66
15	2195	650	47, 56, 66
16	1800	650	47, 56, 66
17	1500	650	47, 56, 66
18	1200	650	47, 56, 66
19	900	650	47, 56, 66
20	600	650	47, 56, 66
21	300	650	47, 56, 66
22	0	650	47, 56, 66

CAT I, 46 ft tail heights

```
  SPEED  TYPE OF REPORT   OCA/H    TOTAL     HIGHEST RISK
OBSTACLE
  CAT.                    FEET     RISK      IDENT
DESCRIPTION    RISK
    A   SPECIFIED   OCH     200   3.7E-12  12        12
1.6E-12
    B   SPECIFIED   OCH     200   1.9E-11  12        12
7.9E-12
    C   SPECIFIED   OCH     200   8.9E-11  12        12
3.8E-11
    D   SPECIFIED   OCH     200   4.2E-10  12        12
1.9E-10
```

CAT II, 46 ft tail heights

```
  SPEED  TYPE OF REPORT   OCA/H    TOTAL     HIGHEST RISK
OBSTACLE
  CAT.                    FEET     RISK      IDENT
DESCRIPTION    RISK
    A   SPECIFIED   OCH     100   3.7E-12             GROUND
PLANE    3.7E-12
    B   SPECIFIED   OCH     100   5.2E-11             GROUND
PLANE    5.2E-11
    C   SPECIFIED   OCH     100   7.1E-10             GROUND
PLANE    7.0E-10
    D   SPECIFIED   OCH     100   9.4E-09             GROUND
PLANE    9.3E-09
```

CAT I, 55 ft tail heights

```
  SPEED  TYPE OF REPORT   OCA/H    TOTAL     HIGHEST RISK
OBSTACLE
  CAT.                    FEET     RISK      IDENT
DESCRIPTION    RISK
    A   SPECIFIED   OCH     200   3.2E-11  12         12
2.6E-11
    B   SPECIFIED   OCH     200   1.7E-10  12         12
1.4E-10
    C   SPECIFIED   OCH     200   9.4E-10  12         12
7.6E-10
    D   SPECIFIED   OCH     200   5.0E-09  12         12
4.1E-09
```

CAT II, 55 ft tail heights

```
  SPEED  TYPE OF REPORT   OCA/H    TOTAL     HIGHEST RISK
OBSTACLE
  CAT.                    FEET     RISK      IDENT
DESCRIPTION    RISK
    A   SPECIFIED   OCH     100   5.2E-12             GROUND
PLANE    3.7E-12
    B   SPECIFIED   OCH     100   7.5E-11             GROUND
PLANE    5.2E-11
    C   SPECIFIED   OCH     100   1.1E-09             GROUND
PLANE    7.0E-10
    D   SPECIFIED   OCH     100   1.4E-08             GROUND
PLANE    9.3E-09
```

CAT I, 65 ft tail heights

```
  SPEED  TYPE OF REPORT   OCA/H    TOTAL     HIGHEST RISK
OBSTACLE
  CAT.                    FEET     RISK      IDENT
DESCRIPTION    RISK
    A   SPECIFIED   OCH     200   9.7E-10  12         12
9.3E-10
    B   SPECIFIED   OCH     200   4.5E-09  12         12
4.3E-09
    C   SPECIFIED   OCH     200   2.1E-08  12         12
1.9E-08
    D   SPECIFIED   OCH     200   9.3E-08  12         12
8.8E-08
```

CAT II, 65 ft tail heights

```
  SPEED  TYPE OF REPORT   OCA/H    TOTAL     HIGHEST RISK
OBSTACLE
  CAT.                    FEET     RISK      IDENT
DESCRIPTION    RISK
    A   SPECIFIED   OCH     100   3.0E-10  12         12
2.9E-10
    B   SPECIFIED   OCH     100   3.2E-09  12         12
3.2E-09
    C   SPECIFIED   OCH     100   3.3E-08  12         12
3.3E-08
    D   SPECIFIED   OCH     100   3.4E-07  12         12
3.3E-07
    D   MINIMUM     OCH     109   8.2E-08  12         12
7.9E-08
```

APPENDIX A. DFW END AROUND TAXIWAY COLLISION RISK MODEL ANALYSES

Runway 17 R

Obstacle Data Base

OBS No.	x dist	y dist	z dist
01	0	-1130	46, 55, 65
02	300	-1130	46, 55, 65
03	600	-1130	46, 55, 65
04	900	-1130	46, 55, 65
05	1200	-1130	46, 55, 65
06	1500	-1130	46, 55, 65
07	1800	-1130	46, 55, 65
08	2100	-1130	46, 55, 65
09	2400	-1130	46, 55, 65
10	2643	-1130	46, 55, 65
11	2650	-850	46, 55, 65
12	2650	-520	46, 55, 65
13	2650	-260	46, 55, 65
14	2650	0	46, 55, 65
15	2650	300	46, 55, 65
16	2650	600	46, 55, 65
17	2400	600	46, 55, 65
18	2100	600	46, 55, 65
19	1800	600	46, 55, 65
20	1500	600	46, 55, 65
21	1200	600	46, 55, 65
22	900	600	46, 55, 65
23	600	600	46, 55, 65
24	300	600	46, 55, 65
25	0	600	46, 55, 65

CAT I, 46 ft tail heights

```
  SPEED  TYPE OF REPORT   OCA/H    TOTAL     HIGHEST RISK
OBSTACLE
  CAT.                    FEET     RISK      IDENT
DESCRIPTION    RISK
    A   SPECIFIED   OCH     200   2.7E-12  14         14
1.1E-12
    B   SPECIFIED   OCH     200   1.3E-11  14         14
5.3E-12
    C   SPECIFIED   OCH     200   6.3E-11  14         14
2.6E-11
```

```
    D   SPECIFIED   OCH     200   3.0E-10  14         14
1.3E-10
```

CAT II, 46 ft tail heights

```
  SPEED  TYPE OF REPORT   OCA/H    TOTAL     HIGHEST RISK
OBSTACLE
  CAT.                    FEET     RISK      IDENT
DESCRIPTION    RISK
    A   SPECIFIED   OCH     100   3.7E-12            GROUND
PLANE    3.7E-12
    B   SPECIFIED   OCH     100   5.2E-11            GROUND
PLANE    5.2E-11
    C   SPECIFIED   OCH     100   7.1E-10            GROUND
PLANE    7.0E-10
    D   SPECIFIED   OCH     100   9.4E-09            GROUND
PLANE    9.4E-09
```

CAT I, 55 ft tail heights

```
  SPEED  TYPE OF REPORT   OCA/H    TOTAL     HIGHEST RISK
OBSTACLE
  CAT.                    FEET     RISK      IDENT
DESCRIPTION    RISK
    A   SPECIFIED   OCH     200   2.1E-11  14         14
1.7E-11
    B   SPECIFIED   OCH     200   1.2E-10  14         14
9.7E-11
    C   SPECIFIED   OCH     200   6.5E-10  14         14
5.4E-10
    D   SPECIFIED   OCH     200   3.6E-09  14         14
3.0E-09
```

CAT II, 55 ft tail heights

```
  SPEED  TYPE OF REPORT   OCA/H    TOTAL     HIGHEST RISK
OBSTACLE
  CAT.                    FEET     RISK      IDENT
DESCRIPTION    RISK
    A   SPECIFIED   OCH     100   4.6E-12            GROUND
PLANE    3.7E-12
    B   SPECIFIED   OCH     100   6.6E-11            GROUND
PLANE    5.2E-11
    C   SPECIFIED   OCH     100   9.2E-10            GROUND
PLANE    7.0E-10
    D   SPECIFIED   OCH     100   1.3E-08            GROUND
PLANE    9.4E-09
```

CAT I, 65 ft tail heights

```
  SPEED  TYPE OF REPORT   OCA/H    TOTAL     HIGHEST RISK
OBSTACLE
  CAT.                    FEET     RISK      IDENT
DESCRIPTION    RISK
    A   SPECIFIED   OCH     200   7.0E-10  14         14
6.8E-10
    B   SPECIFIED   OCH     200   3.3E-09  14         14
3.1E-09
    C   SPECIFIED   OCH     200   1.5E-08  14         14
1.4E-08
    D   SPECIFIED   OCH     200   6.9E-08  14         14
6.5E-08
```

CAT II, 65 ft tail heights

```
  SPEED  TYPE OF REPORT   OCA/H    TOTAL     HIGHEST RISK
OBSTACLE
  CAT.                    FEET     RISK      IDENT
DESCRIPTION    RISK
    A   SPECIFIED   OCH     100   1.8E-10  14         14
1.7E-10
    B   SPECIFIED   OCH     100   2.0E-09  14         14
2.0E-09
    C   SPECIFIED   OCH     100   2.2E-08  14         14
2.1E-08
    D   SPECIFIED   OCH     100   2.3E-07  14         14
2.2E-07
    D   MINIMUM     OCH     106   9.6E-08  14         14
9.1E-08
```

APPENDIX A. DFW END AROUND TAXIWAY COLLISION RISK MODEL ANALYSES

Runway 18 L

Obstacle Data Base

OBS No.	x dist	y dist	z dist
01	0	-600	48, 57, 67
01	0	-600	48, 57, 67
02	300	-600	48, 57, 67
03	600	-600	48, 57, 67
04	900	-600	48, 57, 67
05	1200	-600	48, 57, 67
06	1500	-600	48, 57, 67
07	1800	-600	48, 57, 67
08	2100	-600	48, 57, 67
09	2400	-600	48, 57, 67
10	2650	-600	48, 57, 67
11	2650	-300	48, 57, 67
12	2650	0	48, 57, 67
13	2650	300	48, 57, 67
14	2650	600	48, 57, 67
15	2650	900	48, 57, 67
16	2650	1120	48, 57, 67
17	2400	1120	48, 57, 67
18	2100	1120	48, 57, 67
19	1800	1120	48, 57, 67
20	1500	1120	48, 57, 67
21	1200	1120	48, 57, 67
22	900	1120	48, 57, 67
23	600	1120	48, 57, 67
24	300	1120	48, 57, 67
25	0	1120	48, 57, 67

CAT I, 46 ft tail heights

```
  SPEED  TYPE OF REPORT   OCA/H    TOTAL     HIGHEST RISK
OBSTACLE
  CAT.                    FEET     RISK      IDENT
DESCRIPTION    RISK
    A   SPECIFIED   OCH     200   4.3E-12  12         12
2.4E-12
    B   SPECIFIED   OCH     200   2.2E-11  12         12
1.2E-11
```

```
    C   SPECIFIED   OCH     200   1.0E-10  12         12
5.7E-11
    D   SPECIFIED   OCH     200   5.0E-10  12         12
2.8E-10
```

CAT II, 46 ft tail heights

```
  SPEED  TYPE OF REPORT   OCA/H    TOTAL     HIGHEST RISK
OBSTACLE
  CAT.                    FEET     RISK      IDENT
DESCRIPTION    RISK
    A   SPECIFIED   OCH     100   3.7E-12             GROUND
PLANE    3.7E-12
    B   SPECIFIED   OCH     100   5.3E-11             GROUND
PLANE    5.2E-11
    C   SPECIFIED   OCH     100   7.2E-10             GROUND
PLANE    7.1E-10
    D   SPECIFIED   OCH     100   9.5E-09             GROUND
PLANE    9.4E-09
```

CAT I, 55 ft tail heights

```
  SPEED  TYPE OF REPORT   OCA/H    TOTAL     HIGHEST RISK
OBSTACLE
  CAT.                    FEET     RISK      IDENT
DESCRIPTION    RISK
    A   SPECIFIED   OCH     200   4.5E-11  12         12
4.0E-11
    B   SPECIFIED   OCH     200   2.4E-10  12         12
2.1E-10
    C   SPECIFIED   OCH     200   1.3E-09  12         12
1.1E-09
    D   SPECIFIED   OCH     200   6.6E-09  12         12
5.8E-09
```

CAT II, 55 ft tail heights

```
  SPEED  TYPE OF REPORT   OCA/H    TOTAL     HIGHEST RISK
OBSTACLE
  CAT.                    FEET     RISK      IDENT
DESCRIPTION    RISK
    A   SPECIFIED   OCH     100   6.3E-12             GROUND
PLANE    3.7E-12
    B   SPECIFIED   OCH     100   9.2E-11             GROUND
PLANE    5.2E-11
    C   SPECIFIED   OCH     100   1.3E-09             GROUND
PLANE    7.1E-10
```

```
    D   SPECIFIED   OCH     100   1.8E-08            GROUND
PLANE    9.4E-09
```

CAT I, 65 ft tail heights

```
  SPEED  TYPE OF REPORT   OCA/H    TOTAL     HIGHEST RISK
OBSTACLE
  CAT.                    FEET     RISK      IDENT
DESCRIPTION    RISK
    A   SPECIFIED   OCH     200   1.4E-09  12         12
1.3E-09
    B   SPECIFIED   OCH     200   6.2E-09  12         12
6.0E-09
    C   SPECIFIED   OCH     200   2.8E-08  12         12
2.7E-08
    D   SPECIFIED   OCH     200   1.3E-07  12         12
1.2E-07
    D   MINIMUM     OCH     202   9.3E-08  12         12
9.0E-08
```

CAT II 65 ft tail heights

```
  SPEED  TYPE OF REPORT   OCA/H    TOTAL     HIGHEST RISK
OBSTACLE
  CAT.                    FEET     RISK      IDENT
DESCRIPTION    RISK
    A   SPECIFIED   OCH     100   5.1E-10  12         12
5.0E-10
    B   SPECIFIED   OCH     100   5.3E-09  12         12
5.2E-09
    C   SPECIFIED   OCH     100   5.2E-08  12         12
5.1E-08
    D   SPECIFIED   OCH     100   4.8E-07  12         12
4.7E-07
    D   MINIMUM     OCH     111   8.9E-08  12         12
8.7E-08
```

APPENDIX A. DFW END AROUND TAXIWAY COLLISION RISK MODEL ANALYSES

Runway 18 R

Obstacle Data Base

OBS No.	x dist	y dist	z dist
01	0	-975	46, 55, 65
02	300	-975	46, 55, 65
03	600	-975	46, 55, 65
04	900	-975	46, 55, 65
05	1200	-975	46, 55, 65
06	1500	-975	46, 55, 65
07	1800	-975	46, 55, 65
08	2100	-975	46, 55, 65
09	2400	-975	46, 55, 65
10	2650	-975	46, 55, 65
11	2650	-600	46, 55, 65
12	2650	-300	46, 55, 65
13	2650	0	46, 55, 65
14	2650	300	46, 55, 65
15	2650	600	46, 55, 65
16	2400	600	46, 55, 65
17	2100	600	46, 55, 65
18	1800	600	46, 55, 65
10	1500	600	46, 55, 65
20	1200	600	46, 55, 65
21	900	600	46, 55, 65
22	600	600	46, 55, 65
23	300	600	46, 55, 65
24	0	600	46, 55, 65

CAT I, 46 ft tail heights

```
  SPEED  TYPE OF REPORT   OCA/H    TOTAL     HIGHEST RISK
OBSTACLE
  CAT.                    FEET     RISK      IDENT
DESCRIPTION    RISK
    A   SPECIFIED   OCH     200   2.7E-12  13         13
1.1E-12
    B   SPECIFIED   OCH     200   1.3E-11  13         13
5.6E-12
    C   SPECIFIED   OCH     200   6.5E-11  13         13
2.7E-11
```

```
    D   SPECIFIED   OCH     200   3.1E-10  13         13
1.3E-10
```

CAT II, 46 ft tail heights

```
  SPEED  TYPE OF REPORT   OCA/H    TOTAL     HIGHEST RISK
OBSTACLE
  CAT.                    FEET     RISK      IDENT
DESCRIPTION    RISK
    A   SPECIFIED   OCH     100   3.7E-12            GROUND
PLANE    3.7E-12
    B   SPECIFIED   OCH     100   5.2E-11            GROUND
PLANE    5.2E-11
    C   SPECIFIED   OCH     100   7.1E-10            GROUND
PLANE    7.1E-10
    D   SPECIFIED   OCH     100   9.5E-09            GROUND
PLANE    9.4E-09
```

CAT I, 55 ft tail heights

```
  SPEED  TYPE OF REPORT   OCA/H    TOTAL     HIGHEST RISK
OBSTACLE
  CAT.                    FEET     RISK      IDENT
DESCRIPTION    RISK
    A   SPECIFIED   OCH     200   2.2E-11  13         13
1.8E-11
    B   SPECIFIED   OCH     200   1.2E-10  13         13
1.0E-10
    C   SPECIFIED   OCH     200   6.7E-10  13         13
5.6E-10
    D   SPECIFIED   OCH     200   3.7E-09  13         13
3.1E-09
```

CAT II, 55 ft tail heights

```
  SPEED  TYPE OF REPORT   OCA/H    TOTAL     HIGHEST RISK
OBSTACLE
  CAT.                    FEET     RISK      IDENT
DESCRIPTION    RISK
    A   SPECIFIED   OCH     100   4.6E-12            GROUND
PLANE    3.7E-12
    B   SPECIFIED   OCH     100   6.7E-11            GROUND
PLANE    5.2E-11
    C   SPECIFIED   OCH     100   9.3E-10            GROUND
PLANE    7.1E-10
    D   SPECIFIED   OCH     100   1.3E-08            GROUND
PLANE    9.4E-09
```

CAT I, 65 ft tail heights

```
  SPEED  TYPE OF REPORT   OCA/H    TOTAL     HIGHEST RISK
OBSTACLE
  CAT.                    FEET     RISK      IDENT
DESCRIPTION    RISK
    A   SPECIFIED   OCH     200   7.2E-10  13         13
7.0E-10
    B   SPECIFIED   OCH     200   3.4E-09  13         13
3.2E-09
    C   SPECIFIED   OCH     200   1.5E-08  13         13
1.5E-08
    D   SPECIFIED   OCH     200   7.1E-08  13         13
6.8E-08
```

CAT II, 65 ft tail heights

```
  SPEED  TYPE OF REPORT   OCA/H    TOTAL     HIGHEST RISK
OBSTACLE
  CAT.                    FEET     RISK      IDENT
DESCRIPTION    RISK
    A   SPECIFIED   OCH     100   1.8E-10  13         13
1.8E-10
    B   SPECIFIED   OCH     100   2.1E-09  13         13
2.0E-09
    C   SPECIFIED   OCH     100   2.2E-08  13         13
2.2E-08
    D   SPECIFIED   OCH     100   2.4E-07  13         13
2.3E-07
    D   MINIMUM     OCH     106   9.9E-08  13         13
9.4E-08
```

APPENDIX A. DFW END AROUND TAXIWAY COLLISION RISK MODEL ANALYSES

Runway 35 C

Obstacle Data Base

OBS No.	x dist	y dist	z dist
01	0	-975	47, 56, 66
02	300	-975	47, 56, 66
03	600	-975	47, 56, 66
04	900	-975	47, 56, 66
05	1200	-975	47, 56, 66
06	1500	-975	47, 56, 66
07	1800	-975	47, 56, 66
08	2100	-975	47, 56, 66
09	2400	-975	47, 56, 66
10	2650	-975	47, 56, 66
11	2650	-600	47, 56, 66
12	2650	-300	47, 56, 66
13	2650	0	47, 56, 66
14	2650	300	47, 56, 66
15	2650	600	47, 56, 66
16	2400	600	47, 56, 66
17	2100	600	47, 56, 66
18	1800	600	47, 56, 66
10	1500	600	47, 56, 66
20	1200	600	47, 56, 66
21	900	600	47, 56, 66
22	600	600	47, 56, 66
23	300	600	47, 56, 66
24	0	600	47, 56, 66

CAT I, 46 ft tail heights

```
  SPEED  TYPE OF REPORT   OCA/H    TOTAL     HIGHEST RISK
OBSTACLE
  CAT.                    FEET     RISK      IDENT
DESCRIPTION    RISK
    A   SPECIFIED   OCH     200   3.4E-12  13         13
1.6E-12
    B   SPECIFIED   OCH     200   1.7E-11  13         13
7.9E-12
    C   SPECIFIED   OCH     200   8.0E-11  13         13
3.8E-11
```

```
    D   SPECIFIED   OCH     200   3.8E-10  13         13
1.9E-10
```

CAT II, 46 ft tail heights

```
  SPEED  TYPE OF REPORT   OCA/H    TOTAL     HIGHEST RISK
OBSTACLE
  CAT.                    FEET     RISK      IDENT
DESCRIPTION    RISK
    A   SPECIFIED   OCH     100   3.7E-12             GROUND
PLANE    3.7E-12
    B   SPECIFIED   OCH     100   5.2E-11             GROUND
PLANE    5.2E-11
    C   SPECIFIED   OCH     100   7.1E-10             GROUND
PLANE    7.1E-10
    D   SPECIFIED   OCH     100   9.5E-09             GROUND
PLANE    9.4E-09
```

CAT I, 55 ft tail heights

```
  SPEED  TYPE OF REPORT   OCA/H    TOTAL     HIGHEST RISK
OBSTACLE
  CAT.                    FEET     RISK      IDENT
DESCRIPTION    RISK
    A   SPECIFIED   OCH     200   3.1E-11  13         13
2.7E-11
    B   SPECIFIED   OCH     200   1.7E-10  13         13
1.5E-10
    C   SPECIFIED   OCH     200   9.3E-10  13         13
8.0E-10
    D   SPECIFIED   OCH     200   5.0E-09  13         13
4.3E-09
```

CAT II, 55 ft tail heights

```
  SPEED  TYPE OF REPORT   OCA/H    TOTAL     HIGHEST RISK
OBSTACLE
  CAT.                    FEET     RISK      IDENT
DESCRIPTION    RISK
    A   SPECIFIED   OCH     100   5.2E-12             GROUND
PLANE    3.7E-12
    B   SPECIFIED   OCH     100   7.6E-11             GROUND
PLANE    5.2E-11
    C   SPECIFIED   OCH     100   1.1E-09             GROUND
PLANE    7.1E-10
    D   SPECIFIED   OCH     100   1.5E-08             GROUND
PLANE    9.4E-09
```

CAT I, 65 ft tail heights

```
  SPEED  TYPE OF REPORT   OCA/H    TOTAL     HIGHEST RISK
OBSTACLE
  CAT.                    FEET     RISK      IDENT
DESCRIPTION    RISK
    A   SPECIFIED   OCH     200   9.9E-10  13         13
9.6E-10
    B   SPECIFIED   OCH     200   4.6E-09  13         13
4.4E-09
    C   SPECIFIED   OCH     200   2.1E-08  13         13
2.0E-08
    D   SPECIFIED   OCH     200   9.5E-08  13         13
9.2E-08
```

CAT II, 65 ft tail heights

```
  SPEED  TYPE OF REPORT   OCA/H    TOTAL     HIGHEST RISK
OBSTACLE
  CAT.                    FEET     RISK      IDENT
DESCRIPTION    RISK
    A   SPECIFIED   OCH     100   3.0E-10  13         13
3.0E-10
    B   SPECIFIED   OCH     100   3.3E-09  13         13
3.2E-09
    C   SPECIFIED   OCH     100   3.4E-08  13         13
3.4E-08
    D   SPECIFIED   OCH     100   3.5E-07  13         13
3.4E-07
    D   MINIMUM     OCH     109   8.5E-08  13         13
8.2E-08
```

APPENDIX A. DFW END AROUND TAXIWAY COLLISION RISK MODEL ANALYSES

Runway 35 L

Obstacle Data Base

OBS No.	x dist	y dist	z dist
01	0	-600	47, 56, 66
02	300	-600	47, 56, 66
03	600	-600	47, 56, 66
04	900	-600	47, 56, 66
05	1200	-600	47, 56, 66
06	1500	-600	47, 56, 66
07	1800	-600	47, 56, 66
08	2100	-600	47, 56, 66
09	2400	-600	47, 56, 66
10	2650	-600	47, 56, 66
11	2650	-300	47, 56, 66
12	2650	0	47, 56, 66
13	2650	300	47, 56, 66
14	2650	600	47, 56, 66
15	2650	900	47, 56, 66
16	2650	1130	47, 56, 66
17	2400	1130	47, 56, 66
18	2100	1130	47, 56, 66
19	1800	1130	47, 56, 66
20	1500	1130	47, 56, 66
21	1200	1130	47, 56, 66
22	900	1130	47, 56, 66
23	600	1130	47, 56, 66
24	300	1130	47, 56, 66
25	0	1130	47, 56, 66

CAT I, 46 ft tail heights

```
  SPEED  TYPE OF REPORT   OCA/H    TOTAL     HIGHEST RISK
OBSTACLE
  CAT.                    FEET     RISK      IDENT
DESCRIPTION    RISK
    A   SPECIFIED   OCH     200   2.7E-12  12         12
1.1E-12
    B   SPECIFIED   OCH     200   1.3E-11  12         12
5.3E-12
    C   SPECIFIED   OCH     200   6.3E-11  12         12
2.6E-11
```

```
    D   SPECIFIED   OCH     200   3.0E-10  12        12
1.3E-10
```

CAT II, 46 ft tail heights

```
  SPEED  TYPE OF REPORT   OCA/H    TOTAL     HIGHEST RISK
OBSTACLE
  CAT.                    FEET     RISK      IDENT
DESCRIPTION    RISK
    A   SPECIFIED   OCH     100   3.7E-12            GROUND
PLANE    3.7E-12
    B   SPECIFIED   OCH     100   5.2E-11            GROUND
PLANE    5.2E-11
    C   SPECIFIED   OCH     100   7.1E-10            GROUND
PLANE    7.0E-10
    D   SPECIFIED   OCH     100   9.4E-09            GROUND
PLANE    9.3E-09
```

CAT I, 55 ft tail heights

```
  SPEED  TYPE OF REPORT   OCA/H    TOTAL     HIGHEST RISK
OBSTACLE
  CAT.                    FEET     RISK      IDENT
DESCRIPTION    RISK
    A   SPECIFIED   OCH     200   2.1E-11  12        12
1.7E-11
    B   SPECIFIED   OCH     200   1.2E-10  12        12
9.7E-11
    C   SPECIFIED   OCH     200   6.5E-10  12        12
5.4E-10
    D   SPECIFIED   OCH     200   3.6E-09  12        12
3.0E-09
```

CAT II, 55 ft tail heights

```
  SPEED  TYPE OF REPORT   OCA/H    TOTAL     HIGHEST RISK
OBSTACLE
  CAT.                    FEET     RISK      IDENT
DESCRIPTION    RISK
    A   SPECIFIED   OCH     100   4.6E-12            GROUND
PLANE    3.7E-12
    B   SPECIFIED   OCH     100   6.6E-11            GROUND
PLANE    5.2E-11
    C   SPECIFIED   OCH     100   9.2E-10            GROUND
PLANE    7.0E-10
    D   SPECIFIED   OCH     100   1.3E-08            GROUND
PLANE    9.3E-09
```

CAT I, 65 ft tail heights

```
  SPEED  TYPE OF REPORT   OCA/H    TOTAL     HIGHEST RISK
OBSTACLE
  CAT.                    FEET     RISK      IDENT
DESCRIPTION    RISK
    A   SPECIFIED   OCH     200   7.0E-10  12         12
6.7E-10
    B   SPECIFIED   OCH     200   3.2E-09  12         12
3.1E-09
    C   SPECIFIED   OCH     200   1.5E-08  12         12
1.4E-08
    D   SPECIFIED   OCH     200   6.8E-08  12         12
6.5E-08
```

CAT II, 65 ft tail heights

```
  SPEED  TYPE OF REPORT   OCA/H    TOTAL     HIGHEST RISK
OBSTACLE
  CAT.                    FEET     RISK      IDENT
DESCRIPTION    RISK
    A   SPECIFIED   OCH     100   1.8E-10  12         12
1.7E-10
    B   SPECIFIED   OCH     100   2.0E-09  12         12
2.0E-09
    C   SPECIFIED   OCH     100   2.2E-08  12         12
2.1E-08
    D   SPECIFIED   OCH     100   2.3E-07  12         12
2.2E-07
    D   MINIMUM     OCH     106   9.6E-08  12         12
9.1E-08
```

APPENDIX A. DFW END AROUND TAXIWAY COLLISION RISK MODEL ANALYSES

Runway 36 L

Obstacle Data Base

OBS No.	x dist	y dist	z dist
01	0	-600	47, 56, 66
01	0	-600	46, 55, 65
02	300	-600	46, 55, 65
03	600	-600	46, 55, 65
04	900	-600	46, 55, 65
05	1200	-600	46, 55, 65
06	1500	-600	46, 55, 65
07	1800	-600	46, 55, 65
08	2100	-600	46, 55, 65
09	2400	-600	46, 55, 65
10	2650	-600	46, 55, 65
11	2650	-300	46, 55, 65
12	2650	0	46, 55, 65
14	2650	300	46, 55, 65
15	2650	600	46, 55, 65
16	2650	850	46, 55, 65
17	2300	890	46, 55, 65
18	1950	930	46, 55, 65
19	1800	970	46, 55, 65
20	1600	970	46, 55, 65
21	1200	970	46, 55, 65
22	900	970	46, 55, 65
23	600	970	46, 55, 65
24	300	970	46, 55, 65
25	0	970	46, 55, 65

CAT I, 46 ft tail heights

```
  SPEED  TYPE OF REPORT   OCA/H    TOTAL     HIGHEST RISK
OBSTACLE
  CAT.                    FEET     RISK      IDENT
DESCRIPTION    RISK
    A   SPECIFIED   OCH     200   2.7E-12  12         12
1.1E-12
    B   SPECIFIED   OCH     200   1.3E-11  12         12
5.4E-12
    C   SPECIFIED   OCH     200   6.4E-11  12         12
2.7E-11
```

```
    D   SPECIFIED   OCH     200   3.1E-10  12         12
1.3E-10
```

CAT II, 46 ft tail heights

```
  SPEED  TYPE OF REPORT   OCA/H    TOTAL     HIGHEST RISK
OBSTACLE
  CAT.                    FEET     RISK      IDENT
DESCRIPTION    RISK
    A   SPECIFIED   OCH     100   3.7E-12            GROUND
PLANE    3.7E-12
    B   SPECIFIED   OCH     100   5.2E-11            GROUND
PLANE    5.2E-11
    C   SPECIFIED   OCH     100   7.1E-10            GROUND
PLANE    7.1E-10
    D   SPECIFIED   OCH     100   9.4E-09            GROUND
PLANE    9.4E-09
```

CAT I, 55 ft tail heights

```
  SPEED  TYPE OF REPORT   OCA/H    TOTAL     HIGHEST RISK
OBSTACLE
  CAT.                    FEET     RISK      IDENT
DESCRIPTION    RISK
    A   SPECIFIED   OCH     200   2.1E-11  12         12
1.7E-11
    B   SPECIFIED   OCH     200   1.2E-10  12         12
9.9E-11
    C   SPECIFIED   OCH     200   6.6E-10  12         12
5.5E-10
    D   SPECIFIED   OCH     200   3.6E-09  12         12
3.1E-09
```

CAT II, 55 ft tail heights

```
  SPEED  TYPE OF REPORT   OCA/H    TOTAL     HIGHEST RISK
OBSTACLE
  CAT.                    FEET     RISK      IDENT
DESCRIPTION    RISK
    A   SPECIFIED   OCH     100   4.6E-12            GROUND
PLANE    3.7E-12
    B   SPECIFIED   OCH     100   6.6E-11            GROUND
PLANE    5.2E-11
    C   SPECIFIED   OCH     100   9.3E-10            GROUND
PLANE    7.1E-10
    D   SPECIFIED   OCH     100   1.3E-08            GROUND
PLANE    9.4E-09
```

CAT I, 65 ft tail heights

```
  SPEED  TYPE OF REPORT   OCA/H    TOTAL     HIGHEST RISK
OBSTACLE
  CAT.                    FEET     RISK      IDENT
DESCRIPTION    RISK
    A   SPECIFIED   OCH     200   7.1E-10  12        12
6.9E-10
    B   SPECIFIED   OCH     200   3.3E-09  12        12
3.2E-09
    C   SPECIFIED   OCH     200   1.5E-08  12        12
1.5E-08
    D   SPECIFIED   OCH     200   6.9E-08  12        12
6.6E-08
```

CAT II, 65 ft tail heights

```
  SPEED  TYPE OF REPORT   OCA/H    TOTAL     HIGHEST RISK
OBSTACLE
  CAT.                    FEET     RISK      IDENT
DESCRIPTION    RISK
    A   SPECIFIED   OCH     100   1.8E-10  12        12
1.8E-10
    B   SPECIFIED   OCH     100   2.0E-09  12        12
2.0E-09
    C   SPECIFIED   OCH     100   2.2E-08  12        12
2.1E-08
    D   SPECIFIED   OCH     100   2.3E-07  12        12
2.2E-07
    D   MINIMUM     OCH     106   9.7E-08  12        12
9.2E-08
```

APPENDIX A. DFW END AROUND TAXIWAY COLLISION RISK MODEL ANALYSES

Runway 36 R

Obstacle Data Base

OBS No.	x dist	y dist	z dist
01	0	-1130	50, 59, 69
02	300	-1130	50, 59, 69
03	600	-1130	50, 59, 69
04	900	-1130	50, 59, 69
05	1200	-1130	50, 59, 69
06	1500	-1130	50, 59, 69
07	1800	-1130	50, 59, 69
08	2100	-1130	50, 59, 69
09	2400	-1130	50, 59, 69
10	2650	-1130	50, 59, 69
11	2650	-900	50, 59, 69
12	2650	-600	50, 59, 69
13	2650	-300	50, 59, 69
14	2650	0	50, 59, 69
15	2650	300	50, 59, 69
16	2650	600	50, 59, 69
17	2400	600	50, 59, 69
18	2100	600	50, 59, 69
19	1800	600	50, 59, 69
20	1500	600	50, 59, 69
21	1200	600	50, 59, 69
22	900	600	50, 59, 69
23	600	600	50, 59, 69
24	300	600	50, 59, 69
25	0	600	50, 59, 69

CAT I, 46 ft tail heights

```
  SPEED  TYPE OF REPORT   OCA/H    TOTAL     HIGHEST RISK
OBSTACLE
  CAT.                    FEET     RISK      IDENT
DESCRIPTION    RISK
    A   SPECIFIED   OCH     200   6.3E-12  14         14
4.1E-12
    B   SPECIFIED   OCH     200   3.2E-11  14         14
2.1E-11
    C   SPECIFIED   OCH     200   1.6E-10  14         14
1.1E-10
```

```
    D   SPECIFIED   OCH     200   8.3E-10  14        14
5.5E-10
```

CAT II, 46 ft tail heights

```
  SPEED  TYPE OF REPORT   OCA/H    TOTAL     HIGHEST RISK
OBSTACLE
  CAT.                    FEET     RISK      IDENT
DESCRIPTION    RISK
    A   SPECIFIED   OCH     100   3.7E-12            GROUND
PLANE    3.7E-12
    B   SPECIFIED   OCH     100   5.3E-11            GROUND
PLANE    5.2E-11
    C   SPECIFIED   OCH     100   7.2E-10            GROUND
PLANE    7.0E-10
    D   SPECIFIED   OCH     100   9.7E-09            GROUND
PLANE    9.4E-09
```

CAT I, 55 ft tail heights

```
  SPEED  TYPE OF REPORT   OCA/H    TOTAL     HIGHEST RISK
OBSTACLE
  CAT.                    FEET     RISK      IDENT
DESCRIPTION    RISK
    A   SPECIFIED   OCH     200   9.4E-11  14        14
8.6E-11
    B   SPECIFIED   OCH     200   4.8E-10  14        14
4.3E-10
    C   SPECIFIED   OCH     200   2.4E-09  14        14
2.2E-09
    D   SPECIFIED   OCH     200   1.2E-08  14        14
1.1E-08
```

CAT II, 55 ft tail heights

```
  SPEED  TYPE OF REPORT   OCA/H    TOTAL     HIGHEST RISK
OBSTACLE
  CAT.                    FEET     RISK      IDENT
DESCRIPTION    RISK
    A   SPECIFIED   OCH     100   1.1E-11  14        14
7.6E-12
    B   SPECIFIED   OCH     100   1.6E-10  14        14
1.1E-10
    C   SPECIFIED   OCH     100   2.2E-09  14        14
1.5E-09
    D   SPECIFIED   OCH     100   2.9E-08  14        14
2.0E-08
```

CAT I, 65 ft tail heights

```
  SPEED  TYPE OF REPORT   OCA/H    TOTAL     HIGHEST RISK
OBSTACLE
  CAT.                    FEET     RISK      IDENT
DESCRIPTION    RISK
    A   SPECIFIED   OCH     200   2.6E-09  14         14
2.5E-09
    B   SPECIFIED   OCH     200   1.1E-08  14         14
1.1E-08
    C   SPECIFIED   OCH     200   5.0E-08  14         14
4.8E-08
    D   SPECIFIED   OCH     200   2.2E-07  14         14
2.1E-07
```

CAT II, 65 ft tail heights

```
  SPEED  TYPE OF REPORT   OCA/H    TOTAL     HIGHEST RISK
OBSTACLE
  CAT.                    FEET     RISK      IDENT
DESCRIPTION    RISK
    A   SPECIFIED   OCH     100   1.6E-09  14         14
1.6E-09
    B   SPECIFIED   OCH     100   1.4E-08  14         14
1.4E-08
    C   SPECIFIED   OCH     100   1.1E-07  14         14
1.1E-07
    C   MINIMUM     OCH     101   9.9E-08  14         14
9.8E-08
    D   SPECIFIED   OCH     100   9.1E-07  14         14
9.0E-07
    D   MINIMUM     OCH     115   9.7E-08  14         14
9.7E-08
```

APPENDIX B. 14 CFR 25.111, .121 and 121.189

§ 25.111 Takeoff path.

(a) The takeoff path extends from a standing start to a point in the takeoff at which the airplane is 1,500 feet above the takeoff surface, or at which the transition from the takeoff to the en route configuration is completed and V_{FTO} is reached, whichever point is higher. In addition—

(1) The takeoff path must be based on the procedures prescribed in §25.101(f);

(2) The airplane must be accelerated on the ground to VEF, at which point the critical engine must be made inoperative and remain inoperative for the rest of the takeoff; and

(3) After reaching VEF, the airplane must be accelerated to V_2.

(b) During the acceleration to speed V_2, the nose gear may be raised off the ground at a speed not less than VR. However, landing gear retraction may not be begun until the airplane is airborne.

(c) During the takeoff path determination in accordance with paragraphs (a) and (b) of this section—

(1) The slope of the airborne part of the takeoff path must be positive at each point;

(2) The airplane must reach V2 before it is 35 feet above the takeoff surface and must continue at a speed as close as practical to, but not less than V2, until it is 400 feet above the takeoff surface;

(3) At each point along the takeoff path, starting at the point at which the airplane reaches 400 feet above the takeoff surface, the available gradient of climb may not be less than—

(i) 1.2 percent for two-engine airplanes;

(ii) 1.5 percent for three-engine airplanes; and

(iii) 1.7 percent for four-engine airplanes; and

(4) Except for gear retraction and automatic propeller feathering, the airplane configuration may not be changed, and no change in power or thrust that requires action by the pilot may be made, until the airplane is 400 feet above the takeoff surface.

(d) The takeoff path must be determined by a continuous demonstrated takeoff or by synthesis from segments. If the takeoff path is determined by the segmental method—

(1) The segments must be clearly defined and must be related to the distinct changes in the configuration, power or thrust, and speed;

(2) The weight of the airplane, the configuration, and the power or thrust must be constant throughout each segment and must correspond to the most critical condition prevailing in the segment;

(3) The flight path must be based on the airplane's performance without ground effect; and

(4) The takeoff path data must be checked by continuous demonstrated takeoffs up to the point at which the airplane is out of ground effect and its speed is stabilized, to ensure that the path is conservative relative to the continuous path.

The airplane is considered to be out of the ground effect when it reaches a height equal to its wingspan.

(e) For airplanes equipped with standby power rocket engines, the takeoff path may be determined in accordance with section II of appendix E.

§ 25.121 Climb: One-engine-inoperative.

(a) *Takeoff, landing gear extended.* In the critical takeoff configuration existing along the flight path (between the points at which the airplane reaches VLOF and at which the landing gear is fully retracted) and in the configuration used in §25.111 but without ground effect, the steady gradient of climb must be positive for two-engine airplanes, and not less than 0.3 percent for three-engine airplanes or 0.5 percent for four-engine airplanes, at VLOF and with—

(1) The critical engine inoperative and the remaining engines at the power or thrust available when retraction of the landing gear is begun in accordance with §25.111 unless there is a more critical power operating condition existing later along the flight path but before the point at which the landing gear is fully retracted; and

(2) The weight equal to the weight existing when retraction of the landing gear is begun, determined under §25.111.

(b) *Takeoff; landing gear retracted.* In the takeoff configuration existing at the point of the flight path at which the landing gear is fully retracted, and in the configuration used in §25.111 but without ground effect, the steady gradient of climb may not be less than 2.4 percent for two-engine airplanes, 2.7 percent for three-engine airplanes, and 3.0 percent for four-engine airplanes, at V_2 and with—

(1) The critical engine inoperative, the remaining engines at the takeoff power or thrust available at the time the landing gear is fully retracted, determined under §25.111, unless there is a more critical power operating condition existing later along the flight

path but before the point where the airplane reaches a height of 400 feet above the takeoff surface; and

(2) The weight equal to the weight existing when the airplane's landing gear is fully retracted, determined under §25.111.

(c) *Final takeoff.* In the en route configuration at the end of the takeoff path determined in accordance with §25.111, the steady gradient of climb may not be less than 1.2 percent for two-engine airplanes, 1.5 percent for three-engine airplanes and 1.7 percent for four-engine airplanes, at *V*FTO and with

(1) The critical engine inoperative and the remaining engines at the available maximum continuous power or thrust; and

(2) The weight equal to the weight existing at the end of the takeoff path, determined under §25.111.

(d) *Approach.* In a configuration corresponding to the normal all-engines-operating procedure in which *V*SR for this configuration does not exceed 110 percent of the *V*SR for the related all-engines-operating landing configuration, the steady gradient of climb may not be less than 2.1 percent for two-engine airplanes, 2.4 percent for three-engine airplanes, and 2.7 percent for four engine airplanes, with

(1) The critical engine inoperative, the remaining engines at the go-around power or thrust setting;

(2) The maximum landing weight;

(3) A climb speed established in connection with normal landing procedures, but not more than 1.4 *V*SR; and

(4) Landing gear retracted.

§ 121.189 Airplanes: Turbine engine powered: Takeoff limitations.

(a) No person operating a turbine engine powered airplane may take off that airplane at a weight greater than that listed in the Airplane Flight Manual for the elevation of the airport and for the ambient temperature existing at takeoff.

(b) No person operating a turbine engine powered airplane certificated after August 26, 1957, but before August 30, 1959 (SR422, 422A), may take off that airplane at a weight greater than that listed in the Airplane Flight Manual for the minimum distances required for takeoff. In the case of an airplane certificated after September 30, 1958 (SR422A, 422B), the takeoff distance may include a clearway distance but the clearway distance included may not be greater than 1/2 of the takeoff run.

(c) No person operating a turbine engine powered airplane certificated after August 29, 1959 (SR422B), may take off that airplane at a weight greater than that listed in the Airplane Flight Manual at which compliance with the following may be shown:

(1) The accelerate-stop distance must not exceed the length of the runway plus the length of any stopway.

(2) The takeoff distance must not exceed the length of the runway plus the length of any clearway except that the length of any clearway included must not be greater than one-half the length of the runway.

(3) The takeoff run must not be greater than the length of the runway.

(d) No person operating a turbine engine powered airplane may take off that airplane at a weight greater than that listed in the Airplane Flight Manual—

(1) In the case of an airplane certificated after August 26, 1957, but before October 1, 1958 (SR422), that allows a takeoff path that clears all obstacles either by at least (35+0.01D) feet vertically (D is the distance along the intended flight path from the end of the runway in feet), or by at least 200 feet horizontally within the airport boundaries and by at least 300 feet horizontally after passing the boundaries; or

(2) In the case of an airplane certificated after September 30, 1958 (SR 422A, 422B), that allows a net takeoff flight path that clears all obstacles either by a height of at least 35 feet vertically, or by at least 200 feet horizontally within the airport boundaries and by at least 300 feet horizontally after passing the boundaries.

(e) In determining maximum weights, minimum distances, and flight paths under paragraphs (a) through (d) of this section, correction must be made for the runway to be used, the elevation of the airport, the effective runway gradient, the ambient temperature and wind component at the time of takeoff, and, if operating limitations exist for the minimum distances required for takeoff from wet runways, the runway surface condition (dry or wet). Wet runway distances associated with grooved or porous friction course runways, if provided in the Airplane Flight Manual, may be used only for runways that are grooved or treated with a porous friction course (PFC) overlay, and that the operator determines are designed, constructed, and maintained in a manner acceptable to the Administrator.

(f) For the purposes of this section, it is assumed that the airplane is not banked before reaching a height of 50 feet, as shown by the takeoff path or net takeoff flight path data (as appropriate) in the Airplane Flight Manual, and thereafter that the maximum bank is not more than 15 degrees.

(g) For the purposes of this section the terms, *takeoff distance, takeoff run, net takeoff flight path* and *takeoff path* have the same meanings as set forth in the rules under which the airplane was certificated.

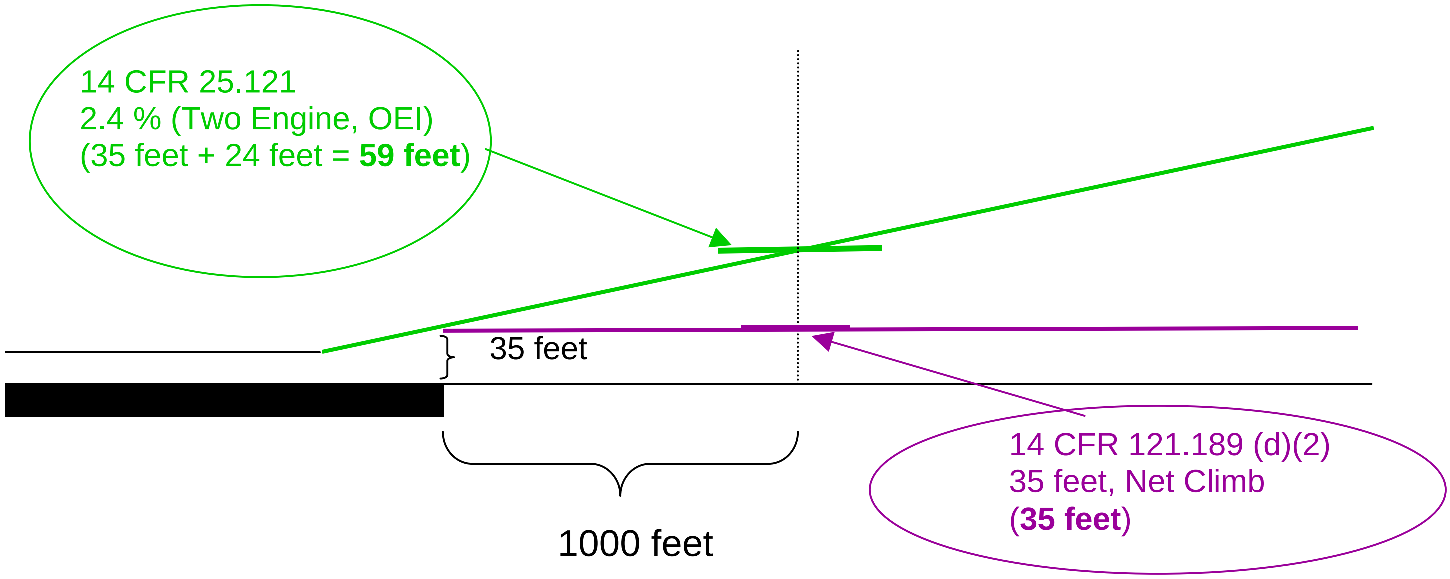
APPENDIX C. Comparison of 14 CFR 25 Subpart B and 14 CFR 121 Subpart I Climb Requirements

Un-metered End Around Taxiway (EAT) aircraft are considered obstacles for the purpose of performance planning.

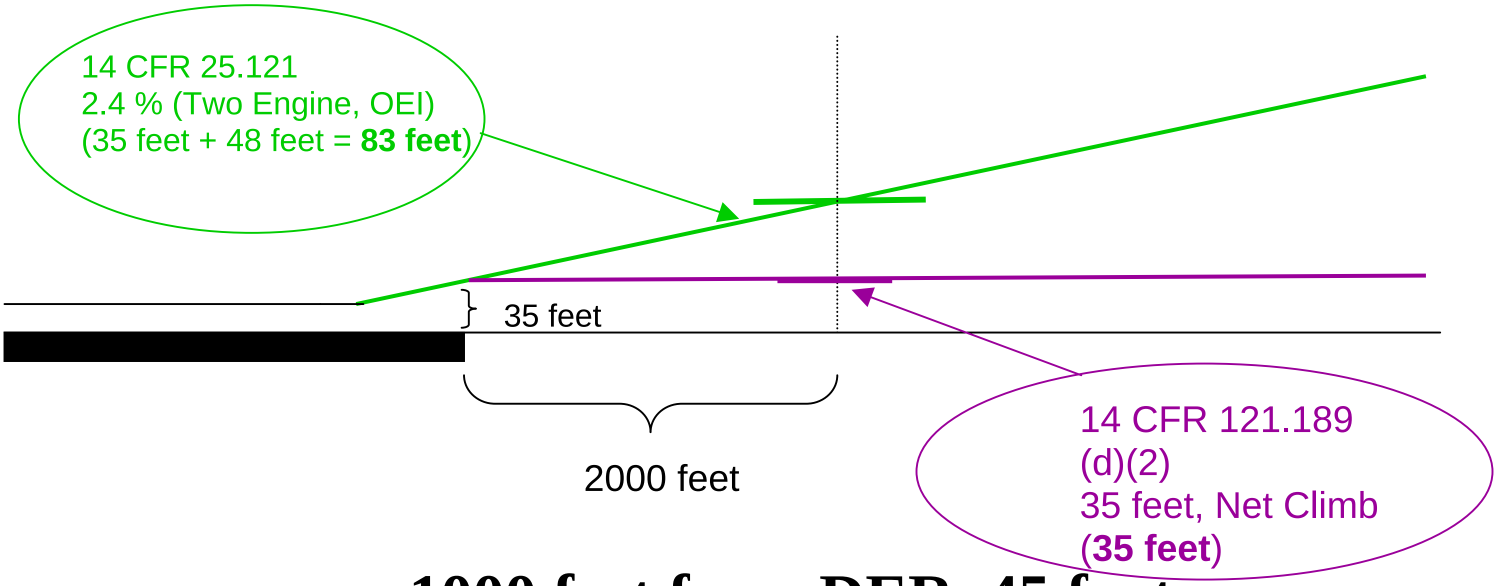
Pertinent rules are

- –14 CFR 25.111, and .121, and,
- –14 CFR 121.189

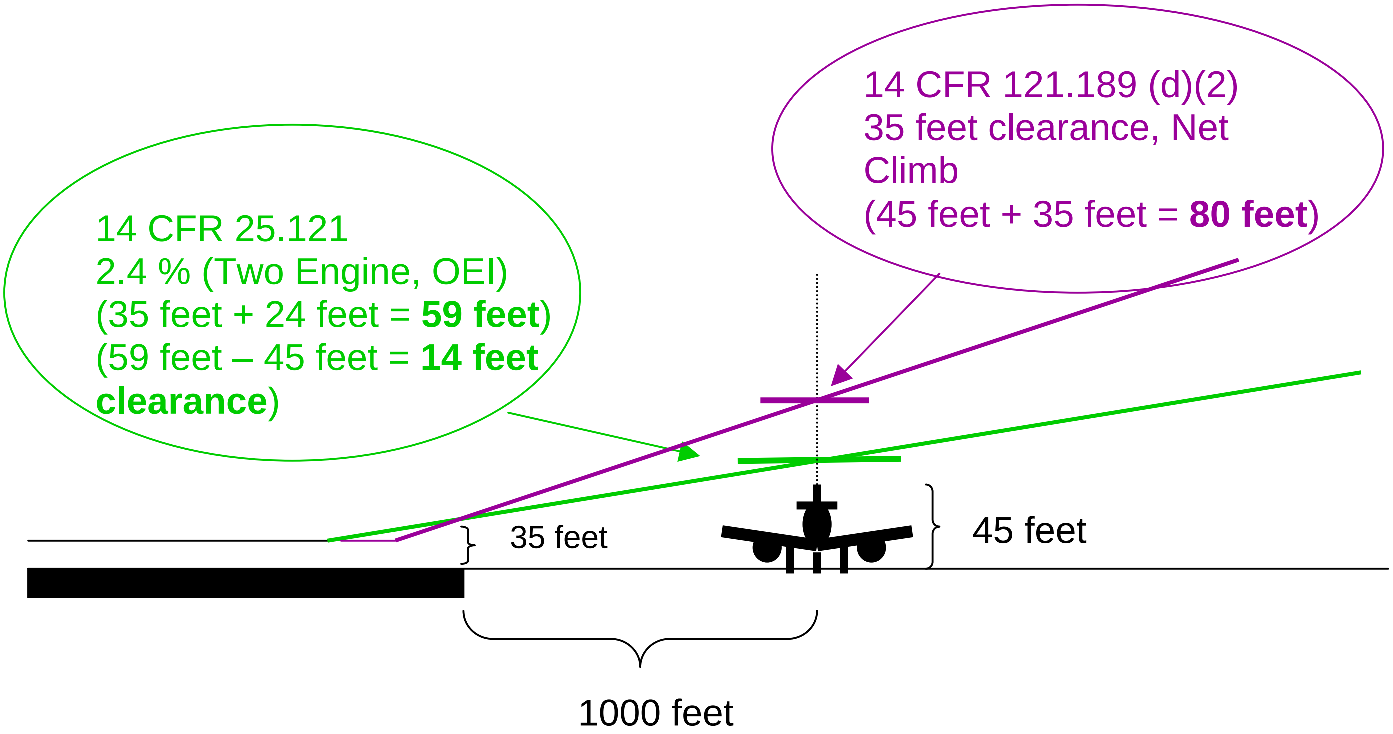
1000 feet from DER, no Obstacle



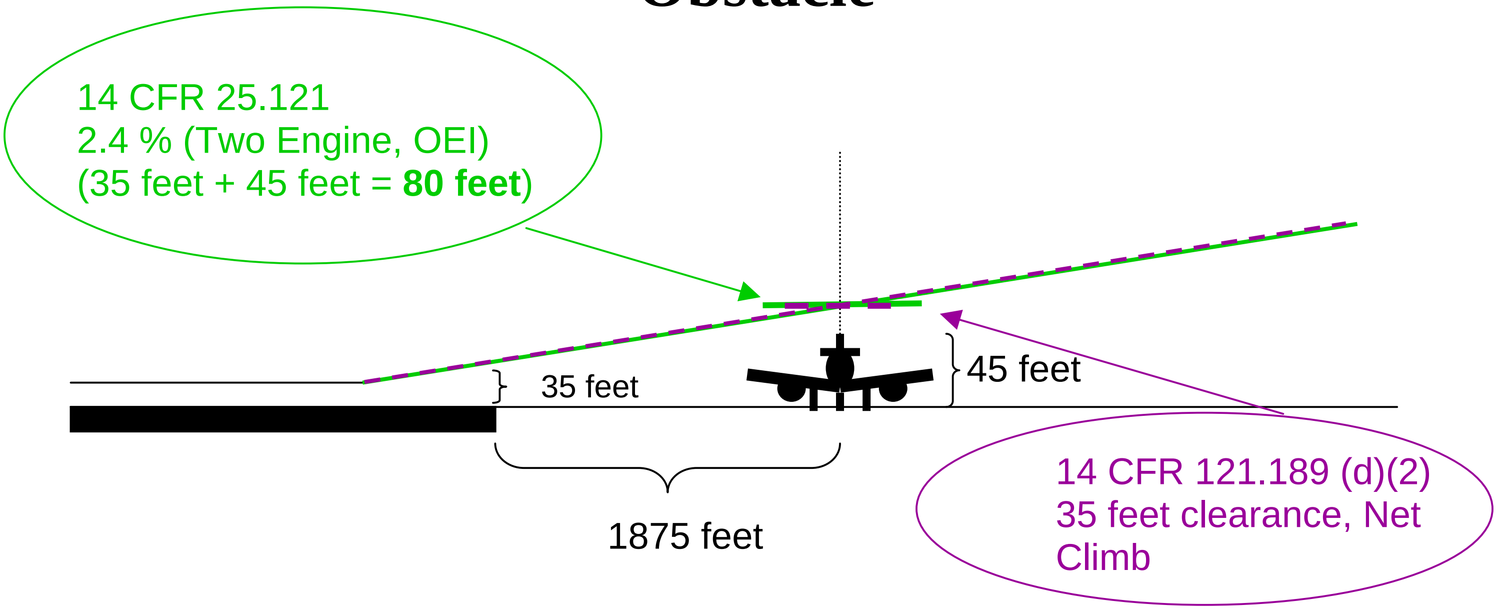
2000 feet from DER, no Obstacles



1000 feet from DER, 45 foot Obstacle



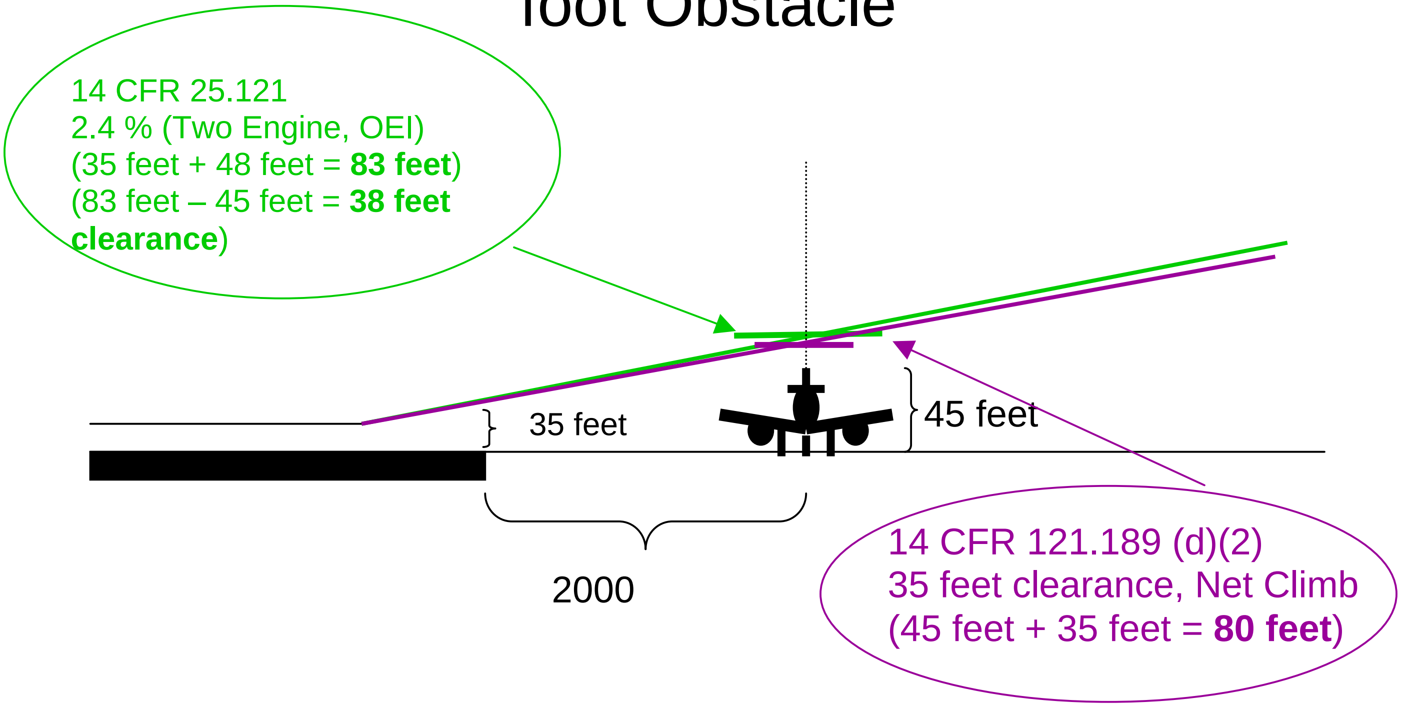
1875 feet from DER, 45 foot Obstacle



14 CFR 25.121
2.4 % (Two Engine, OEI)
(35 feet + 45 feet = **80 feet**)

14 CFR 121.189 (d)(2)
35 feet clearance, Net Climb

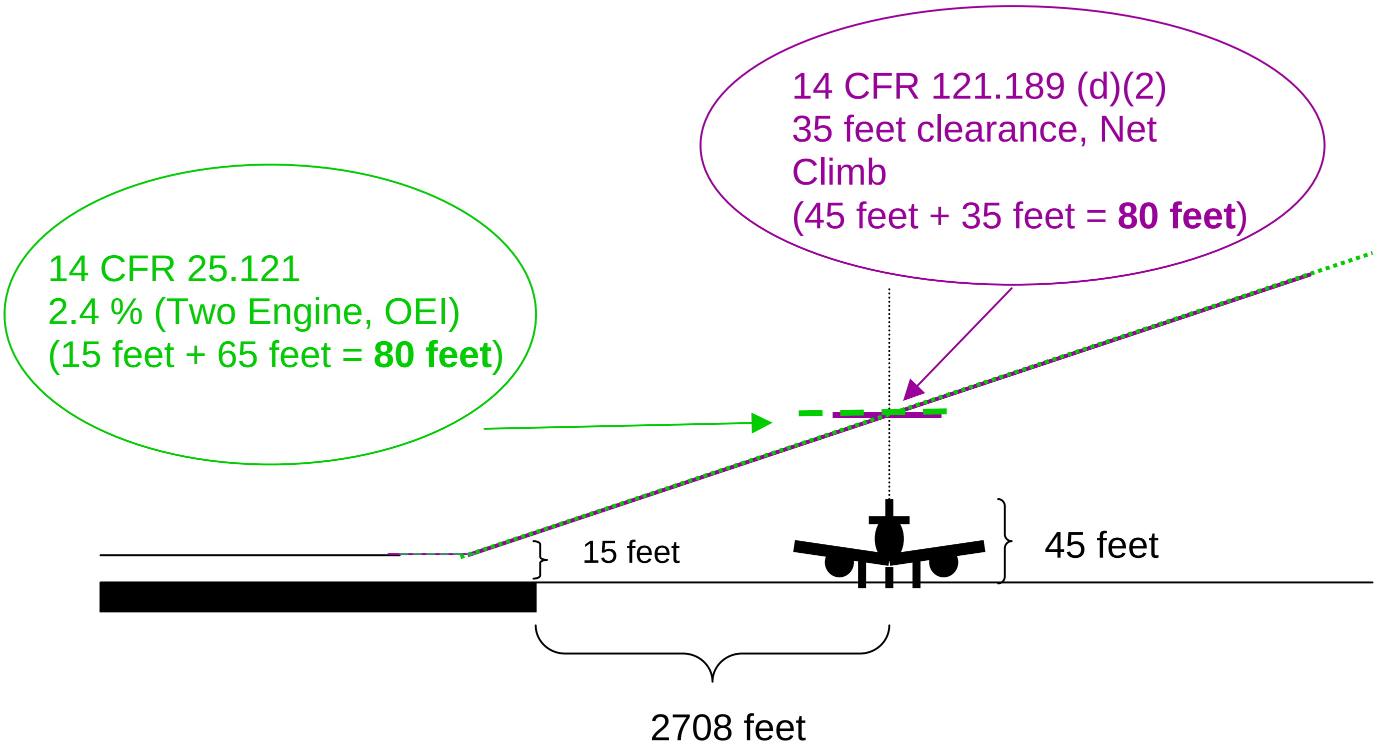
2000 feet from DER, 45 foot Obstacle



14 CFR 25.121
2.4 % (Two Engine, OEI)
(35 feet + 48 feet = **83 feet**)
(83 feet – 45 feet = **38 feet clearance**)

14 CFR 121.189 (d)(2)
35 feet clearance, Net Climb
(45 feet + 35 feet = **80 feet**)

Wet Runway, 15 foot screen height, 2708 feet from DER, 45 foot Obstacle


14 CFR 121.189 (d)(2)
35 feet clearance, Net
Climb
(45 feet + 35 feet = **80 feet**)

14 CFR 25.121
2.4 % (Two Engine, OEI)
(15 feet + 65 feet = **80 feet**)

Summary

Take-off weight must be reduced or limited to that weight which allows

–14 CFR 25 Subpart B (certification rule) climb requirements, or,

–14 CFR 121 Subpart I (operational rule) climb requirements to be met, whichever results in a lower weight.

In operations without an obstacle present, the certification limit will control.

In example operations with an obstacle present at 1,000 feet from DER, the operational limit will control. At 2,000 feet, the certification limit controls. The “break point” is 1,875 feet from the Departure End of the Runway (DER). In the event the operator chooses the wet runway provisions of 14 CFR 25.113, this “break point” moves out to 2,708 feet from the DER.

Note

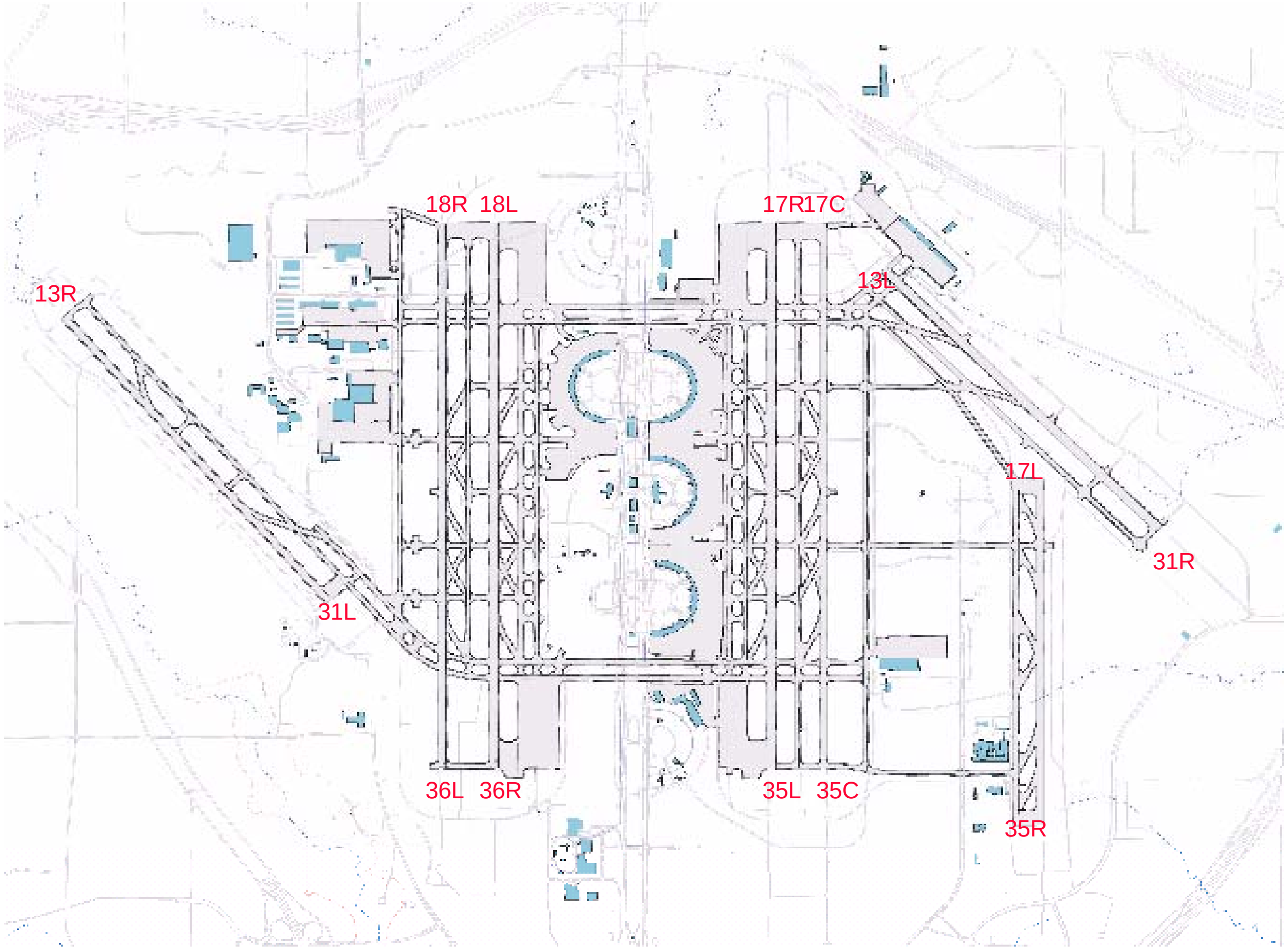
Use of airplanes with three and four-engine configurations will skew requirements more toward the certification limit (net climb requirements are higher).

CONCLUSION

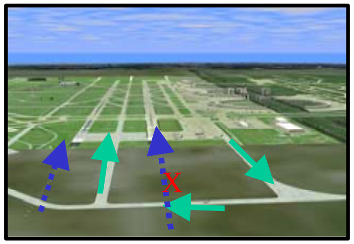
The use of End Around Taxiways in the example configurations will result in an increased climb gradient requirement and associated reduction in take-off weight for climb-limited aircraft when the EAT is within 1,875 feet from the DER (assuming a maximum EAT aircraft height of 45 feet), or within 2,708 feet if the operator is using the wet runway provisions of the certification rule.

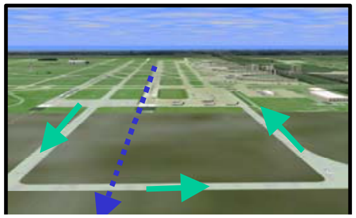
Under these conditions, this reduction in take-off weight would typically result in lost passenger and/or cargo throughput capacity for the airport.

D/FW International Airport



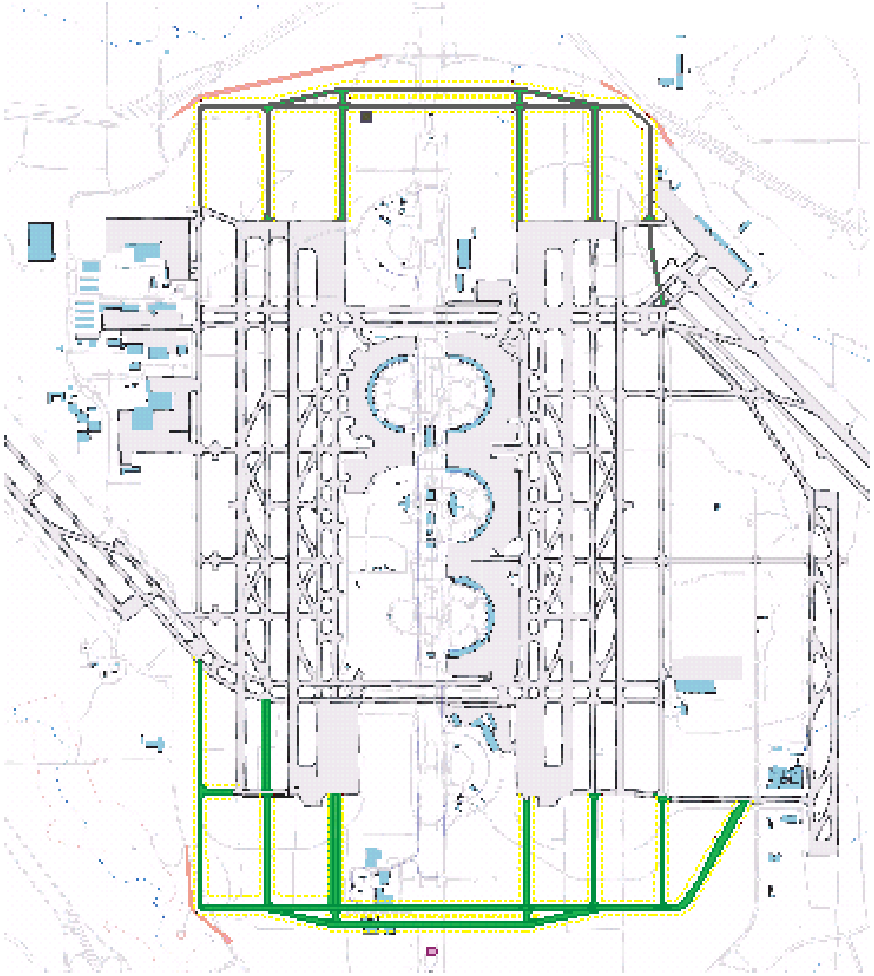
Analysis





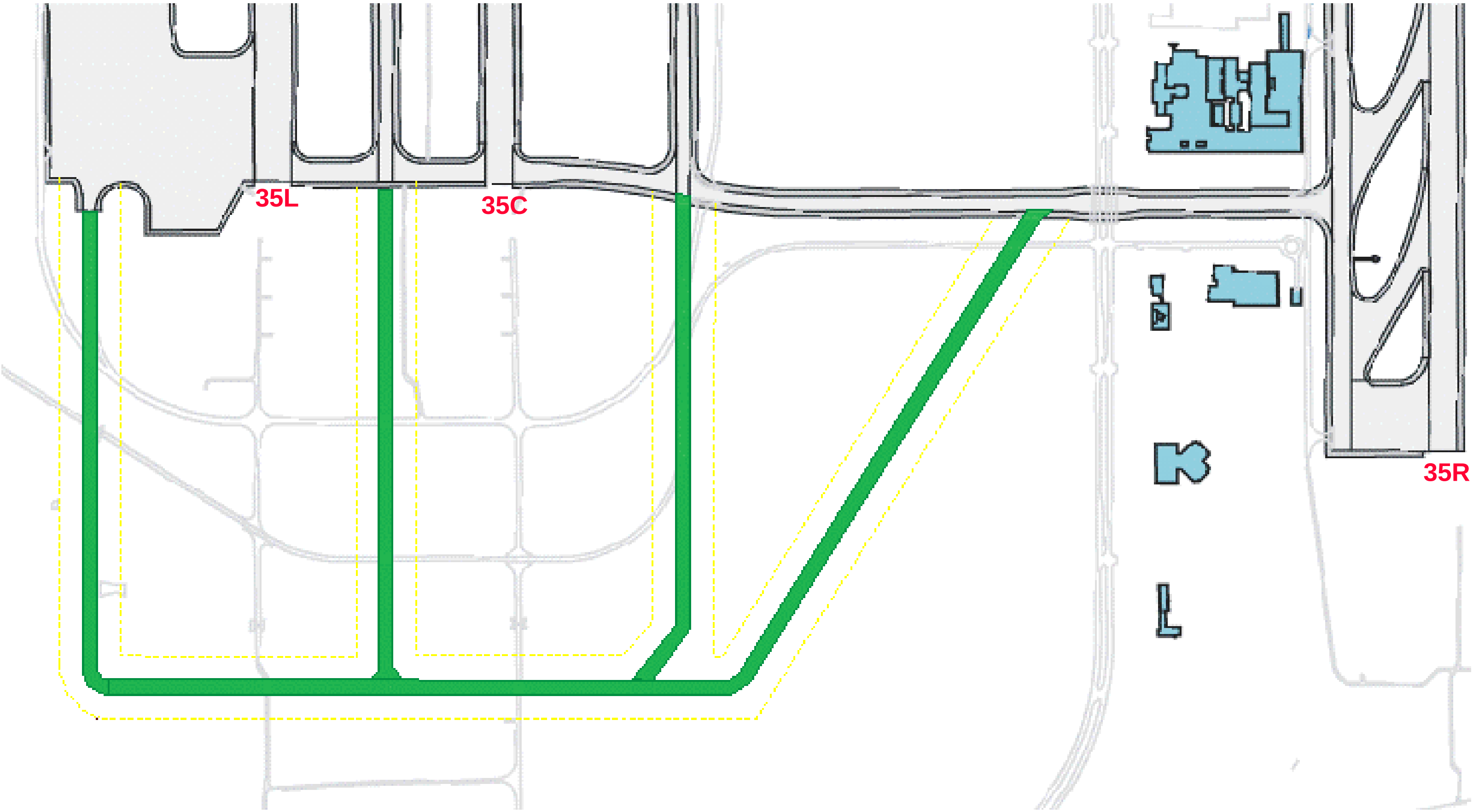
- DFW Perimeter Taxiway Concept
    - Perimeter taxiways cross under final approaches and takeoff paths 2650-ft. from the ends of the runways.
    - No penetrations of IFR approach surfaces.
    - The IFR departure surface is penetrated only if it commences at the runway elevation (35-ft. is OK).
    - Perimeter taxiways will be free flowing – without routine tower intervention.
    - They will be used for taxiing aircraft under aircraft that are both landing and taking off in both VFR and IFR conditions.

Perimeter Taxiway System

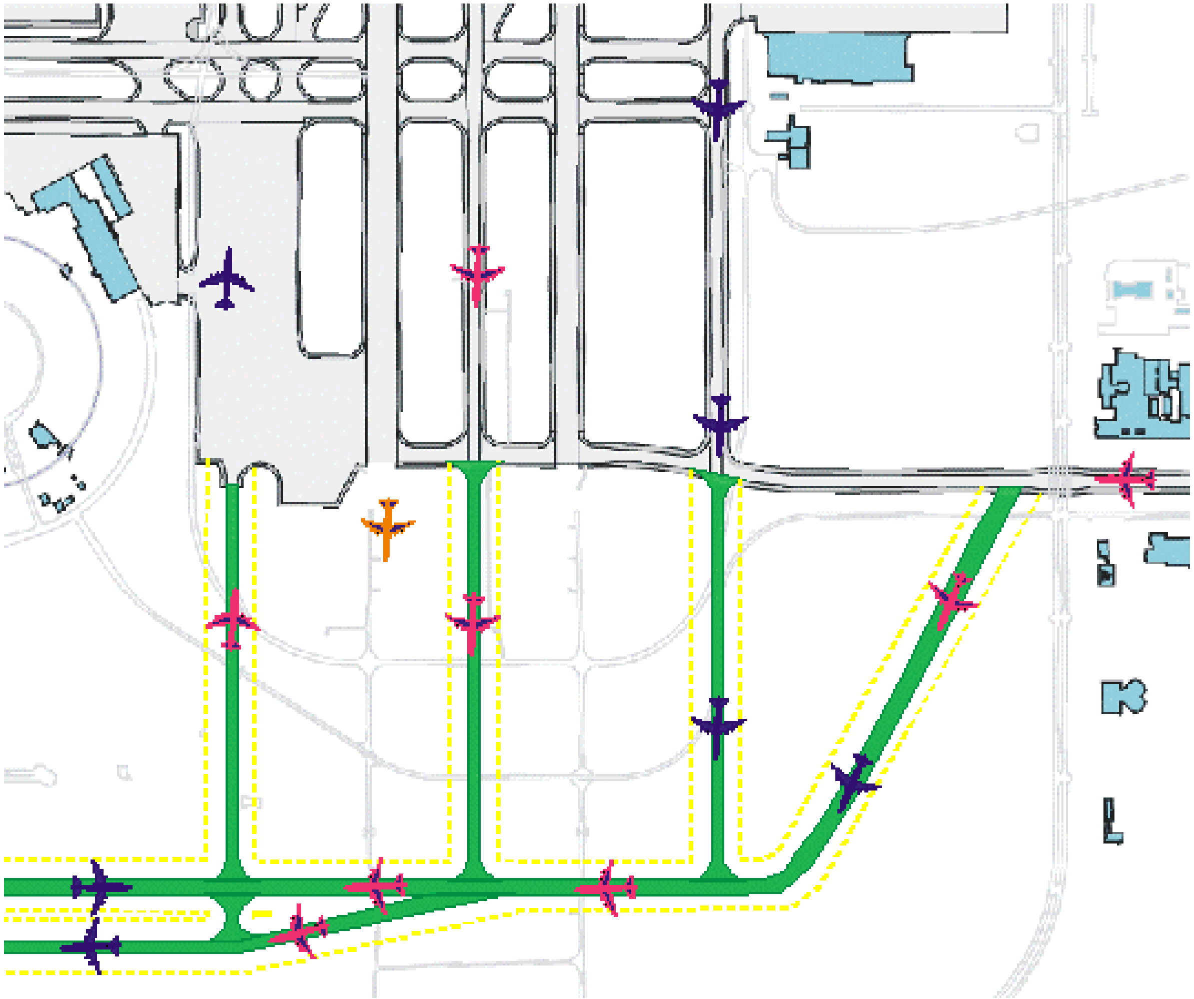


- DFW proposal: Unrestricted departures and arrivals over end-around taxiways, which are 2,650’ beyond the runway threshold at its furthest point -- in all weather conditions.

Southeast Quadrant



Taxiway Route Operation



ATTACHMENT 2

25-26 August 2004 – AMERICAN AIRLINES FLIGHT ACADEMY

FAA personnel traveled from Oklahoma City and Washington, D.C. on the day of 24 August, 2004. Arrangements were made with Jeff Parks, American Airlines, to meet at the American Airlines Training Academy and simulator facility at 4:30 a.m. on the morning of 25 August to conduct coordination and simulator familiarization prior to the demonstration at 7:30 a.m. Jeff Parks escorted the FAA Test Director to the simulator where he was introduced to several key AA employees (hardware and software engineers) who were instrumental in configuring the Boeing 767 simulator according to the specifications required for the demonstration. Also present was Brent Blackwell, Managing Director, Operations Engineering (former Army Helicopter Pilot) who was responsible for crew scheduling.

Mark Reisweber, under the guidance of Brent Blackwell, was given approximately 2 hours in the simulator. That time was spent accomplishing several tasks: (1). Ensuring that the simulation scenarios were programmed correctly; (2). Becoming familiar with the planned scenarios; and (3). Proposing changes, as needed, that could be re-programmed into the simulator prior to the conduct of the evaluation later that morning. Jeff Parks performed as the cockpit coordinator and simulator controller. This pre-demonstration simulation was absolutely essential and proved to be successful as it provided the FAA team with a very good familiarization for conducting the demonstration the following week at NASA AMES and that day (25th) at the American Airlines facility. Also, several minor changes were made to the scenarios.

Test personnel, observers, and A.M. period aircrews arrived at approximately 6:30 a.m. on 25 August. Mark Reisweber conducted the first crew briefing at approximately 6:30 a.m. The briefing lasted 20 minutes, during which time crews were briefed on the purpose of their participation, our role as evaluators and observers, and the procedural aspects of EAT operations.

The simulator coordinator was Jeff Parks. American Airlines provided six separate crews to participate in the study. The aircrews were all senior, current commercial airlines pilots with varied aviation backgrounds and many years of experience. Several members of the Airline Pilot Association (ALPA) were present.

The evaluation consisted of nine distinct scenarios. Each crew conducted the first nine scenarios per the approved plan, alternating between captain and first officer for each scenario. After completing each 9-scenario set, each crew conducted the same full set again, alternating in different order (i.e., each crewmember would fly each of the nine scenarios, for a total of 18 scenarios per crew).

After each scenario/run, each crewmember (regardless of pilot-flying or pilot-not-flying) was given a six-question, check-the-block, subjective questionnaire. We stressed that each questionnaire was designed to capture pilot reaction to that particular stand-alone scenario. NOTE: Based upon time and the needs of the evaluation, several non-required scenarios were truncated from the schedule in order to insure completion of more departures, upon which EAT approval/disapproval was predicated.

Each scenario was timed at approximately one minute in length. Each questionnaire took less than one-minute to complete. During that “downtime,” the simulator controller reset the simulation to the next scenario. It took about one minute to reset to the next scenario in the sequence. Each crew spent approximately 60-90 minutes to complete all scenarios, questionnaires and debriefing.

After each crew simulation, both the Captain and First Officer were given one final post-simulation questionnaire to gather their sense of the operation, as a whole, encompassing all scenarios/runs. Immediately following completion of the final questionnaire, the crew and evaluators/observers conducted a verbal post-simulation de-brief.

Prior to completion of the first crew’s simulation, the next crew was in-briefed by Dick Temple and/or John Helleberg, who would then accompany that crew into the simulator. As the post-simulation de-brief was conducted with the first crew, the next crew entered the simulator and began the next sequence of scenarios with the evaluator and observer that in-briefed them. This insured that we had no disruption of the flow of the evaluation and we could maximize limited simulator time.

ATTACHMENT 3

23, 31 August 2004 – NASA AMES RESEARCH CENTER

As the test director, Mark Reisweber traveled from Oklahoma City to Moffett Field, CA on 23 August 2004 to conduct coordination and simulator familiarization/validation prior to the demonstration on 31 August 2004. Mark Reisweber met with Ken Christensen, Terry Rager, Jim Miller, Bob Cornell and several of NASA Ames' simulator engineers. As was the case with the American Airlines facility, during a two-hour simulator flight in the NASA AMES Research Center's Boeing 747-400, several tasks were accomplished: (1). Ensured that the simulation scenarios were programmed correctly; (2). Became familiar with scenarios; and (3). Proposed changes, as needed, that could be re-programmed into the simulator for the following day. Bob Cornell and Mark Reisweber flew in the Captain and First Officer seats, respectively. Jim Miller performed as the cockpit coordinator and simulator controller from the controller station, outside the cab. Jim would perform this function during the actual evaluation as well.

FAA evaluators and crews from Washington, D.C., and the Dallas/Fort Worth local area began to arrive on the day of 31 August. Ken Christensen made arrangements for all non-NASA personnel to obtain security passes and directions to the facility.

Test personnel, observers, and A.M. period aircrews arrived before 8:00 a.m. on 31 August. Mark Reisweber conducted the first crew briefing at approximately 8:00 a.m. The briefing lasted 20 minutes, during which time crews were briefed on the purpose of their participation, our role as evaluators and observers, and the procedural aspects of EAT operations.

The simulator coordinator was Jim Miller, Operations Group Manager at the Crew Vehicle Systems Research Facility. Terry Rager and Ken Christensen provided three crews from the local area to participate in the study. The aircrews were all senior, current commercial airline pilots with varied aviation backgrounds and many years of experience. While several of the crewmembers were not type-rated in the 747-400, they were all type-rated in similar, heavy, commercial aircraft and were teamed with Captains who were type-rated in the test aircraft.

Prior to the start or each scenario set, the crews were given the opportunity to make a few departures and approaches to landing to get comfortable with the simulator and its characteristics.

This simulator evaluation also consisted of nine distinct scenarios. Each crew conducted the first nine scenarios per the approved plan, alternating between captain and first officer for each scenario.

After completing each 9-scenario set, each crew conducted the same full set again, alternating in different order (i.e., each crewmember would fly each of the nine scenarios, for a total of 18 scenarios per crew). After each scenario/run, each crewmember (regardless of pilot-flying or pilot-not-flying) was given a 6-question, check-the-block, subjective questionnaire. We stressed that each questionnaire was designed to capture pilot reaction to that particular stand-alone scenario. With few exceptions, all crews completed most or all of the 18 scheduled scenario runs.

Again, each scenario was timed at approximately one minute in length. Each questionnaire took less than one-minute to complete. During that "downtime," the simulator controller reset the simulation to the next scenario. It took about one minute to reset to the next scenario in the sequence. Each crew spent approximately 90-120 minutes to complete all scenarios, questionnaires and debriefing.

After each crew simulation, both the Captain and First Officer were given one final post-simulation questionnaire to gather their sense of the operation, as a whole, encompassing all scenarios/runs. Immediately following completion of the final questionnaire, the crew and evaluators/observers conducted a verbal post-simulation de-brief.

Prior to completion of the first crew's simulation, the next crew was in-briefed by Dick Temple and/or John Helleberg, who would then accompany that crew into the simulator. As the post-simulation de-brief was conducted with the first crew, the next crew entered the simulator and began the next sequence of scenarios with the evaluator and observer that in-briefed them. This insured that we had no disruption of the flow of the evaluation and we could maximize limited simulator time.

At our request, NASA software engineers provided us with aircraft performance data, taken during the course of the simulation. NOTE: this data is only to be used by FAA performance modelers in developing and using various evaluation tools. It is not intended for the purpose of evaluating this EAT operation.

Jim Miller and the NASA team provided us with time-stamped Audio/Video recording of all runs that provides simultaneous views of each crewmember's face, the PFD and view of the cockpit from just-behind the crew's head.