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**Time to Missed Approach
Project**

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12. Abstract In an effort to increase airport capacity by allowing independent operation of closely spaced parallel runways, pilot reaction time to an ATC directed missed approach is critical to avoid conflicts with blundering aircraft on parallel approaches. After clarifying the definition of the word "immediate" as it applies to ATC direction maximum reaction time was reduced from over 20 seconds in two previous studies to only 11 seconds in this study.		
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TIME TO MISSED APPROACH WITH THE WORD "IMMEDIATELY" DEFINED

1.0 INTRODUCTION. This project was conducted by the Federal Aviation Administration (FAA) on the FAA's B-727 Simulator to support the major air carrier airport capacity enhancement program for operations in instrument meteorological conditions and was developed as a follow-on to two previous projects. The earlier projects showed that some pilots were slow to respond to the word "immediately" when directed to execute a specific maneuver by air traffic control (ATC). The word "immediately" when used by ATC is intended to convey a concept of urgency that requires immediate response by the pilot in order to ensure the safety of the aircraft. The FAA Standards Development Branch, AVN-540, conducted the simulator project and the FAA Aviation Standards Branch, AAC-950, was responsible for providing engineering support for the B-727 simulator.

1.1 STATEMENT OF PROBLEM. One method of improving airport capacity at several airports would be to operate simultaneous instrument approaches to parallel runways with distances less than 4,300 feet between centerlines. According to criteria in Order 8260.3B, U. S. Standard for Terminal Instrument Procedures (TERPS), paragraph 992, "RUNWAY SEPARATION," if separation between parallel runway centerlines where simultaneous operations are less than 4,300 feet are approved, separation must be provided by Air Traffic Control (ATC). A possible conflict can occur when aircraft on an ILS approach blunders off of the localizer centerline and penetrates the "No Transgression Zone (NTZ)" when another aircraft is aligned on an adjacent parallel approach. The NTZ is 2,000 feet wide equidistant between runway centerlines extended and is intended to provide a basis for alerting controllers to give deviating aircraft maneuvering space to return to course without interfering with parallel traffic within their own normal operating zone (NOZ). Minor deviations off of the centerline are normal and expected on ILS approaches. This is a problem when the distance of the deviation from the centerline becomes excessive during parallel operations.

1.2 OBJECTIVES. The purpose of the test was to evaluate the time requirements necessary when executing an ATC directed missed approach maneuver when the meaning of the word "immediately" was reinforced during the pilot preflight briefing as compared to the time requirements for the same maneuver when the word "immediately" was not reinforced. The meaning of the word "immediately" was not included in the pilot preflight briefings for the earlier B-727 and DC-10 projects. The definition of the word "immediately" in this test was to convey the fact that ATC has observed a situation that requires urgent response to ATC direction in order to ensure the safety of the aircraft. This test essentially studied the average time and standard deviation of the time necessary to initiate a missed approach maneuver when directed to do so by ATC during a simulated instrument meteorological conditions (IMC) approach on an instrument landing system (ILS). The scenarios were designed based on these objectives:

a. Evaluate the pilot/autopilot performance when faced with an ATC directed missed approach.

b. Evaluate the time requirements to initiate an ATC directed missed approach.

1.3 RELATED PROJECTS. Demonstration projects have been initiated at Raleigh-Durham (RDU) and Memphis (MEM) International Airports to evaluate distances less than the presently required 4,300 feet between parallel runway centerlines for independent simultaneous ILS/MLS approaches. Also projects on the B-727 simulator at the Mike Monroney Aeronautical Center, Oklahoma City, OK and on the DC-10 simulator at Federal Express, Memphis, TN have been completed related to pilot workload and reaction time under IMC on air traffic control (ATC) directed missed approaches. This project is a follow on to the B-727 Missed Approach Crew Performance Simulator Project (project number FAA-AVN-500-52).

2.0 TEST LOCATION. The Time to Missed Approach Project was conducted on the B-727 simulator at the Mike Monroney Aeronautical Center, in Oklahoma City, OK.

3.0 TEST DESCRIPTION.

3.1 METHOD. Currently type rated pilots from the airline industry participated in this test. The approach scenarios were designed for dual-pilot with a test director and ATC in the cab to operate the test. The pilots flew simulated straight-in approaches which were initiated beyond the outer marker utilizing autopilot or manual (flight director) approaches. The airport selected for this test was Memphis International Airport with parallel runways 36R and 36L having 3,400 feet of separation between centerlines. The elevation for Memphis International Airport was 332 feet. The ILS approaches for this test were flown to runway 36L. The published MA for this runway's ILS approach is "CLIMB TO 1000 FEET, THEN CLIMBING LEFT TURN TO 1800 FEET DIRECT ME LOM AND HOLD." (See Appendix I).

3.2 FLIGHT PROCEDURES. By test design, the simulator maintained the maximum gross landing weight for a nominal heavy approach to landing for a B-727. The simulator was set to intercept altitude beyond the outer marker. The captain and first officer flew the approaches with flight director or autopilot. Approaches started before the localizer intercept and terminated in a landing or an MA. All runs included normal ATC phraseology. At DH, the pilot made the decision to land or execute an MA, except on scenarios where the ATC directed the pilot to turn. Prior to each run, the pilots were given information needed to accomplish each test run. The scenarios were:

a. Turn the aircraft as soon as pilot was satisfied with the aircraft reconfiguration and follow the published MA.

b. Follow the direction of the controller when pilot is

able. The Phraseology used was "TURN (Left/Right) HEADING (Degrees) IMMEDIATELY, CLIMB AND MAINTAIN (Altitude)." The controller started the message at height of 580 feet mean sea level (MSL) prior to DH of 100 feet and 680 feet MSL prior to DH of 200 feet. For the scenario with the turn occurring six miles from threshold, the height was 2,400 feet MSL.

The ATC phraseology used in item "b" above was taken from FAA Directive 7110.65F, paragraph 5-126, "SIMULTANEOUS ILS/MLS APPROACHES." This form of phraseology is used when an aircraft is observed penetrating the NTZ. The ATC instructs the aircraft on the adjacent final approach course to immediately alter course to avoid the deviating aircraft.

The simulator personnel recorded the system parameters listed in Table 1. Digital tape recordings and data listing were provided for postflight analysis. Observer logs were utilized to record equipment problems, subject pilot comments and special factors such as the length of time taken for the ATC message, crew procedures, etc., to assist in the final analysis.

Table 1.

Recorded Parameters

Parameter	Units
Time	Seconds
Indicated Air Speed	Nautical Miles per Hour
Radio Altitude	Feet
Rate of Climb	Feet/Minute
Pitch Angle	Degrees
Roll Angle	Degrees
Yaw Angle	Degrees
Ground Distance	Feet
Centerline Deviation	Feet
Event Marker	(255=on)
On Ground Flag	(255=on)
EPR Engine #2	Ratio

3.3 TEST SIMULATOR. The B-727 flight simulator has a six-axis motion base and the simulator provided a computer generated visual image which simulates a twilight visual display. This gives the flight crew a 90° field of vision.

3.4 SUBJECT PILOTS. Subject pilots were currently type rated industry pilots. Upon arriving at the test site, the pilots were briefed on the purpose of the test and test procedures. Within this briefing the meaning of the word "immediately" was clarified as to its use by ATC. Each pilot completed and returned a pilot experience form and questionnaire.

3.5 APPROACH/MISSED APPROACH SCENARIOS. Prior to the simulator tests, coordination with AVN-540, Lincoln Laboratory, ALPA, Flight Standards and other FAA personnel was conducted to define appropriate approach and MA scenarios. FAA test pilots flew each of the scenarios to verify their authenticity prior to participation by the subject pilots.

4.0 DATA ANALYSIS. This analysis includes only the ATC directed missed approach portion of each scenario. The purpose of this project was not to produce an exhaustive study of the time issue, but only to gather sufficient data runs to address the question of whether or not the clarification of the word "immediately" made a difference in the time necessary to initiate an ATC directed missed approach.

The phase II B-727 Simulator at the Mike Monroney Aeronautical Center was utilized to gather data on the directed missed approaches. Both manual control and autopilot control approaches were conducted by a series of currently type rated pilots. The intent of the analysis was to determine the average time and standard deviation of the time to initiate a missed approach upon direction from ATC. The intent was also to observe if there were any occurrences of excessive times (15 or more seconds) to initiate an ATC directed missed approach as were observed in both the B-727 and DC-10 Pilot Workload Projects.

Table 2 shows time statistics for the DC-10 Pilot Workload Project, the B-727 Pilot Workload Project, and this, the Time to Missed Approach Project. In both of the former projects the word "immediately" was not clarified, nor even mentioned in the pilot briefing as it relates to ATC directed missed approaches. Each pilot responded according to previous training and experience unique to that pilot. However, in this project the word "immediately" was included in the pre-flight briefing for each pilot, but not before each data run.

5.0 CONCLUSIONS AND RECOMMENDATIONS. The results show that there is not a significant difference in the mean time to initiate an ATC directed missed approach nor in the standard deviations in any of the three projects, i. e., the differences shown could be accounted for by chance. However, there are no excessive times reflected on any case for the current project. In addition, the maximum case which took 11 seconds was the result of ATC having to repeat the directive for an immediate turn. Appendix II contains frequency histograms of the time difference between ATC request and turn initiation for the B-727. The first histogram is from the B-727 Pilot Workload Project where the word "immediately" was not defined, and the second histogram is from the current project where the word "immediately" was defined. These two distributions are visually distinguishable only by the excessive reaction times shown on the first histogram.

Including data from all three projects, the average pilot takes about 6.3 seconds to initiate a turn as measured from the beginning

of an ATC directed missed approach turn directive. The standard deviation is about 4.0 seconds. Supposing that the distribution of pilot reaction times is normally distributed then less than 1.5% of the cases would result in turn initiation times in excess of 15 seconds (z-score = 2.175), and less than 0.03% would result in turn initiation times in excess of 20 seconds (z-score = 3.425). If only the current project is considered where the word "immediately" was defined, the mean was 5.6 seconds and the standard deviation was only 2.285 seconds. In a normally distributed function this results in less than 0.003% of the cases would exceed 15 seconds (z-score = 4.11) and less than 0.000 000 01% of the would exceed 20 seconds (z-score = 6.30), essentially a non-event.

A recommendation to improve safety on simultaneous independent parallel approach procedures is to include the meaning of the word "immediately" or another word that conveys this concept of urgency as it applies to ATC direction to pilots for aircraft maneuvers in all phases of training, and specifically, include ATC directed missed approaches during recurrent simulator training.

Table 2

Time Difference between Initiation of
ATC Directed Missed Approach and Turn Initiation

DC-10	The word "immediately" <u>not defined</u> . *	
	Number of cases	32
	Maximum time to turn	15 sec
	Minimum time to turn	2 sec
	Mean time to turn	6 sec
	Standard deviation	4 sec
B-727	The word "immediately" <u>not defined</u> . *	
	Number of cases	39
	Maximum time to turn	22 sec
	Minimum time to turn	2 sec
	Mean time to turn	7 sec
	Standard deviation	5 sec
B-727	The word "immediately" <u>defined</u> .	
	Number of cases	32
	Maximum time to turn	11 sec
	Minimum time to turn	2 sec
	Mean time to turn	5.6 sec
	Standard deviation	2.285 sec

Notes: Time was measured to the whole second. A turn was defined as exceeding and then maintaining more than 3° of left bank after ATC intervention.

* Denotes results from previous tests.

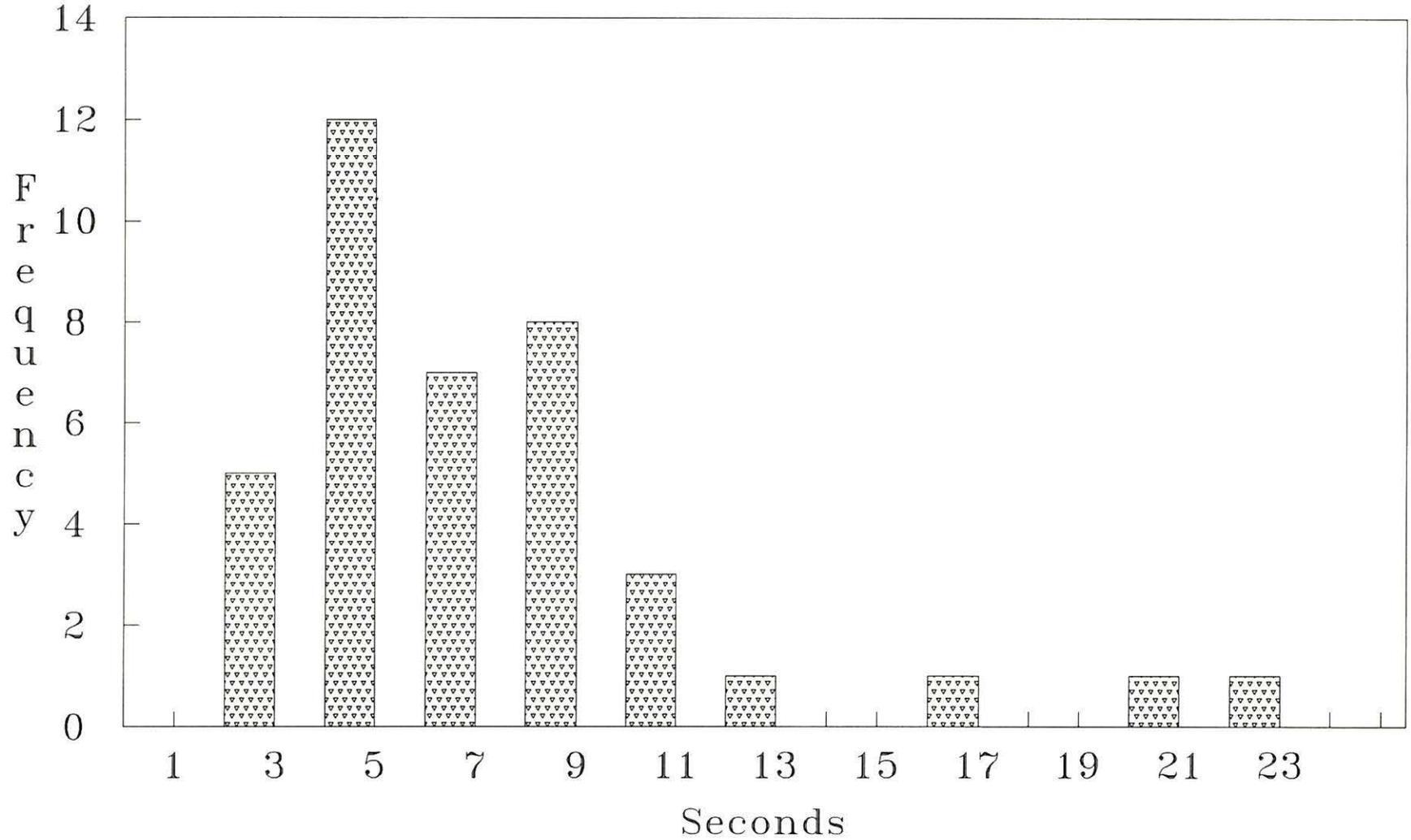
APPENDIX I

MEMPHIS
ILS RWY 36L
APPROACH CHART

APPENDIX II

- B-727 FREQUENCY HISTOGRAMS
i) "IMMEDIATELY" NOT DEFINED
ii) "IMMEDIATELY" DEFINED

Time Difference between ATC Request and
Turn Initiation
B-727
"Immediate" Not Defined



Time Difference between ATC Request and
Turn Initiation
B-727
"Immediate" Defined

