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Separation Requirements for Triple Simultaneous Independent Close Parallel Approaches - High Update Rate Surveillance Not Required

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Technical Report

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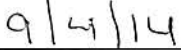
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12. Abstract The Federal Aviation Administration (FAA) Flight Standards closely spaced parallel operations team analyzed the risk of a collision between aircraft conducting triple simultaneous independent close parallel approaches without high update rate surveillance. The configurations analyzed were triple simultaneous independent close parallel approaches to (1) parallel runways with a runway centerline spacing (RCLS) of 3,900 feet or greater at airfield elevations 2,000 feet mean sea level or less; (2) approaches with a single 2.5° to 3° offset to either outside parallel runway with an RCLS of 3,000 feet or more and 2 parallel approaches to the other runways separated by 3,900 feet; and (3) approaches with two 2.5° to 3° offset approaches to both outside runways with an RCLS of 3,000 feet for all 3 runways at airfield elevations up to and including 2,000 feet. The analysis found the collision risk to be less than 1×10^{-9} per operation as required by the FAA Safety Management System (SMS). Hartsfield - Jackson Atlanta International Airport runway configuration and evasion case was also analyzed for this study. The analysis found the collision risk for the Atlanta case exceeded 1×10^{-9} per operation as required by the FAA SMS.		
13. Key Words blunder data collection effort (DCE) final monitor aid (FMA) GBAS Landing System (GLS) Ground-Based Augmentation System (GBAS) high update rate (HUR) human in the loop (HITL) Instrument Landing System (ILS) Localizer Performance with Vertical guidance (LPV) no transgression zone (NTZ) Precision Runway Monitor (PRM) probability density function (pdf) runway centerline spacing (RCLS) Standard Terminal Automation Replacement System (STARS) test criterion violation (TCV) Traffic Alert and Collision Avoidance System (TCAS)		14. Distribution Statement Uncontrolled
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EXECUTIVE SUMMARY

This report addresses the collision risk for triple simultaneous independent close parallel approach operations without the use of high update rate (HUR) surveillance. HUR means 1.0 second to 2.4 seconds, and close means the runways are separated by less than 4,300 feet.

This report builds upon the findings of two previous studies for simultaneous independent close parallel approaches without the use of HUR, which has previously been required for these operations. One study provided for a reduction in the required runway centerline spacing (RCLS) from 4,300 feet to 3,600 feet for dual parallel approaches without HUR [4], and the second study provided for offset operations to parallel runways separated by 3,000 feet or greater without HUR. [6] The Federal Aviation Administration (FAA) Safety Management System (SMS) collision risk of 1×10^{-9} per operation was used as the success criteria.

The analysis for all three studies was conducted with the Flight Technologies and Procedures Division's fast time simulation tool for aviation related safety assessments. Values for the input parameters to the tool were developed from several human in the loop studies previously conducted by the FAA. These inputs are based on the modern aircraft fleet, a 4.8 second surveillance update rate, the Standard Terminal Automation Replacement System (STARS) automation system using a final monitor aid (FMA) with visual and aural alerts, and a color digital display set to a 4-to-1 (4:1) aspect ratio (AR).

This study analyzed three triple parallel runway instrument approach configurations, i.e., (1) three parallel instrument approaches, (2) a 2.5° to 3° offset approach to either outside runway and two straight-in approaches to the other runways, and (3) 2.5° to 3° offset approaches to both outside runways with a straight-in approach to the center runway. For each configuration, there was no stagger between runway thresholds. The no transgression zone (NTZ) was 2,000 feet wide. Using the SMS collision risk of 1×10^{-9} per operation as the success criteria, and for airport field elevations at or below 2,000 feet mean sea level (MSL), the analysis resulted in an RCLS requirement for the first configuration of 3,900 feet. For the second configuration, the RCLS requirement between the two parallel approaches was 3,900 feet, and 3,000 feet for the offset. For the third configuration, the RCLS required between all three parallel runways was 3,000 feet.

Included in this study is an analysis of the Hartsfield - Jackson Atlanta International Airport (ATL) triple approach operations with a modified blunder evasion procedure utilizing a straight-ahead climb from the center runway. The RCLS between runways 8L/26R and 9R/27L is 6,450 feet, and between runways 9R/27L and 10/28 is 4,200 feet. This operation did not meet the SMS collision risk success criteria.

This study focused on the risk of collision only. No other safety risks were evaluated.

1.0 INTRODUCTION

The FAA is evaluating standards and methods for conducting closely spaced parallel operations with the goals of increasing capacity during instrument meteorological condition operations, reducing delays and maintaining safety. A blunder occurs when one aircraft unexpectedly turns toward the aircraft on the final approach course to a parallel runway and places the non-blundering aircraft at risk. The risk of collision due to a blunder is the prime concern.

The FAA Air Traffic Organization requested a collision risk evaluation for allowing triple simultaneous independent close parallel approach operations without the HUR surveillance requirement.

1.1 Purpose

The original purpose of this study was twofold. One was to determine the minimum RCLS for triple Simultaneous Independent Close Parallel Approach operations that would meet the FAA SMS collision risk of 1×10^{-9} per operation without the use of HUR surveillance. The second was to determine the RCLS for offset approaches to one or both outside runways using the same success criteria.

An additional purpose was to conduct a site specific analysis of triple operations at ATL.

1.2 Background

FAA Order JO 7110.65V, *Air Traffic Control*, paragraph 5-9-7, Simultaneous Independent Approaches – Dual and Triple, states that controllers may authorize simultaneous independent approaches to triple runways when centerlines are separated by at least 5,000 feet to airfields with elevations less than 1,000 feet MSL. The RCLS requirement can be reduced to at least 4,300 feet if a high-resolution color monitor with alert algorithms, such as the final monitor aid or that required in the precision runway monitor (PRM) program is used to monitor approaches. Triple parallel approaches to airports where the airport field elevation is 1,000 feet MSL or more and runways are at least 4,300 feet apart require the high resolution color monitor with alert algorithms and an approved FAA aeronautical study. [1]

Paragraph 5-9-8, of the Order, Simultaneous Independent Close Parallel Approaches – High Update Radar, states that controllers may authorize simultaneous close parallel approaches to dual runways separated by 3,400 feet to 4,300 feet by utilizing precision runway monitors and a surveillance update rate of 2.4 seconds or less. By utilizing a PRM system with a 1.0 second radar update system, and one final approach course offset by 2.5° to 3.0° , runway centerline spacing may be reduced to 3,000 feet. [1]

The Order also requires instrument approach procedures which authorize the simultaneous independent operation. The controllers must provide a minimum separation of 1,000 feet vertical or a minimum separation of 3 nautical miles (NM) between aircraft during turn-on to parallel final approach paths. They must also provide the minimum applicable radar separation between aircraft on the same final approach course.

An NTZ at least 2,000 feet wide is required to be established an equal distance between extended runway final approach courses and depicted on the monitor display. The NTZ begins from the point along the final approach courses where 1,000 feet of vertical aircraft separation is lost and terminates 0.5 NM beyond the furthest departure end of the runway and must be monitored to a height of 50 feet for category I, II, and III approaches. Separate monitor controllers, each with transmit/receive and override capability on the local control frequency are required for each runway and must issue breakout instructions if an aircraft penetrates the depicted NTZ. To avoid blocked transmissions, each runway will have two frequencies, a tower and a PRM monitor frequency. The PRM monitor controller's transmissions, if needed, will override both frequencies. Pilots are only allowed to transmit on the tower controller's frequency, but will listen to both frequencies. An Attention All Users Page is required which describes specific procedures used at each airport where these approaches are conducted. Special PRM training is required for pilots conducting simultaneous independent close parallel approaches, see Appendix C and Figure C-2.

The FMA function of the STARS automation system was used for this and other referenced studies in this report. It duplicates the functionality of the PRM FMA display.

1.3 Runway Approach Configurations

This section addresses the three generic runway approach configurations that were analyzed for this study. No stagger existed between runway thresholds, and the NTZ was 2,000 feet wide. Airport field elevation was varied up to and including 2,000 feet MSL for the following configurations. The first configuration included three parallel instrument approaches, see Figure 1-1. The normal operating zone (NOZ) allows for the normal deviations of the aircraft about the final approach course as well as for anomalies of the navigation signal in space.

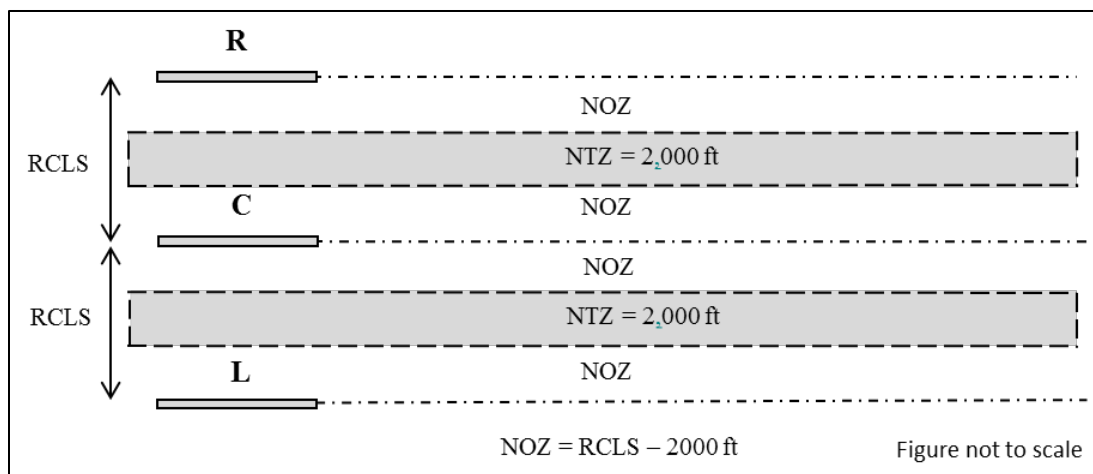


Figure 1-1. Triple Simultaneous Independent Close Parallel Approaches

The second configuration included a single offset instrument approach to either outside runway and straight-in approaches to the other two runways, see Figure 1-2. The use of an offset approach to one of the runways in dual simultaneous independent instrument approach operations provides for greater aircraft lateral separation at increasing distance from the threshold. As stated by FAA Order 8260.3b, *United States Standard for Terminal Instrument Procedures (TERPS)*, the final course is normally aligned with the runway centerline extended

($\pm 0.03^\circ$) through the runway threshold (± 5 feet). [2] Where a unique operational requirement indicates a need to offset the course from runway centerline, the offset must be not less than 2.5° or more than 3° . The offset course must intersect the runway centerline at a point 1,100 feet to 1,200 feet inside the decision altitude point. For offset courses, the minimum height above threshold at the decision altitude is 250 feet. The offset geometry required is depicted in Figures 1-2 and 1-3.

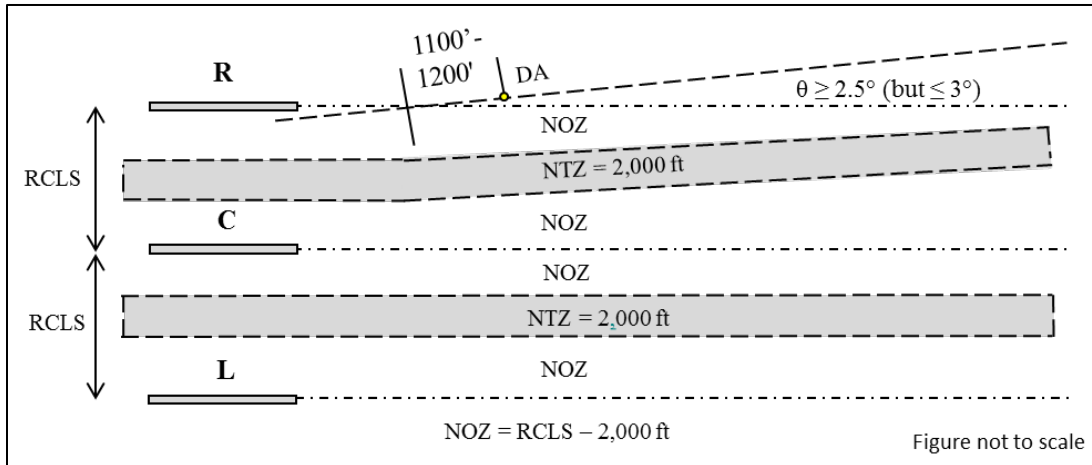


Figure 1-2. Triple Simultaneous Independent Instrument Approaches – Single Offset

The third configuration included offset instrument approaches on both outside runways and a straight-in approach to the center runway, see Figure 1-3. The use of an offset approach to both outside runways provides the most aircraft lateral separation at increasing distance from the threshold which allows a reduction in the required RCLS for all three runways when compared to the two configurations discussed above.

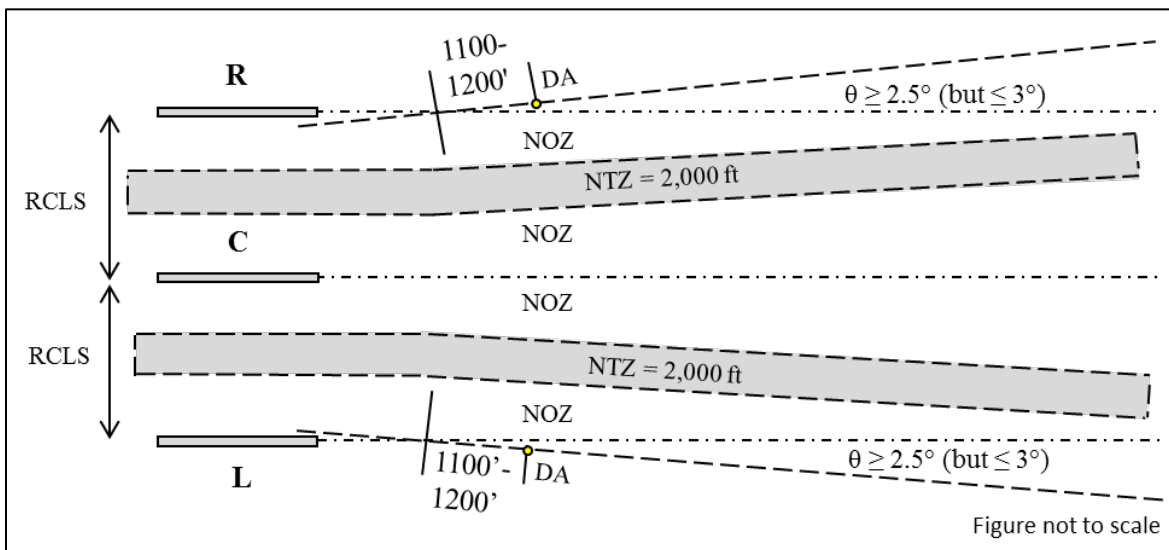


Figure 1-3. Triple Simultaneous Independent Instrument Approaches – Dual Offsets

1.4 Scope

The focus of this study was to evaluate the collision risk of the proposed operations without HUR surveillance. Of the requirements stated in Section 1.2, this study removed the requirement for HUR surveillance and determined an RCLS that met the acceptable level of risk. The airport field elevation was evaluated up to and including 2,000 feet MSL, which affects ground speed, decent rate and aircraft closure rates. Wake vortex studies have shown that the wake has dissipated to a negligible level once it is beyond 2,500 feet from the runway centerline. Since the operations analyzed in this study were to runways separated by 3,000 feet or greater, wake vortex encounters and their associated risks were not evaluated.

2.0 STUDY METHODOLOGY

This study evaluated the runway geometries described in Section 1.3 using an Airport Surveillance Radar-9 with a 4.8 second update rate, a STARS FMA with color digital display, visual and aural alerts, and a 4:1 AR. This AR is specified by FAA Order JO 6191.3a. [3]. The FMA displays each runway, the approach course to each runway, and an outline of the NTZ between them. It also displays each aircraft target, the aircraft type and call sign, and a 10 second predictor target line which depicts the target position 10 seconds into the future. When the predictor target line indicates an aircraft is within 10 seconds of entering the NTZ, the outline of the NTZ turns yellow, a yellow “NTZ” flashes directly above the aircraft call sign, the call sign of the aircraft and “caution” are announced. If the aircraft enters the NTZ, the outline of the NTZ turns red, the flashing “NTZ” turns red, the call sign of the aircraft and “warning” are announced. With the exception of HUR surveillance, the requirements for this operation meet those of FAA Order JO 7110.65V, *Air Traffic Control*, paragraph 5-9-8; Simultaneous Independent Close Parallel Approaches – High Update Radar. [1]

2.1 Fast Time Simulation

2.1.1 Airspace Simulation and Analysis Tool – new generation

The primary analysis tool for this safety study was the Flight Systems Laboratory Airspace Simulation and Analysis Tool – new generation (ASAT^{ng}). ASAT^{ng} is a multifaceted fast time simulation tool for aviation related safety assessments. The analysis tool uses high fidelity models of all components of an aviation scenario to evaluate the overall risk of the operation. A wide range of parameters covering operational aspects, such as aircraft performance, navigation system performance, Air Traffic Control (ATC) monitoring and surveillance equipment along with pilot response time and controller response time (CRT) probability density functions (pdfs) enable very efficient and realistic modeling of complex operational scenarios. ASAT^{ng} uses official FAA databases of navigation and surveillance facilities, runways, fixes, etc., and its flight dynamic models account for atmospheric conditions. Aircraft fleet mix for the National Airspace System (NAS) interest is incorporated into the simulations.

2.1.2 Pilot Response Time and Controller Response Time pdfs

Several human in the loop simulations have been conducted on simultaneous parallel, closely spaced independent approaches by the FAA. Using the data from these human in the loop simulations, pdfs have been developed for the parameters required for input to the fast time simulation tool. The pdfs are described in References 4 to 6. This study applied the pilot response times associated with closely spaced, simultaneous independent parallel instrument approaches, which implies each pilot understands the importance of rapid response to the event of a blunder and briefs the breakout maneuver before initiation of the approach.

2.1.3 Blunders

MITRE was tasked by the FAA to examine approach data at 12 major airports where parallel approach operations are conducted during instrument meteorological conditions. The Flight Systems Laboratory developed a mathematical method for fitting polynomial curves to the area of each flight track where the blunder or course deviation occurred in the data set. An additional

mathematical procedure was developed and used to provide an estimate of the deviation angle. Deviation rates for blunder angles, and 99% confidence intervals (assuming a binomial distribution) for those rates, were calculated and are used in the fast time simulation.

2.1.4 Fleet Mix

The fleet mix used in this study and the study in Reference 4 was developed to be a representation of the traffic observed in the NAS. It was developed using data obtained from the Extended Traffic Management System count of aircraft at all major airports in the NAS that operate simultaneous instrument approaches. The Extended Traffic Management System data suggests that, on average, the percentage of heavy aircraft in the NAS is approximately 5%. During peak intervals, this percentage can increase to a higher level, but it has never been greater than 20%. Not all aircraft types are used in this study. This particular fleet mix reflects a conservative representation of NAS traffic as it includes a higher than expected percentage of heavy aircraft. The mix was comprised of 20% heavy aircraft (10% Boeing 747-400 and 10% Airbus A330-200), 40% Boeing B737-800 and 40% Embraer Regional Jet ERJ-145.

2.1.5 Assumptions

Assumptions used in this study included the following:

- The approach procedures authorized the simultaneous operation;
- Approved approaches included:
 - Instrument Landing System (ILS);
 - Ground-Based Augmentation System Landing System (GLS);
 - Area Navigation (RNAV) (Global Positioning System (GPS)); and
 - RNAV (Required Navigation Performance (RNP)).
- Vertical guidance was utilized;
- The aircraft was flown using a flight director or autopilot;
- Breakout obstacle assessments were completed in the design of the instrument approach procedure;
- The instrument approach procedures all use a nominal 3° glide path. Different glide path angles between the adjacent parallel approaches would reduce the collision risk;
- Aircraft were established on the final approach course pursuant to all other criteria contained in FAA Order JO 7110.65V; [1]
- Aircraft followed approach control directed speeds up to the point of configuring for the final approach; the aircraft would begin decelerating to their final approach speed no later than 2 NM prior to the final approach fix;
- The surveillance source provided the coverage specified in Section 1.2 and was independent from the navigation system;
- Controllers were qualified and certified for final monitor duties;
- Each runway had a separate NTZ monitor controller and tower controller, and two frequencies, a tower and a PRM monitor frequency. The tower controller transmitted on both frequencies. The PRM monitor controller's transmissions, if needed, overrode both frequencies;
- Pilots were qualified to fly simultaneous close parallel approaches;
- Pilots reviewed and complied with the requirements listed in the Attention All Users Page, see Appendix C and Figure C-2:
 - To notify ATC if not qualified to participate in the operation;
 - To comply with specific briefing points required prior to beginning the procedure;
 - To comply with dual VHF communications tuning and monitoring requirements; and
 - To comply with hand flying the specified breakout procedures immediately.
- Blunders were initiated uniformly along the final approach course;
- Aircraft fleet mix included a 20% heavy aircraft which is a conservative representative of the traffic at major airports such as Dallas Fort Worth International, San Francisco International, John F. Kennedy International; and
- As described in Section 1.3, no stagger exists between runway thresholds. Staggered thresholds would reduce the collision risk.

3.0 COLLISION RISK EVALUATION

A collision between aircraft is the catastrophic event used to determine the acceptable level of risk specified in the FAA SMS. For this study, a test criterion violation (TCV) was used as a mathematical model of a collision and is described as a cylinder, with a radius of 265 feet and a height of 160 feet (± 80) centered on the endangered aircraft's center of gravity. [7] If the blundering aircraft center of gravity penetrated this TCV cylinder, a collision was assumed to have occurred. Several human in the loop Data Collection Efforts (DCE)s conducted since July 2009 have been used to refine the CRT, pilot response time and aircraft dynamics used in the ASAT^{ng} fast time simulations to study various runway spacing distances and proposed operations within the NAS. [4]

A test environment can sometimes lead to erroneous sample results. For example, in the real-time simulations used to collect pilot and controller response times, blunders are simulated at an unrealistic rate. Since each pilot or controller participates in numerous blunder scenarios, there is the possibility that their response times are shortened due to the learning effect. The investigator can gain insight into the significance of the learning effect by a process called sensitivity analysis. In this case, the mean of the controller or the pilot response time can be shifted or increased by known increments to determine the effect of longer response times than those observed during the real-time simulation.

The mean of a distribution used in a fast time simulation can be increased during the simulation by adding the desired amount of the shift to each random value generated by the probability density function. In study DOT-FAA-AFS-450-69, *Simultaneous Independent Close Parallel Approaches – High Update Radar Not Required*, a sensitivity analysis was performed on the total collision risk to determine compensation requirements resulting from the learning effect. The sensitivity analysis recommended a two second shift in the mean of the CRT pdf to compensate for the learning effect. [4] Therefore, the mean of the CRT pdf was shifted to the right by two seconds in this study.

3.1 Collision Risk Data Analysis

Should an aircraft on one of the outside runways blunder, the aircraft on the opposite outside runway (if at risk) will always have more time to evade, therefore the risk for this aircraft is less than for the center aircraft. The controllers monitoring the evading aircraft are co-located, and it is assumed that these two controllers are coordinating their actions so there is no danger of the evaders colliding.

For the collision risk analysis of the three parallel instrument approach configurations, using a CRT increased by two seconds (2-second CRT delta), see Tables 3-1 and 3-2. Table 3-1 presents the collision risk results for airport field elevations up to 1,000 feet MSL. The results indicate that for triple simultaneous independent close parallel approach operations to runways spaced 3,900 feet or greater with field elevations at or below 1,000 feet MSL, the collision risk is less than 1×10^{-9} per operation. For detailed analysis of the data, see Appendix B and Table B-1.

Table 3-1. Triple Simultaneous Independent Close Parallel Approach Collision Risk (≤ 1,000 feet MSL)

1,000 feet Runway Elevation						
RCLS	ILS-ILS-ILS	RNP-ILS-ILS / ILS-ILS-RNP	ILS-RNP-ILS	RNP-RNP-ILS / ILS-RNP-RNP	RNP-ILS-RNP	RNP-RNP-RNP
3,600	1.16E-09	1.18E-09	1.18E-09	1.19E-09	1.19E-09	1.20E-09
3,700	1.09E-09	1.10E-09	1.12E-09	1.11E-09	1.11E-09	1.11E-09
3,800	1.02E-09	1.02E-09	1.02E-09	1.02E-09	1.03E-09	1.03E-09
3,900	9.40E-10	9.42E-10	9.51E-10	9.51E-10	9.43E-10	9.52E-10

Table 3-2 presents the collision risk results for triple simultaneous independent close parallel approach operations to runways spaced 3,900 feet or greater with airport field elevations at or below 2,000 feet MSL. As can be seen, runways spaced 3,900 feet or greater with field elevations at or below 2,000 feet MSL, meet the required level of collision risk. For detailed analysis of the data, see Appendix B and Table B-1.

Table 3-2. Triple Simultaneous Independent Close Parallel Approach Collision Risk (≤ 2,000 Feet MSL)

2,000 feet Runway Elevation						
RCLS	ILS-ILS-ILS	RNP-ILS-ILS / ILS-ILS-RNP	ILS-RNP-ILS	RNP-RNP-ILS / ILS-RNP-RNP	RNP-ILS-RNP	RNP-RNP-RNP
3,600	1.24E-09	1.24E-09	1.23E-09	1.24E-09	1.24E-09	1.24E-09
3,700	1.14E-09	1.15E-09	1.15E-09	1.15E-09	1.16E-09	1.16E-09
3,800	1.06E-09	1.07E-09	1.06E-09	1.07E-09	1.08E-09	1.09E-09
3,900	9.82E-10	9.86E-10	9.89E-10	9.92E-10	9.90E-10	9.95E-10

A 2.5° to 3° offset approach provides an increase in the width of the NOZ with increasing distance from the runway threshold, see Figures 1-2 and 1-3. This added distance between approach paths increases the amount of time for a controller to respond to a blunder. This is seen by a decrease in the collision risk as compared to the parallel approach configuration.

For the collision risk results using a 2-second CRT delta for single and dual offset approaches to triple runway configurations with field elevations at or below 2,000 feet MSL, see Table 3-3. Results are shown for a single offset approach to one outside runway with an RCLS of 3,000 feet or more and 2 parallel approaches to the other 2 runways separated by 3,900 feet or more. For a detailed analysis of the data, see Appendix B and Table B-2.

Table 3-3. Single and Dual Offset Approaches to Triple Runway Collision Risk

Runway Elevation (ft)	Offset Approach Type	Navigation Configuration	RCLS (Offset Apch Pair)	RCLS (Parallel Apch Pair)	Total Risk
2,000	Single	ILS offset / ILS / ILS	3,000	3,900	8.28E-10
2,000	Dual	ILS offset / ILS / ILS offset	3,000 / 3,000	N/A	6.91E-10

3.2 ATL Specific Collision Risk Analysis

Atlanta TRACON requested a collision risk evaluation of the ATL runway configuration for allowing triple simultaneous independent close parallel operations without the HUR surveillance requirement. The runway configuration analyzed for ATL included parallel instrument approaches to three parallel runways with an RCLS of 6,450 feet between runways 26R/08L and 27L/09R, and 4,200 feet between runways 27L/09R and 28/10. The northern runway (26R/08L) landing threshold is staggered 2,723 feet east of the southern runway pair. For a depiction of the airfield diagram, see Appendix C and Figure C-1.

Additional data analysis was required to address Atlanta TRACON’s planned procedure for resolving a center runway evasion due to a blunder from either outside runway. The analysis in Section 3.1 was based on the evading center runway aircraft turning 45° or more away from their final approach course to avoid the blundering aircraft. Atlanta TRACON requested analysis based on the evading center runway aircraft climbing on runway heading. For the collision risk results for triple simultaneous independent close parallel approach operations at ATL using a two-second CRT delta, see Table 3-4. The results show two different evasion cases considered for ATL. The baseline comparison (turning evasion) values shown in column 2 indicate that evading aircraft that turn 45° or more away from a blundering aircraft result in a collision risk less than 1×10^{-9} per operation. However, the climb-only evasion results fail to meet the FAA SMS collision risk requirement.

Table 3-4. ATL Triple Simultaneous Independent Close Parallel Approach

RWY 28 Blunder to 27L	Turning Evasion (Base Line Comparison)	Climb-Only Evasion Results
ILS-ILS	7.81E-10	2.05E-09
ILS-RNP	7.44E-10	2.07E-09
RNP-ILS	8.02E-10	2.06E-09
RNP-RNP	7.86E-10	2.07E-09

4.0 CONCLUSIONS

This section summarizes the results of the collision risk analyses.

4.1 Risk Analysis

Triple simultaneous independent close parallel approaches to the runway configurations described in Section 1.3 were analyzed with the assumptions listed in section 2.1.5. The analysis used a surveillance update rate of 4.8 seconds or less, a STARS FMA with visual and aural alerts, and a color digital display set to a 4:1 AR. The success criteria used was a collision risk less than 1×10^{-9} per operation as required by the FAA SMS. The following runway centerline spacing distances met the criteria:

- Triple simultaneous independent close parallel approach operations at airport elevations at or below 2,000 feet MSL for runways separated by 3,900 feet or greater;
- Triple simultaneous independent close parallel approach operations with a single 2.5° to 3.0° offset approach to either outside runway separated by 3,000 feet or more and parallel approaches to the other 2 runways separated by 3,900 feet or more at airport elevations at or below 2,000 feet MSL;
- Triple simultaneous independent close parallel approach operations to runways separated by 3,000 feet or greater with 2.5° to 3.0° offset approaches to both outside runways at airport elevations at or below 2,000 feet MSL; and
- Any combination of ILS, RNAV (GPS), RNAV (RNP), or Ground-Based Augmentation System Landing System (GLS) Approaches with vertical guidance for aircraft using the flight director or autopilot.

4.2 ATL Site Specific Evaluation

The results of the ATL site specific analysis described in Section 3.2 indicate the risk is greater than 1×10^{-9} per operation for triple simultaneous independent close parallel approach operations utilizing a climb straight-ahead evasion method for the center runway to avoid a blundering aircraft while flying the procedure. However, if standard evasion procedures were utilized (45° turn or more away from their final approach course to avoid the blundering aircraft), the analysis indicated the collision risk would be met.

4.3 Other Risks

This study focused on the risk of collision. No other safety risks were evaluated.

REFERENCES

1. **FAAO JO 7110.65V**, *Air Traffic Control*, April 2014, U.S. Department of Transportation/Federal Aviation Agency/Air Traffic Organization Policy.
2. **FAA Order 8260.3b**, United States Standard for Terminal Instrument Procedures (TERPS), February 2014.
3. **FAA Order JO 6191.3a**, Standard Terminal Automation Replacement System (STARS), November 2006.
4. **DOT-FAA-AFS-450-69**, *Simultaneous Independent Close Parallel Approaches – High Update Radar Not Required*, September 2011
5. **DOT-FAA-AFS-450-80**, *Dual Simultaneous Independent Parallel Instrument Approach (SIPIA) Closely Spaced Parallel Operations (CSPO) Site Specific Evaluation for Chicago O’Hare*, September 2013.
6. **DOT-FAA-AFS-450-84**, *Separation Requirements for Simultaneous Offset Independent Dual Instrument Approaches Using a 2.5 to 3.0 Degree Offset*, July 2013.
7. **DOT-FAA-AFS-450-63**, Technical Report, *Geometrical Models for Aircraft in Terminal Area Risk Analyses*, May 2011.
8. **DOT-FAA-AFS-450-41**, Safety Study Report on Simultaneous Parallel Instrument Landing System (ILS) and Area Navigation (RNAV)/Required Navigation Performance (RNP) Approaches—Phases 1B and 2B, Dr. Gerry McCartor, AFS-450, Shahar Ladecky, ATSI, December 2008.
9. **DOT/FAA/RD-91/5**, Precision Runway Monitor Demonstration Report, Precision Runway Monitor Program Office, ARD-300, February, 1991.
10. **MP120414**, *Frequency and Severity of Deviations during Simultaneous Independent Approaches to Parallel Runways 2008 - 2012*, The MITRE Corp., Eckstein, A.C., Massimini, S. V., McNeil, G.C., Niles, F.A., August 2012.

APPENDIX A. RISK ANALYSIS

Several events must occur simultaneously for a collision to occur during a simultaneous instrument approach. Clearly, a blunder must occur, or there would be no significant deviation from course, see Figure A-1. The blundering aircraft must be aligned so that a TCV will occur without timely action from both the air traffic controller and the pilot of the evading aircraft. An aligned blunder is called an at-risk blunder (ARB) and is denoted in the equation. If all of the above events develop in a manner supporting a collision, a TCV occurs unless the controllers and pilots react in sufficient time to separate the blundering and the evading aircraft.

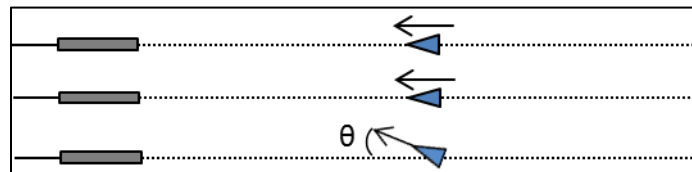


Figure A-1. Blunder Depiction

In addition, the blundering aircraft must not respond to ATC directions to return to the localizer azimuth course. This is called a non-responding blunder (NRB). The value used for NRB (1/100) has been used in numerous prior studies. [8, 9] This number is further validated by the results of an extensive blunder DCE performed by MITRE. [10] MITRE investigated over 1.8 million simultaneous approaches at 12 United States airports and observed 82 deviations of aircraft from their final approach courses that entered the NTZ, whether or not there was an aircraft on the parallel approach. These were determined to be blunders. Of these 82 blunders, all deviating aircraft corrected back to course. The majority of these corrections are assumed to have been initiated by the controller instructing the aircraft to return to course, highlighting the importance of controller approach monitoring. This data is consistent with an NRB rate of 1/100 NRB as follows.

If the random variable X represents the number of successes in n trials of a binomial experiment¹ in which the probability of a single independent success is p , the probability that $X = x$ is given by the binomial distribution equation:

$$P(X = x) = \binom{n}{x} p^x (1 - p)^{n-x} \quad (\text{A-1})$$

If there are 82 trials (i.e., $n = 82$) and no successes (i.e., $x = 0$) then:

$$P(X = 0) = \binom{82}{0} p^0 (1 - p)^{82} = (1 - p)^{82} \quad (\text{A-2})$$

Therefore, a distribution for the unknown parameter, p , the probability of a success given the empirical result of no successes in 82 trials, can be based on Equation A-2.

Since p represents a probability, its values must range between 0 and 1 and a pdf for the distribution derived from Equation A-2 must integrate to the value of 1 between those bounds. This is enough information to derive a unique pdf for p , given the empirical result. Equation A-3 is that pdf and Figure A-2 is its graph.

$$f(p) = 83(1 - p)^{82} \quad (\text{A-3})$$

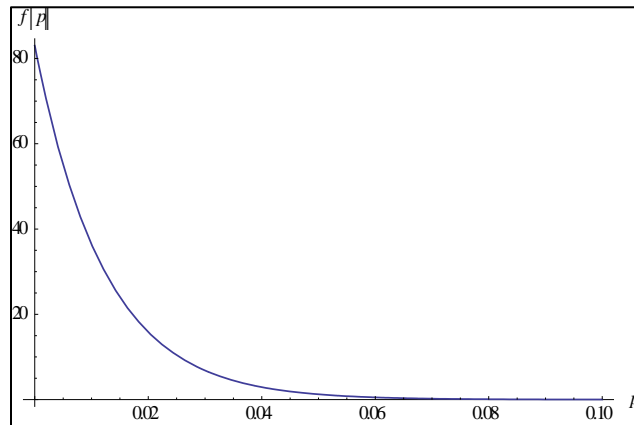


Figure A-2. Graph of Equation A-3 pdf

¹ In this experiment, a trial is a blunder and a success is a NRB.

The pdf (Equation A-3) can be used to calculate likely values for p . For example, the median value for p , is the value p_m for which the integral from 0 to p_m is 0.5. This calculation shows that $p_m = 0.00832$. This value would then be the most realistic estimate, statistically, for p , given the empirical result. Thus, given the available data, the value of 1/100 is a conservative estimate for the NRB factor in calculations below.

A collision involves two aircraft and results in two accidents, as defined by the National Transportation Safety Board. Assuming that a TCV will result in a collision, the probability of a collision can be expressed in mathematical terms by:

$$P(\text{Collision}) = P(\text{TCV}|\text{NRB} \cap \text{ARB} \cap \text{BL}) \times P(\text{NRB}|\text{ARB} \cap \text{BL}) \times P(\text{ARB}|\text{BL}) \times P(\text{BL}) \quad (\text{A-4})$$

The symbol “ \cap ” stands for “and”. The symbol “ $|$ ” stands for “given”.

Factor 1 in the equation is expressed as:

$$P(\text{TCV}|\text{NRB} \cap \text{ARB} \cap \text{BL}) \quad (\text{A-5})$$

Factor 1 determines the probability that a TCV occurs given that a non-responding, ARB has occurred. This is the TCV rate that is determined from the simulation.

Factor 2 in the equation is expressed as:

$$P(\text{NRB}|\text{ARB} \cap \text{BL}) \quad (\text{A-6})$$

Factor 2 determines the probability that the blundering aircraft does not respond to ATC instruction to return to course given that an at-risk blunder has occurred. The value of this factor is 1/100.

Factor 3 in the equation is expressed as:

$$P(\text{ARB}|\text{BL}) \quad (\text{A-7})$$

Factor 3 is the probability that the blunder is an ARB given that a blunder has occurred. The value of this factor was estimated from simulation data using the TCV shape described in Section 3.0 of this report and was found to be 3.17×10^{-2} .

Factor 4 in the equation is expressed as:

$$P(\text{BL}) \quad (\text{A-8})$$

Factor 4 is the probability of a blunder of a specified angle, such as 20°. The probability and frequency of the occurrence of various blunder angles up to 35° has been determined from blunder data captured from actual simultaneous approaches conducted in less than visual meteorological conditions.

APPENDIX B. ASAT^{ng} ANALYSIS RESULTS

Fast time simulations were conducted using the ASAT^{ng} simulation tool to determine the probability of collision based on varying airport field elevations, RCLS, navigation configurations, and blunder angles. Although only RNP and ILS approaches are listed in Table B-1, all potential navigation configuration combinations were considered based on their equivalence and for the results of the fast time simulation, see Table B-1.

Table B-1. ASATng Calculation Method and Resulting Probabilities Triple Simultaneous Independent Close Parallel Approach

Runway Elevation (ft)	Navigation Configuration (L – C – R)	Runway Spacings (ft)	Blunder Angle, θ (°)	150,000 Simulations		P(Collision θ)	P(Collision)
				Level Blunder TCV's	Descending Blunder TCV's		
1,000	ILS-ILS-ILS	3,600/3,600	20	5,262	4,907	2.74E-10	1.16E-09
			30	30,827	40,130	8.85E-10	
1,000	RNP-ILS-ILS / ILS-ILS-RNP	3,600/3,600	20	5,336	4,913	2.76E-10	1.18E-09
			30	31,731	40,576	9.02E-10	
1,000	ILS-RNP-ILS	3,600/3,600	20	5,179	4,964	2.73E-10	1.18E-09
			30	32,324	40,534	9.08E-10	
1,000	RNP-RNP-ILS / ILS-RNP-RNP	3,600/3,600	20	5,275	5,058	2.78E-10	1.19E-09
			30	32,587	40,768	9.15E-10	
1,000	RNP-ILS-RNP	3,600/3,600	20	5,409	4,891	2.78E-10	1.19E-09
			30	32,649	40,899	9.17E-10	
1,000	RNP-RNP-RNP	3,600/3,600	20	5,370	5,123	2.83E-10	1.20E-09
			30	32,863	40,879	9.19E-10	
1,000	ILS-ILS-ILS	3,700/3,700	20	4,446	4,141	2.31E-10	1.09E-09
			30	30,958	37,900	8.59E-10	
1,000	RNP-ILS-ILS / ILS-ILS-RNP	3,700/3,700	20	4,552	4,090	2.33E-10	1.10E-09
			30	31,533	38,158	8.69E-10	
1,000	ILS-RNP-ILS	3,700/3,700	20	4,812	4,295	2.45E-10	1.12E-09
			30	31,545	38,501	8.73E-10	
1,000	RNP-RNP-ILS / ILS-RNP-RNP	3,700/3,700	20	4,644	4,192	2.38E-10	1.11E-09
			30	31,660	38,506	8.75E-10	
1,000	RNP-ILS-RNP	3,700/3,700	20	4,656	4,033	2.34E-10	1.11E-09
			30	32,095	38,524	8.81E-10	
1,000	RNP-RNP-RNP	3,700/3,700	20	4,473	4,083	2.31E-10	1.11E-09
			30	31,763	38,619	8.78E-10	
1,000	ILS-ILS-ILS	3,800/3,800	20	3,747	3,308	1.90E-10	9.84E-10
			30	27,709	35,948	7.94E-10	
1,000	RNP-ILS-ILS / ILS-ILS-RNP	3,800/3,800	20	3,770	3,341	1.92E-10	1.01E-09
			30	29,213	36,046	8.14E-10	
1,000	ILS-RNP-ILS	3,800/3,800	20	3,857	3,490	1.98E-10	1.02E-09
			30	30,076	35,621	8.19E-10	
1,000	RNP-RNP-ILS / ILS-RNP-RNP	3,800/3,800	20	3,822	3,463	1.96E-10	1.02E-09
			30	30,419	35,876	8.27E-10	
1,000	RNP-ILS-RNP	3,800/3,800	20	3,793	3,362	1.93E-10	1.03E-09
			30	30,711	36,248	8.35E-10	
1,000	RNP-RNP-RNP	3,800/3,800	20	3,787	3,423	1.94E-10	1.03E-09
			30	30,756	36,235	8.35E-10	
1,000	ILS-ILS-ILS	3,900/3,900	20	3,266	2,862	1.65E-10	9.40E-10
			30	28,838	33,348	7.75E-10	
1,000	RNP-ILS-ILS / ILS-ILS-RNP	3,900/3,900	20	3,192	2,885	1.64E-10	9.42E-10
			30	28,884	33,507	7.78E-10	
1,000	ILS-RNP-ILS	3,900/3,900	20	3,118	3,023	1.65E-10	9.51E-10
			30	29,142	33,841	7.85E-10	
1,000	RNP-RNP-ILS / ILS-RNP-RNP	3,900/3,900	20	3,166	2,954	1.65E-10	9.51E-10
			30	29,042	34,035	7.86E-10	
1,000	RNP-ILS-RNP	3,900/3,900	20	3,117	2,901	1.62E-10	9.43E-10
			30	28,956	33,647	7.81E-10	
1,000	RNP-RNP-RNP	3,900/3,900	20	3,213	2,879	1.64E-10	9.52E-10
			30	28,968	34,211	7.88E-10	
2,000	ILS-ILS-ILS	3,600/3,600	20	5,935	5,572	3.10E-10	1.24E-09
			30	32,480	42,042	9.29E-10	
2,000	RNP-ILS-ILS / ILS-ILS-RNP	3,600/3,600	20	5,876	5,530	3.07E-10	1.24E-09
			30	32,612	42,068	9.31E-10	
2,000	ILS-RNP-ILS	3,600/3,600	20	5,941	5,530	3.09E-10	1.23E-09
			30	31,980	42,203	9.25E-10	
2,000	RNP-RNP-ILS / ILS-RNP-RNP	3,600/3,600	20	5,909	5,557	3.09E-10	1.24E-09
			30	32,207	42,251	9.28E-10	
2,000	RNP-ILS-RNP	3,600/3,600	20	5,817	5,474	3.04E-10	1.24E-09
			30	32,712	42,092	9.33E-10	
2,000	RNP-RNP-RNP	3,600/3,600	20	5,877	5,570	3.08E-10	1.24E-09

			30	32,401	42,296	9.31E-10	
2,000	ILS-ILS-ILS	3,700/3,700	20	4,879	4,752	2.60E-10	1.14E-09
			30	31,240	39,586	8.83E-10	
2,000	RNP-ILS-ILS / ILS-ILS-RNP	3,700/3,700	20	4,973	4,791	2.63E-10	1.15E-09
			30	31,449	39,861	8.89E-10	
2,000	ILS-RNP-ILS	3,700/3,700	20	5,082	4,845	2.67E-10	1.15E-09
			30	31,051	39,606	8.81E-10	
2,000	RNP-RNP-ILS / ILS-RNP-RNP	3,700/3,700	20	5,108	4,722	2.65E-10	1.15E-09
			30	31,392	39,847	8.88E-10	
2,000	RNP-ILS-RNP	3,700/3,700	20	5,067	4,807	2.66E-10	1.16E-09
			30	31,631	40,189	8.95E-10	
2,000	RNP-RNP-RNP	3,700/3,700	20	5,133	4,577	2.62E-10	1.16E-09
			30	31,707	40,141	8.96E-10	
2,000	ILS-ILS-ILS	3,800/3,800	20	4,114	4,000	2.19E-10	1.06E-09
			30	30,481	37,222	8.44E-10	
2,000	RNP-ILS-ILS / ILS-ILS-RNP	3,800/3,800	20	4,203	4,017	2.21E-10	1.07E-09
			30	30,555	37,474	8.48E-10	
2,000	ILS-RNP-ILS	3,800/3,800	20	4,332	3,940	2.23E-10	1.06E-09
			30	29,856	37,362	8.38E-10	
2,000	RNP-RNP-ILS / ILS-RNP-RNP	3,800/3,800	20	4,376	3,894	2.23E-10	1.07E-09
			30	30,405	37,830	8.51E-10	
2,000	RNP-ILS-RNP	3,800/3,800	20	4,292	4,023	2.24E-10	1.08E-09
			30	30,621	37,760	8.53E-10	
2,000	RNP-RNP-RNP	3,800/3,800	20	4,419	3,838	2.22E-10	1.09E-09
			30	30,946	38,332	8.64E-10	
2,000	ILS-ILS-ILS	3,900/3,900	20	3,620	3,370	1.88E-10	9.82E-10
			30	28,749	34,901	7.94E-10	
2,000	RNP-ILS-ILS / ILS-ILS-RNP	3,900/3,900	20	3,584	3,297	1.85E-10	9.86E-10
			30	29,035	35,193	8.01E-10	
2,000	ILS-RNP-ILS	3,900/3,900	20	3,473	3,279	1.82E-10	9.89E-10
			30	29,200	35,526	8.07E-10	
2,000	RNP-RNP-ILS / ILS-RNP-RNP	3,900/3,900	20	3,564	3,240	1.83E-10	9.92E-10
			30	29,181	35,707	8.09E-10	
2,000	RNP-ILS-RNP	3,900/3,900	20	3,548	3,221	1.82E-10	9.90E-10
			30	29,322	35,457	8.08E-10	
2,000	RNP-RNP-RNP	3,900/3,900	20	3,655	3,199	1.85E-10	9.95E-10
			30	29,163	35,859	8.11E-10	
2,000	ILS-ILS-ILS	4,000/4,000	20	2,807	3,034	1.57E-10	9.21E-10
			30	28,021	33,236	7.64E-10	
2,000	RNP-ILS-ILS / ILS-ILS-RNP	4,000/4,000	20	2,863	2,817	1.53E-10	9.18E-10
			30	28,145	33,186	7.65E-10	
2,000	ILS-RNP-ILS	4,000/4,000	20	3,015	2,792	1.56E-10	9.27E-10
			30	28,098	33,700	7.71E-10	
2,000	RNP-RNP-ILS / ILS-RNP-RNP	4,000/4,000	20	3,021	2,769	1.56E-10	9.24E-10
			30	28,151	33,450	7.68E-10	
2,000	RNP-ILS-RNP	4,000/4,000	20	2,919	2,631	1.50E-10	9.13E-10
			30	28,266	32,980	7.64E-10	
2,000	RNP-RNP-RNP	4,000/4,000	20	3,027	2,778	1.56E-10	9.20E-10
			30	28,202	33,043	7.64E-10	

Table B-2. ASATng Calculation Method and Resulting Probabilities for Single and Dual Offset Triple Simultaneous Independent Close Parallel Approach

2,000	ILS offset-ILS-ILS	3,000/3,900	20	2,455	2,174	1.25E-10	8.28E-10
			30	26,989	29,449	7.04E-10	
2,000	ILS offset-ILS-ILS offset	3,000/3,000	20	1,290	998	6.17E-11	6.91E-10
			30	26,511	23,932	6.29E-10	

ATTENTION ALL USERS PAGE (AAUP)

Pilots who are unable to participate will be afforded appropriate arrival services as operational conditions permit and must notify the controlling ARTCC as soon as practical, but at least 100 miles from destination.

Required Briefing: Brief the bullet points.

ILS PRM Rwy's 8L, 8R, 9L, 9R, 10, 26L, 26R, 27L, 27R, 28

Briefing Points:

- When in range, tune in the PRM monitor frequency on a secondary radio, set the audio volume, then deselect the audio until switched to the tower frequency. If no communications are heard on the PRM frequency, set the volume by tuning to another frequency (i.e. the ATIS) to verify functionality of secondary radio, and return to the PRM monitor frequency.
- When instructed to switch to the tower frequency, select the PRM monitor frequency audio on.
- Descending on the ILS glideslope ensures compliance with any charted crossing restrictions.

EXPANDED PROCEDURES (Optional, brief if necessary)

1. **ATIS.** When the ATIS broadcast advises that simultaneous ILS PRM approaches are in progress, pilots should brief to fly the ILS PRM approach. If later advised to expect an ILS approach, the ILS PRM chart may be used after noting the following:

- a. Minimums and missed approach procedures are unchanged
- b. Monitor frequency no longer required.
- c. A lower glideslope intercept altitude may be assigned when advised to expect an ILS approach.

2. **Dual VHF Communication required.** To avoid blocked transmissions, each runway will have two frequencies, a tower and a PRM monitor frequency. The PRM Monitor controller's transmissions, if needed, will override both frequencies. Pilots will ONLY transmit on the tower controller's frequency, but will listen to both frequencies. When in range, on a second communications radio, select the PRM monitor frequency. Set the audio level to about the same volume as the primary communication radio so that transmissions on the PRM monitor frequency can be heard in the event the tower frequency is blocked. Then, deselect the PRM monitor audio. When instructed by ATC to contact the tower, reselect the PRM monitor frequency audio.

3. **All "Breakouts" are to be hand flown** to assure that the maneuver is accomplished in the shortest amount of time. Pilots, when directed by ATC to break off an approach, must assume that an aircraft is blundering toward their course and a breakout must be initiated immediately.

- a. **ATC Directed "Breakouts":** ATC directed breakouts will consist of a turn and a climb or descent. Pilots must always initiate the breakout in response to an air traffic controller instruction. Controllers will give a descending breakout only when there are no other reasonable options available, but in no case will the descent be below minimum vectoring altitude (MVA) which provides at least 1000 feet required obstruction clearance.
- b. **Phraseology - "TRAFFIC ALERT":** If an aircraft enters the "NO TRANSGRESSION ZONE (NTZ)," the controller will breakout the threatened aircraft on the adjacent approach. The phraseology for the breakout will be:
 "TRAFFIC ALERT, (aircraft call sign) TURN (left/right) IMMEDIATELY,
 HEADING (degrees), CLIMB/DESCEND AND MAINTAIN (altitude)".

SE-4, 28 JUN 2014 to 24 JUL 2014

SE-4, 26 JUN 2014 to 24 JUL 2014

Figure C-2. ATL Attention All Users Page