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Flight Operations Simulation and Analysis Branch
Flight Technologies and Procedures Division
Flight Standards Service

Safety Study Report for San Francisco International Airport (SFO) Required Navigation Performance (RNP) Parallel Approach Transition (RPAT) Operation Using FAA B737-800 Simulator

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NOTICE

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12. Abstract

This report presents the results of a safety study conducted on a RPAT operation developed for SFO runway 28R. SFO typically operates two pairs of closely spaced, intersecting parallel runways, one pair for arrivals (runways 28L and 28R) and one for departures (runways 1L and 1R). The centerlines of runways 28L and 28R are approximately 750 feet apart and dual simultaneous arrival streams are authorized only during visual meteorological conditions (VMC) utilizing the Quiet Bridge arrival or when Simultaneous Offset Instrument Approach (SOIA) operations utilizing the Localizer Directional Aid (LDA) Precision Runway Monitor (PRM) approach to runway 28R are in effect. The runways 28L/R SOIA operation also requires use of the runway 28L Instrument Landing System (ILS). Therefore, when these criteria are not met because of weather or inoperative equipment, i.e. runway 28R localizer, glide slope or PRM, SFO tower is forced to reduce the Airport Acceptance Rate (AAR) by implementing a single runway operation or by staggering approaches to runways 28L/R. The FAA's RNP Program Office as part of its RNP Roadmap for RNP procedure implementation has proposed a RPAT utilizing an RNAV instrument approach with RNP minima to runway 28R as a suitable approach alternative for use in simultaneous approach operations at SFO. The RPAT operation to runway 28R would have the advantage of being independent of both ground based navigation aids and the PRM. The primary purpose of this study was to assess RPAT operational and human factor issues. The safety evaluation reported herein was conducted by the FAA, Flight Operations Simulation and Analysis Branch (AFS-440) using a B737-800, Level D (full motion) flight simulator, located at the Mike Monroney Aeronautical Center, Oklahoma City, OK.

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Executive Summary

This report presents the results of a safety study conducted on a RPAT operation developed for SFO runway 28R. SFO typically operates two pairs of closely spaced, intersecting parallel runways, one pair for arrivals (runways 28L and 28R) and one for departures (runways 1L and 1R). The centerlines of runways 28L and 28R are approximately 750 feet apart and dual simultaneous arrival streams are authorized only during visual meteorological conditions (VMC) utilizing the Quiet Bridge arrival or when Simultaneous Offset Instrument Approach (SOIA) operations utilizing the Localizer Directional Aid (LDA) Precision Runway Monitor (PRM) approach to runway 28R in concert with the Instrument Landing System (ILS) to 28L are in effect. Therefore, when these criteria are not met because of weather or inoperative equipment, i.e. runway 28R localizer, glide slope or PRM, SFO tower is forced to reduce the Airport Acceptance Rate (AAR) by implementing a single runway operation or by staggering approaches to runways 28L/R. The FAA's RNP Program Office as part of its RNP Roadmap for RNP procedure implementation has proposed a RPAT utilizing an RNAV instrument approach with RNP minima to runway 28R as a suitable approach alternative for use in simultaneous approach operations with the 28L ILS at SFO. The RPAT operation to runway 28R would have the advantage of being independent of both ground based navigation aids and the PRM. The primary purpose of this study was to assess RPAT operational and human factor issues. The safety evaluation reported herein was conducted by the FAA, Flight Operations Simulation and Analysis Branch (AFS-440) using a B737-800, Level D (full motion) flight simulator, located at the Mike Monroney Aeronautical Center, Oklahoma City, OK.

The following recommendations are made concerning the SFO RPAT operation to runways 28L and 28R. Some of the recommendations may also be applicable to RPAT operations in general.

1. Design the missed approach procedure for RPAT operations to include an immediate turn to a heading that will provide course divergence from the ILS final approach course. A turning missed approach will have the following advantages: 1) will create the quickest separation from the ILS aircraft, 2) will simplify the missed approach procedure for flight crews by allowing the missed approach heading to be pre-set in the navigation system, and 3) can be utilized anywhere along the RNAV approach, including the curved path segment. The missed approach procedure must meet current simultaneous approach criteria found in FAA Order 8260.3B.

2. Develop a training program to describe and explain RPAT operations and crew coordination issues. Specifically, an Internet-based video training program for flight crews might alleviate concerns with closure rates and close proximity flying, particularly at night, in RPAT scenarios.

3. Require the use of the autopilot by the RNAV aircraft until established on the straight portion of short final approach.

4. Redesign the SFO RNAV approach to mitigate TCAS RAs.

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1.0. Introduction

This report presents the results of a safety study conducted on a RPAT operation developed for SFO runway 28R. SFO typically operates two pairs of closely spaced, intersecting parallel runways, one pair for arrivals (runways 28L and 28R) and one for departures (runways 1L and 1R). The centerlines of runways 28L and 28R are approximately 750 feet apart and dual simultaneous arrival streams are authorized only during visual meteorological conditions (VMC) utilizing the Quiet Bridge arrival or when Simultaneous Offset Instrument Approach (SOIA) operations utilizing the Localizer Directional Aid (LDA) Precision Runway Monitor (PRM) approach to runway 28R in concert with the Instrument Landing System (ILS) to 28L are in effect. Therefore, when these criteria are not met because of weather or inoperative equipment, i.e. runway 28R localizer, glide slope or PRM, SFO tower is forced to reduce the Airport Acceptance Rate (AAR) by implementing a single runway operation or by staggering approaches to runways 28L/R. The FAA's RNP Program Office as part of its RNP Roadmap for RNP procedure implementation has proposed a RPAT utilizing an RNAV instrument approach with RNP minima to runway 28R as a suitable approach alternative for use in simultaneous approach operations with the ILS to 28L at SFO. The RPAT operation to runway 28R would have the advantage of being independent of both ground based navigation aids and the PRM. The primary purpose of this study was to assess RPAT operational and human factor issues. The safety evaluation reported herein was conducted by the FAA, Flight Operations Simulation and Analysis Branch (AFS-440) using a B737-800, Level D (full motion) flight simulator, located at the Mike Monroney Aeronautical Center, Oklahoma City, OK.

2.0. Description of the Evaluation

2.1. SFO RPAT Simulator Evaluation Concept of Operation

The proposed RPAT operation at SFO utilizes two instrument approaches, an ILS approach to runway 28L and an RNAV Special Aircraft Aircrew Authorization Required (SAAAR) approach to runway 28R. The RPAT concept is for two aircraft to be paired by Air Traffic Control (ATC) on the intermediate segments of the respective approaches with the RNAV approach aircraft abeam or behind the ILS aircraft. The intermediate segments of the ILS and the proposed RNAV approach at SFO are separated by 5,000 feet so as to minimize collision and/or wake turbulence issues during the instrument portion of the RPAT operation. Prior to the Precision Final Approach Fix (PFAF), the RNAV flight crew must visually acquire the ILS aircraft and must report this fact to ATC. After verbal acknowledgment by ATC, the RNAV approach aircraft can continue past the PFAF to align with runway 28R. While the RNAV flight crew visually monitors the position of the ILS aircraft, the RNAV aircraft continues to fly the designated RNAV approach lateral and vertical paths. Between the PFAF and the runway 28R threshold, the RNAV flight crew assumes responsibility for wake vortex avoidance and separation from the ILS aircraft approaching runway 28L.

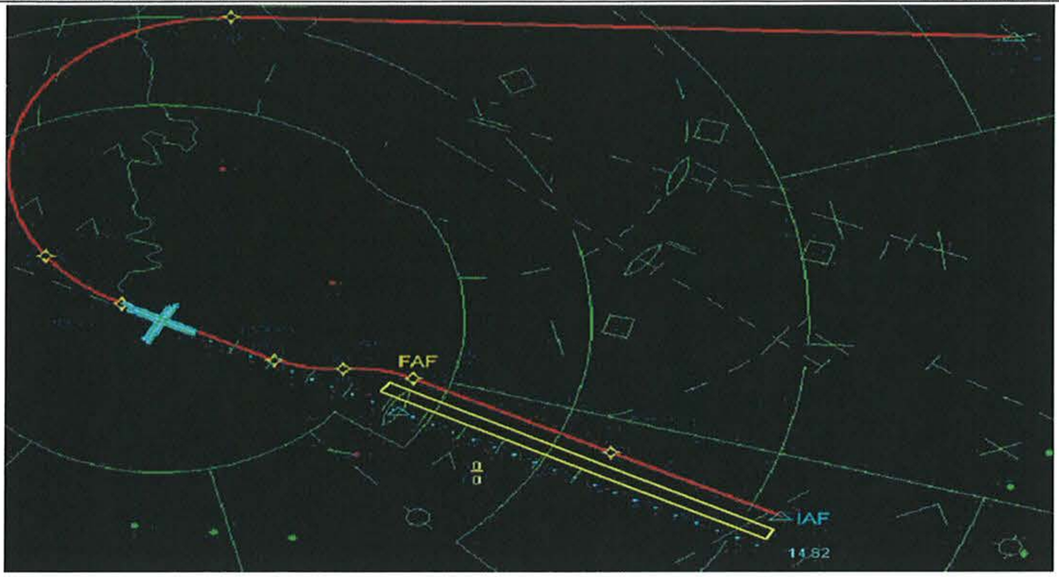

Figure 1: Graphical Depiction of SFO RPAT

A graphical depiction of the SFO RPAT procedure, with the RNAV approach path shown in red and the blue dotted line representing the ILS approach path, is shown in Figure 1. The SFO RPAT operation requires special aircraft authorization as well as specialized training for aircrews and Air Traffic Control (ATC) personnel. In addition, the SFO RPAT requires designation and operational use of a No Transgression Zone (NTZ) which is shown in yellow in Figure 1. The NTZ is a 2,000 feet wide area from the Initial Approach Fix (IAF) to the PFAF (simply labeled as FAF in Figure 1) and is located equidistant between the ILS Localizer course and the RNAV approach intermediate segment course. During RPAT operations, the NTZ is monitored by ATC using a standard Airport Surveillance Radar Model 9 (ASR-9). If an aircraft enters the NTZ or is anticipated to do so, the ATC monitor controller is required to issue breakout instructions to an aircraft at risk on the adjacent approach.

2.2. SFO RNAV Z Runway 28 Approach

An RNAV approach procedure to runway 28R at SFO was developed for purposes of this evaluation. This procedure, titled RNAV Z Rwy 28R, is shown in Figure 2. Obviously, the procedure shown in Figure 2 was not a published public procedure, but the approach chart contained the basic design features to support an RPAT operational assessment in a flight simulator environment. The approach segment from AF28R to FF28R (PFAF) was offset approximately 5,000 feet from the ILS 28L Localizer course. The approach contained two Radius-to-Fix (RF) legs from FF28R to RF28R and from RF28R to FABLA. These RF legs provided a smooth, repeatable transition from the intermediate segment to the course corresponding to the runway 28R centerline extended. After FABLA lateral guidance continued to the runway 28R threshold (RW28R). A vertical path of 3.00° was provided between FF28R and RW28R. A RNP level of 0.3 NM was required to conduct the approach.

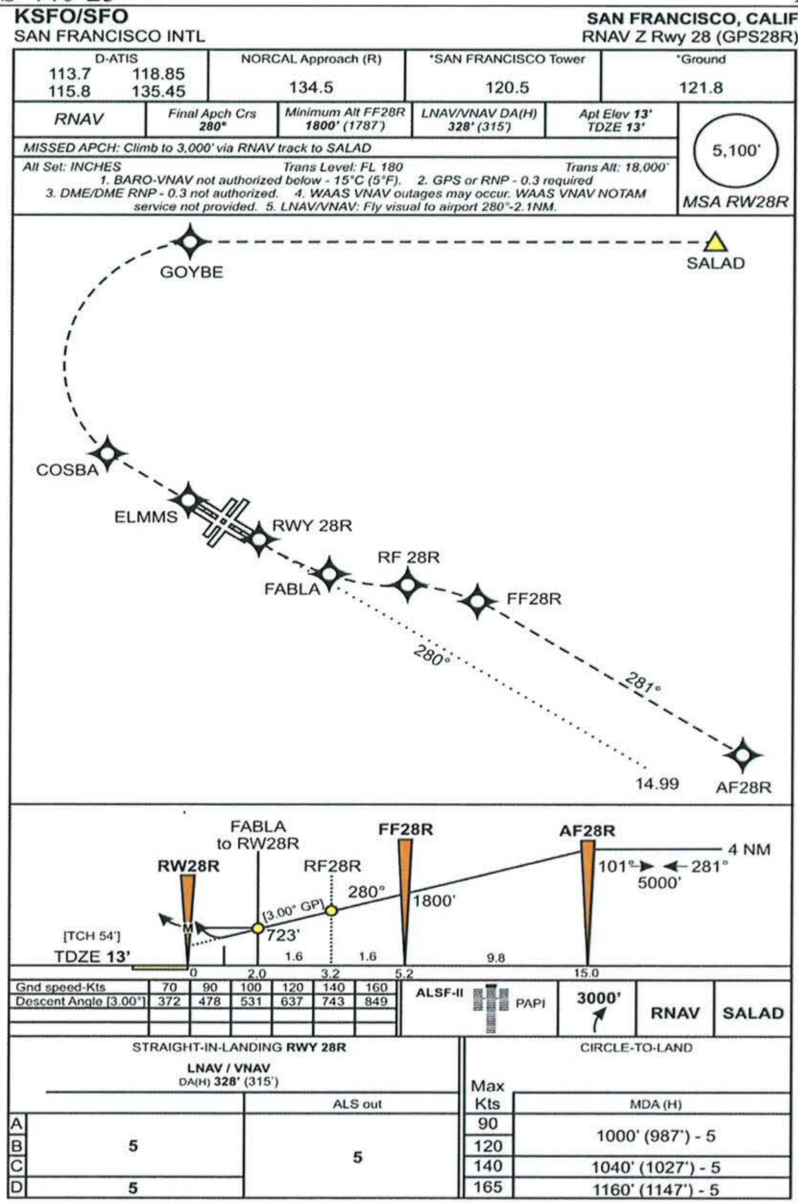

Figure 2: SFO RNAV Z 28R Approach

In order to simulate navigation errors at the maximum value approved for the approach, three different versions, i.e. Nominal, RNP 0.3 left and RNP 0.3 right offset from the nominal, of RNAV Z 28R were coded and programmed in the B737-800 simulator. The Nominal programmed approach represented the RNAV Z 28R approach with no attendant navigation error. The RNP 0.3 left and right approaches were programmed with all waypoints offset 0.3 NM to the left or right, respectively, to represent an approach in which the navigation system error (NSE) resulted in a maximum 0.3 NM left or right error. The navigational databases for the RNP 0.3L and 0.3R approaches also shifted the SFO runway coordinates so that the cockpit navigational display (ND) showed the proper runway relationship to the final approach courses.

The authors of this report realize that it is extremely unlikely that utilizing Global Positioning System (GPS) for navigational information (as required for the RNAV approach) that the NSE would be 0.3 NM. However, the RNP 0.3L and 0.3R approaches were included in the test scenarios to support a conservative assessment of the fly ability characteristics of the RPAT operation. In future studies, a more realistic value will be established for evaluating NSE utilizing GPS.

2.3. B737-800 Flight Simulator Operational Scenarios

Thirty-six different scenarios were programmed in the B737-800 simulator. These scenarios are shown in Table 1.

Table 1: Operational Scenarios

Run #	RNP	Wind	Day/Night	Event	Autopilot	Number Conducted (Landings)	Number Conducted (Missed Approaches)
1	Nom	Calm	Day	None	On	5	1
2	Nom	Calm	Day	None	On	7	0
3	Nom	Calm	Day	Lost Sight	On	0	8
4	Nom	010/10	Day	None	On	8	0
5	0.3L	010/10	Day	Blunder	On	1	6
6	Nom	Calm	Night	None	On	8	0
7	Nom	010/10	Night	None	On	7	1
8	0.3R	Calm	Night	None	On	5	3
9	0.3L	Calm	Night	None	On	5	2
10	Nom	Calm	Night	Blunder	On	0	8
11	Nom	Calm	Day	Lost Sight	On	0	7
12	0.3R	010/10	Day	None	On	7	1
13	0.3L	010/10	Day	None	On	2	6
14	Nom	Calm	Day	Blunder	On	0	8
15	Nom	010/10	Day	None	On	8	0
16	0.3R	010/10	Night	Blunder	On	0	8
17	0.3L	Calm	Night	None	On	7	1
18	Nom	Calm	Night	Lost Sight	On	0	8
19	Nom	010/10	Night	None	On	8	0
20	Nom	010/10	Night	Blunder	On	0	8
21	0.3R	010/10	Day	None	On	7	1

22	0.3L	Calm	Day	Blunder	On	1	7
23	Nom	Calm	Day	Lost Sight	On	0	8
24	0.3R	010/10	Day	None	On	7	1
25	Nom	010/10	Day	None	On	8	0
26	0.3L	Calm	Night	Lost Sight	On	0	7
27	Nom	010/10	Night	Blunder	On	0	8
28	0.3R	Calm	Night	None	On	6	2
29	Nom	Calm	Night	Lost Sight	On	0	7
30	Nom	010/10	Night	None	On	8	0
31	0.3L	Calm	Day	None	On	N/A	N/A
32	0.3R	010/10	Night	None	On	N/A	N/A
33	Nom	Calm	Day	None	Off	6	3
34	Nom	010/10	Night	None	Off	6	1
35	Nom	Calm	Day	None	Off	7	0
36	Nom	010/10	Night	None	Off	6	1
					Total	140	122

Scenarios 31 and 32 were programmed as back-up scenarios, but were not used during this evaluation. An examination of Table 1 shows the following facts concerning the remaining flight simulator scenarios:

a. Six scenarios used the RNP 0.3L approach and six scenarios used the RNP 0.3R approach. The remainder of the procedures used the nominal RNP approach.

b. The winds alternated between calm and a right to left crosswind of 10 knots. A total of eighteen scenarios were designed with calm wind and the remaining sixteen were designed with a wind of 010/10.

c. Half of the scenarios were conducted at night.

d. Six of the scenarios contained a lost sight event. In this event, the RNAV aircraft lost sight of the simulated ILS aircraft during the visual segment of the approach procedure.

e. Seven of the scenarios contained a blunder event. In this event, once both aircraft were in Visual Meteorological Conditions (VMC), the ILS aircraft began to line up with runway 28R instead of runway 28L.

f. Four scenarios were conducted with autopilot and auto-throttles off.

In addition to the winds shown in Table 1, other weather conditions included a 2,300 feet ceiling with a visibility of 5 statue miles with maritime haze. This ceiling/visibility combination allowed flight crews to visually acquire the ILS aircraft at the PFAF, i.e. 5 NM, but did not enable the flight crews to see the landing runway at the same point.
The RNAV aircraft began each test run 1.5 NM (approximately 37 seconds) from the PFAF (FF28R) in Instrument Meteorological Conditions (IMC) at 2,500 feet MSL in an 800 feet-per-minute descent. The aircraft was on the lateral and vertical approach paths and was

maintaining 145 Knots Indicated Airspeed (KIAS). In addition, the RNAV aircraft was fully configured with gear down, flaps 30 degrees, Flight Director was On with command steering bars from LNAV/VNAV engaged, and in scenarios 1 through 32, the autopilot and auto-throttles were engaged. Even though so equipped, the B737-800 heads-up display was not used due to variations in industry fleet equipage. The Traffic Collision Avoidance System (TCAS) was set to the Resolution Advisory (RA) mode. The TCAS indicated an adjacent aircraft on the Navigation Display (ND) at approximately the 9 o'clock position. The Captain and First Officer alternated approaches with the Captain generally flying the odd numbered scenarios while the First Officer generally flew the even numbered scenarios.

At 2,300 feet MSL which was approximately 30 seconds from the PFAF, the RNAV aircraft exited the cloud base. Within these same 30 seconds, the parallel ILS aircraft (a Boeing 737 digitally produced on the simulator flight deck windows) also exited the cloud base. The ILS aircraft was also maintaining a constant speed of 145 KIAS.

As Table 1 indicates, a total of 262 RPAT approaches were conducted with 140 approaches resulting in landings and 122 resulting in missed approaches.

2.4. Simulator Data Collection

Forty-one different parameters were recorded at a 1 Hz. rate during each simulator session. These parameters are shown below:

1) Crew number
2) Pilot flying
3) A/C latitude (degrees)
4) A/C longitude (degrees)
5) A/C Radio Altitude (feet)
6) A/C Rate of Climb (feet/minute)
7) Captain's column position (inches)
8) Captain's wheel position (inches)
9) A/C Pedal position (inches)
10) A/C Flaps position (degrees)
11) A/C Horizontal Stab Position (degrees)
12) A/C Landing Gear position (up/down)
13) A/C Indicated airspeed (knots)
14) A/C Roll angle (degrees)
15) A/C Pitch angle (degrees)
16) A/C Heading angle (degrees)
17) A/C Aileron position (degrees)
18) A/C Elevator position (degrees)
19) A/C Rudder position (degrees)
20) Wind speed and direction at aircraft (knots/degrees)
21) Left and Right engine thrust (pounds)
22) Left and Right N1 (RPM)
23) Left and Right Throttle Lever Angle (degrees)

24) Main Landing Gear Weight on Wheels switch
25) Autopilots A and B
26) LNAV engage
27) VNAV engage
28) TOGO Switch activation
29) Left FMC Cross track Deviation (feet)
30) Left FMC Vertical Deviation (feet)
31) Left FMC RNP (Nautical Miles)
32) Left FMC ANP (Nautical Miles)
33) A/C distance to runway threshold (feet)
34) A/C distance to runway centerline (feet)
35) ILS aircraft latitude (degrees)
36) ILS aircraft longitude (degrees)
37) ILS aircraft altitude, AGL (feet)
38) Visual modes (day/night/dusk)
39) TCAS RA annunciation
40) TCAS TA annunciation
41) Time (seconds)

The collected data parameters supported analysis of the following areas of interest regarding the SFO RPAT:

a. Bank angle and descent rate above/below 500 feet.
b. Touchdown distance of the RNAV aircraft
c. Difference in touchdown times between the RNAV aircraft and the ILS aircraft
d. Closest point of approach between the RNAV aircraft and the ILS aircraft
e. Time from LNAV disengagement to reengagement during missed approach
f. Response time from losing visual acquisition of ILS aircraft to missed approach execution
g. Response time from the ILS aircraft runway alignment blunder to missed approach execution

Areas a. and b. above are considered general approach parameters and are indicative of how well the flight crews managed to conduct a stabilized approach. Areas c. through g. are RPAT specific parameters and give some quantitative measure of the effectiveness and viability of the RPAT operation.

2.5. Evaluation Pilots

A total of eight flight crews, i.e. Captain and First Officer, participated in the evaluation. The flight crews were current and qualified to perform the duties of their respective crew positions. With the exception of one U.S. Navy and one FAA pilot, pilots were from major U.S. airlines. Table 2 contains the ratings, total flying hours and RNP experience of the flight crews. As Table 2 shows the crews were highly experienced, all had B737 type ratings and RNP exposure ranged from none to 2 years.

Table 2: Subject Pilots' Qualifications

Crew #	Crew Position	Ratings	Total Flight Hours	RNP Experience
1	Captain	ATP/CE 500, Saber liner, B737	11,000	No
	First Officer	ATP/T-1, B707, B737	2,500	2 years
2	Captain	ATP/B737	4,300	Minimal
	First Officer	ATP/B737, B707, T-1	3,000	1 year
3	Captain	ATP, CFII/BE 1900, DO 328 Jet, B737	8,000	No response
	First Officer	ATP/B737, B757, B767	8,700	No response
4	Captain	ATP/B737	17,500	None
	First Officer	ATP/B737	6,000	None
5	Captain	ATP/B727, B737, C-130	12,000	3,000 hours
	First Officer	ATP/B707, B737, BE 400	2,300	1.5 years
6	Captain	ATP/B737, B757, B767	11,000	None
	First Officer	ATP/B737, MD88	7,500	None
7	Captain	ATP, CFII, FE/DC9, DC10, B757, B767, A300, B737	12,000	Yes, RNP in Central America
	First Officer	ATP/B737	9,000	1 year
8	Captain	ATP, CFII/B737	7,000	Yes
	First Officer	ATP/B737, B707	1,900	None

Prior to each simulator session, the AFS-440 Test Director gave a RPAT test procedures and conditions briefing to each flight crew. The briefing was in the form of a PowerPoint presentation and covered an explanation of the RPAT concept, the plan view of the SFO RNAV SAAAR approach, the purpose of the test, and any issues that needed to be standardized across flight crews. A copy of this briefing is available upon request from AFS-440.

2.6. Human Factors Evaluation

The human factors portion of this evaluation utilized both subjective and objective measures. Subjective performance measures included post run and post simulation session questionnaires, designed specifically to elicit comments and opinions from the subject pilots. A numerical weighting procedure was used to provide an overall score rating on several human factor issues. Focus was on any potential changes in either mental or physical workload manifested from the RPAT operation as it differs from other approach operations. Objective crew performance measures were accomplished through observation of pilot/flight crew performance by the Test Director/Observer. Both primary and secondary task completions were observed during periods of high cockpit activity or when the flight crew was presented with unusual situations, such as closing on an adjacent aircraft at night.

For the purposes of this evaluation, primary task measures included those tasks and maneuvers directly associated with and specific to performing this type of RNAV approach and RPAT operation, e.g. RF turns, visually acquiring and maintaining contact with parallel traffic, reacting to loss of visual contact with the adjacent aircraft, responding to a runway alignment blunder by the adjacent aircraft, and deteriorating weather conditions. Secondary task measures included those tasks that are considered normal and expected with respect to commercial aircraft operations, e.g., maintaining aircraft heading/airspeed/altitude, communications procedures, aircraft configuration changes, etc. Shedding of either primary or secondary tasks may be indicative of workload changes specific to this operation and may warrant further investigation.

The post run questionnaire is shown below as Figure 3 and the post simulation questionnaire is shown in Figure 4. In addition to the questionnaires, a post simulation debriefing was held with each flight crew using the format shown in Figure 5. Post run questionnaire results were analyzed and the data shown in Figures 12 through 17. Post simulator questionnaires were used in concert with the post simulator debriefing to elicit pilot responses and the results were synopsized by the Test Director in Section 4.0.

POST RUN QUESTIONNAIRE

1. In general, compare the **VISUAL segment** of this RPAT procedure to other approaches that you perform (overall level of effort).

Very Easy · Average · Very Hard

[1] [2] [3] [4] [5] [6] [7] [8] [9]

2. Rate your comfort level with this RPAT approach procedure given the proximity of the parallel traffic.

Very Comfortable · Moderately Comfortable · Uncomfortable

[1] [2] [3] [4] [5] [6] [7] [8] [9]

3. Rate your **level of aircraft stabilization** for the **VISUAL segment** portion of this approach based upon your organization's guidance for a stabilized approach.

High · Moderate · Low

[1] [2] [3] [4] [5] [6] [7] [8] [9]

4. Rate your perceived level of ***Physical workload*** (e.g. head movement, switchology, controls) while flying this approach.

Low · Moderate · High

[1] [2] [3] [4] [5] [6] [7] [8] [9]

5. Rate your perceived level of ***Mental* workload** (e.g. searching, thinking, deciding, calculating) while flying this approach.

Low · Moderate · High

[1] [2] [3] [4] [5] [6] [7] [8] [9]

6. Rate your perceived level of ***Crew* workload** while flying this approach (e.g. thinking, coordinating, searching, communicating, etc.).

Low · Moderate · High

[1] [2] [3] [4] [5] [6] [7] [8] [9]

Figure 3: Post Run Questionnaire

POST SIMULATION QUESTIONNAIRE

1. How safe is this RPAT procedure, considering the proximity to parallel traffic, with respect to maneuvering speed, stabilized visual approach segment, transition to the runway, etc.?

Very Safe			Average			Very Unsafe		
1	2	3	4	5	6	7	8	9

2. Compared to other approaches, rate the *overall* workload for this RPAT approach procedure.

Very Easy			Average			Very Hard		
1	2	3	4	5	6	7	8	9

3. Rate your *overall* comfort level with having to monitor the close proximity parallel traffic while maneuvering on the RNAV approach.

Very Comfortable			Moderately Comfortable			Uncomfortable		
1	2	3	4	5	6	7	8	9

4. Rate the level of difficulty with the visual transition, from parallel traffic to the runway environment.

Very Easy			Average			Very Hard		
1	2	3	4	5	6	7	8	9

5. Rate the sufficiency of the distance allowed to execute the transition from parallel traffic to the runway.

Too Short			Adequate			Too Long		
1	2	3	4	5	6	7	8	9

6. Describe the bank angles required during the visual portion of this RPAT approach procedure

Very Easy			Average			Very Hard		
1	2	3	4	5	6	7	8	9

7. Rate the level of overall workload during the missed approach segment of this procedure.

Very Easy			Moderately Easy			Very Hard		
1	2	3	4	5	6	7	8	9

Figure 4: Post Simulation Questionnaire

POST SIMULATION DEBRIEFING

1. Overall, did you feel comfortable with this approach, based upon your experience with all other approaches that you perform? Why or why not

2. At rollout for alignment with the runway centerline, were you in an acceptable position to complete a landing in keeping with your company's standards? Why or why not

3. What additional mental or physical requirements, if any, were imposed on you during this approach?

4. Would you consider this approach to be stabilized based upon your company's/organization's guidelines for a "stabilized approach"? Why or why not?

5. Did you have any difficulty monitoring the parallel traffic while flying this RNAV approach? Explain why or why not?

6. What impacted your performance most, i.e., monitoring the parallel traffic, flying the RNAV approach, transitioning to the runway environment /lining up with the runway centerline, descent rate to the TDZ?

7. Based on your experience, do you think these RPAT approaches are viable and safe? Why or why not?

8. Any closing comments to the effectiveness of these RPAT approaches?

Figure 5: Post Simulation Debriefing

3.0. Summary of Data Analysis

3.1. Simulator Data Analysis

3.1.1. Stabilized Approach Analysis

Bank angle, descent rate and touchdown point were the parameters used to establish the basis for a stabilized approach determination. Specifically, approaches with bank angles, descent rates and touchdown points which exceeded the following threshold limits did not meet the criteria for a stabilized approach established for this evaluation:

a. Bank angle greater than 25° when the aircraft is above 500 feet AGL.

b. Bank angle greater than 3 degrees for more than 2 seconds when the aircraft is below 500 feet AGL.

c. Descent rate greater than 1,000 feet/minute for more than 2 seconds at any altitude.

d. Touchdown point greater than 3,000 feet from runway 28R threshold.

Table 3 shows the number of approaches that exceeded the bank angle limits given above. Table 3 gives a further breakdown of these approaches as shown.

Table 3: Approaches Exceeding Stabilized Approach Bank Angle Limits

RNP Level	Less than 500 feet AGL		Greater than 500 feet AGL		
	Wind	No Wind	Wind	No Wind	Total
RNP 0.3L		1		1	2
RNP 0.3R	14	18			32
Nominal RNP	10	8		3	21
Nominal RNP - Lost Sight Event				4	4
				Grand Total	59

As Table 3 shows, 59 approaches contained instances when the bank angle exceeded the limits specified for a stabilized approach. It is interesting to note that all of these occurrences happened when the autopilot was disengaged and the vast majority occurred below 500 feet, when aircraft stabilization is most critical. The 59 approaches represent 22% of the total number of approaches. However, 54% (32/59) of these approaches were RNP 0.3R procedures in which the RNAV final approach course did not align with runway 28R. These results suggest that mandatory use of the autopilot until on a short final, i.e. well inside the 500 feet AGL point, might be advisable for the SFO RPAT. A distinction needs to be made between scenarios 33 through 36 which were conducted without use of the autopilot and all other scenarios when the pilot disengaged the autopilot. While scenarios 1 through 30 began with autopilot on, the pilot flying (PF) was free to disengage the autopilot at any time. This explains why the number of approaches exceeding the bank limits shown in Table 3 was greater than the number of approaches flown using scenarios 33 through 36. The data also showed a wide disparity in autopilot disconnect altitude. The mean disconnect altitude was 945 ft with a minimum altitude of 36 ft, a maximum altitude of 2,489 ft and a standard deviation of 522 feet.

Table 4 shows the average maximum bank angle achieved during those instances that exceeded the bank angle limits.

Table 4: Average Maximum Bank Angles

RNP Level	Less Than 500 feet AGL		Greater Than 500 feet AGL	
	Wind	No Wind	Wind	No Wind
0.3L		5.60		39.10
0.3R	10.99	10.14		
Nominal RNP	4.95	4.84		30.30
Nominal RNP - Blunder/Lost Sight Events				31.18

Table 5 shows the number of approaches that exceeded the descent rate limits given above. These rates were observed after the RNAV approach PFAF. Table 5 gives a further breakdown of these approaches as shown. Table 5 also shows in parenthesis the average altitude at which the excessive descent rate was recorded.

Table 5: Approaches Exceeding Stabilized Approach Descent Rate Limits (Average Altitude of Excessive Descent Rate)

RNP Level	Approaches Resulting in Landings		Approaches Resulting in Missed Approaches		
	Wind	No Wind	Wind	No Wind	Total
RNP 0.3L		4 (932')		3 (1809')	7
RNP 0.3R	12 (516')	15 (664')			27
Nominal RNP	12 (1781')	11 (1831')	2 (2366')	2 (2247')	27
RNP 0.3L - Blunder Event			3 (1258')	1 (1034')	4
				Grand Total	65

As Table 5 shows, 65 approaches contained instances when the descent rate exceeded the limits specified for a stabilized approach. It is interesting to note that all of these high descent rates occurred with the autopilot disengaged (see discussion above). The 65 approaches represent 25% of the total number of approaches conducted. These results add further support to mandatory use of the autopilot.

Table 6 shows a statistical analysis of the touchdown point for all landings. Figure 6 shows a touchdown point analysis versus RNP level. As shown in Table 6 and Figure 6, the average touchdown point was well within the 3,000 feet from runway 28R threshold touchdown zone. However, some landings were significantly outside the touchdown zone. A total of 140 landings were made during the evaluation and of this total, 11 landings or approximately 8% exceeded the 3,000 feet touchdown zone. An examination of these 11 landings showed that 9 were made by the same right seat pilot, i.e. First Officer. Therefore, for purposes of this evaluation, the vast majority of long landings can be attributed to the ability/performance of a single pilot. After discounting these 9 landings, only 1.5% (2 of 131) of the landings exceeded the 3,000 feet touchdown zone. Thus, from a touchdown point standpoint, the approaches were conducted in a stabilized manner.

Table 6: Touchdown Point Statistical Analysis (Distance in feet from runway 28R threshold)

Number of Landings	Mean	Minimum	Maximum	Standard Deviation
140	2212	887	5522	591

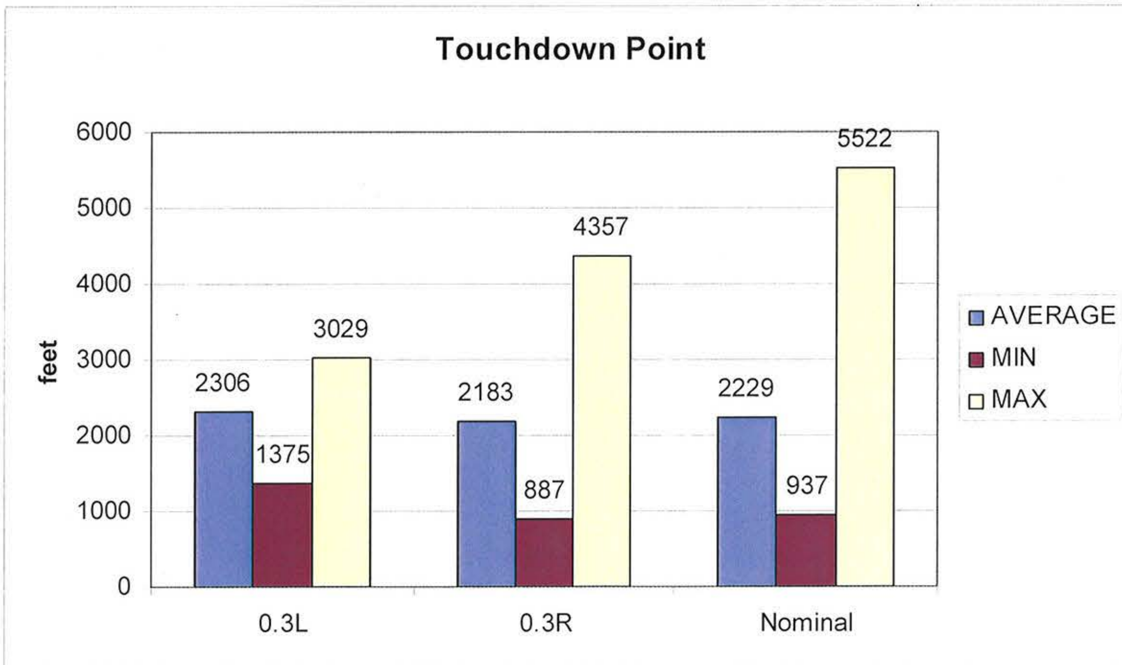

Figure 6: Touchdown Point vs. RNP Level

3.1.2. RPAT Specific Parameter Analysis

<u>Difference in touchdown times between the RNAV aircraft and the ILS aircraft.</u> From both a wake vortex avoidance standpoint (see References 1 and 2) and from an operational standpoint (so departures can be released on runways 1L and 1R), the RNAV aircraft should land on runway 28R within a relatively short period of time behind the ILS aircraft on runway 28L. (RPAT operational constraints do not allow the RNAV aircraft to land in front of the ILS aircraft.)

Table 7: Touchdown Time Difference - ILS vs. RNAV Aircraft (Seconds)

Number of landings	Mean	Minimum	Maximum	Standard Deviation
140	5.9	-1.6	19.1	3.2

As shown in Table 7, the mean time difference between landings was 5.9 seconds which is within the values determined in Reference 2. Even the maximum time of 19.1 seconds is within the values determined in Reference 2. The minimum time showed that some RNAV aircraft landed before the ILS aircraft. In fact, two RNAV aircraft did land before the ILS aircraft. One left seat RNAV pilot landed 1.6 seconds before the ILS aircraft and one right seat RNAV pilot landed 0.08 seconds before the ILS aircraft. As stated previously, this would not be acceptable in actual RPAT operations and a missed approach by the RNAV aircraft would be expected.

Closest point of approach (CPA) distance between the RNAV aircraft and the ILS aircraft. CPA was computed in three dimensions. In general, the CPA between the ILS aircraft and the RNAV aircraft was during the missed approach procedure (MAP) performed by the RNAV aircraft. As the missed approach procedure for the RNAV Z Rwy 28R was a straight ahead MAP instead of a turning MAP which is called for by multiple parallel approach design criteria, this result is not surprising. Table 8 shows the various CPA statistics. Figure 7 shows a more detailed analysis of missed approach CPA for various scenarios.

Table 8: Closest Point of Approach Distance (ft)

Mean	Minimum	Maximum	Standard Deviation
1503	454	6313	1225.7

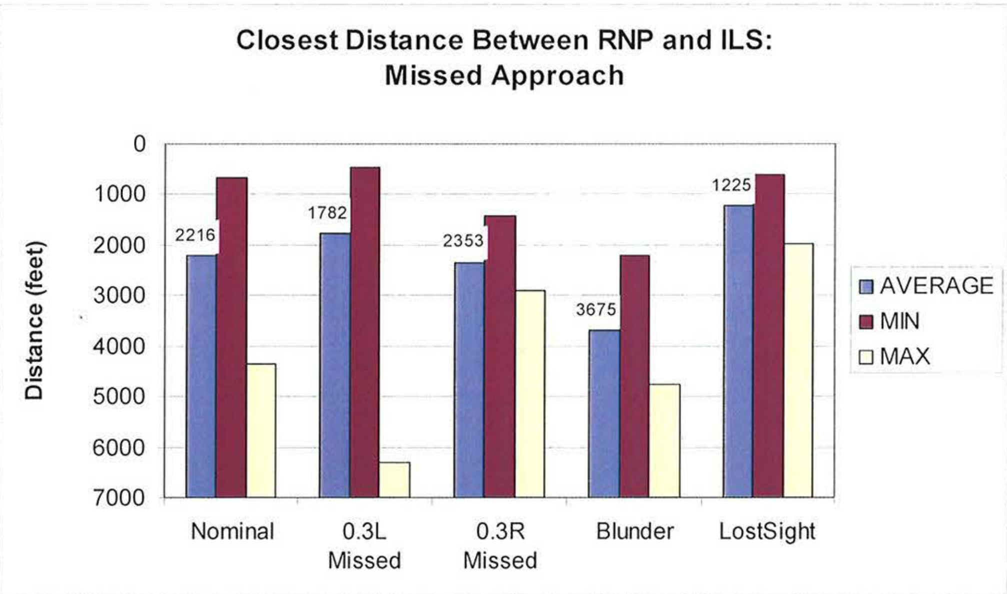

Figure 7: Missed Approach CPA for Various Scenarios

Time from LNAV disengagement to reengagement during missed approach. This parameter is important because during the missed approach maneuver, i.e. when Take-off/Go-around (TOGA) button is pressed, the Flight Management System (FMS) of many aircraft such as the B737-800 disengages LNAV and reverts to a track hold mode. Thus for a finite period of time, the aircraft is incapable of following the missed approach instructions as published on the aeronautical chart or as provided by Air Traffic Control (ATC). Before the aircraft can begin to follow the appropriate missed approach instructions, the flight crew must reengage LNAV. During the LNAV disengagement time, the lateral cross track error can increase. Figure 8 presents a graphical depiction of the relationship between LNAV disengagement time and lateral cross track error recorded during the evaluation for all missed approaches. Note that LNAV disengagement time varied from approximately 5 seconds to approximately 80 seconds as shown in Figure 8. The longest LNAV disengagement time was slightly more than 80 seconds and was recorded during a RNP 0.3 L scenario. The other two disengagement times greater than 60 seconds were recorded during nominal RNP scenarios.

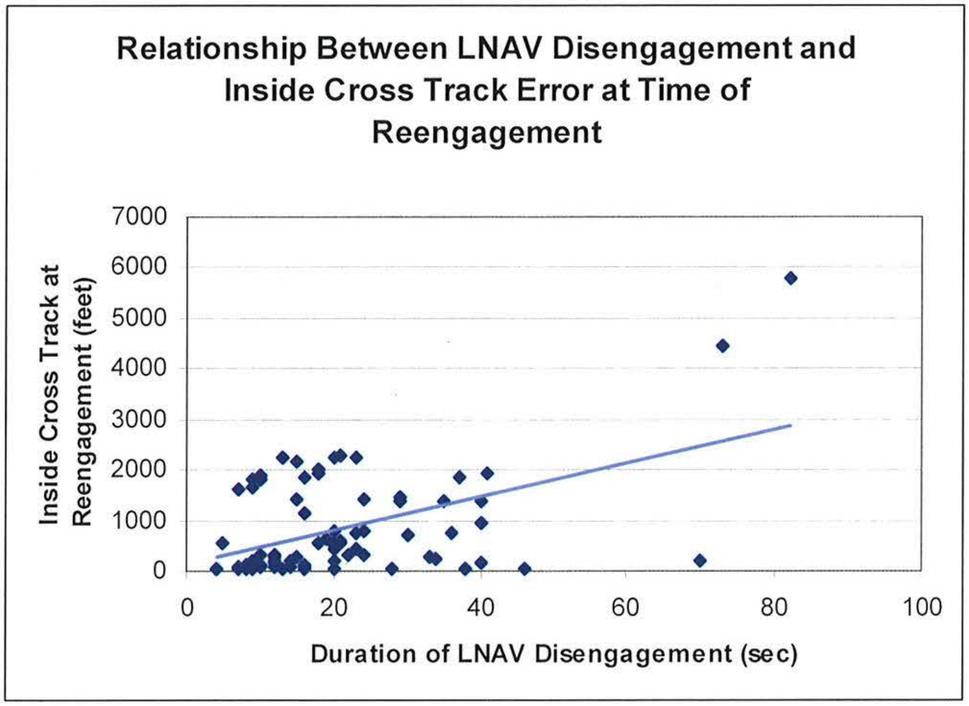

Figure 8: Cross Track Error vs. LNAV Disengagement Time

Response time from losing visual acquisition of ILS aircraft to missed approach execution. Flight crew response times were measured during scenarios when visual acquisition of the parallel ILS aircraft was lost inside the PFAF. This metric sought to quantify the difference between pilot recognition of the event and missed approach execution. All lost sight scenarios occurred when the RNAV aircraft was maneuvering through the curved path portion of the approach. Responses were measured from the time the parallel ILS aircraft disappeared into a simulated cloud formation to the execution of the missed approach. Table 9 summarizes the PF reaction times to the loss of visual acquisition.

Table 9: Lost Sight Event Response Times (Seconds)

Scenario Event	Mean	Minimum	Maximum	Standard Deviation
Lost Sight Day	15.04	10.53	25.54	3.35
Lost Sight Night	15.32	11.47	40.28	6.95
Lost Sight Captain	14.47	10.53	25.54	3.26
Lost Sight First Officer	17.07	11.47	40.28	8.19

On average, it took the pilot flying (PF) approximately 15 seconds to react to the loss of visual acquisition, which equates to about .67 NM at 145 knots.

Figure 9 shows the relationship between CPA and pilot response time. As Figure 9 shows, early recognition of the lost sight event did not always result in a greater CPA. The pilot response time at approximately 40 seconds that was significantly greater than the other response times was observed during a RNP 0.3L approach. All other response times in Figure 9 were for a nominal RNP approach.

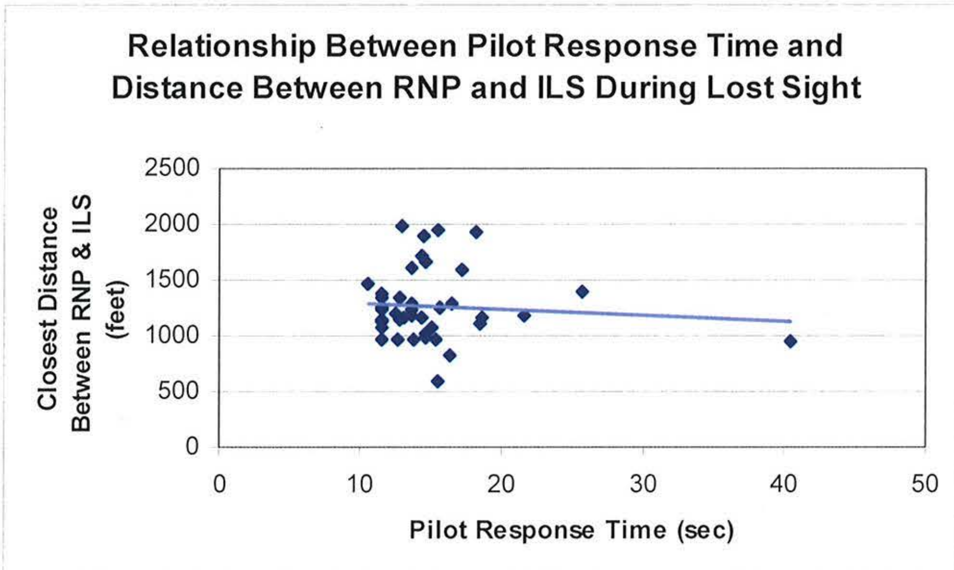

Figure 9: Lost Sight Event Response Time vs. CPA

<u>Response time from the ILS aircraft runway alignment blunder to missed approach execution.</u> Response times were also determined for the runway alignment blunder event during which the ILS aircraft incorrectly lined up on the final approach to runway 28R. The blunder scenario began during the curved path maneuver, when the ILS aircraft banked slightly to the right towards the RNAV aircraft when the ALSF II sequencing flashing approach lights first came into view. Table 10 shows a statistical summary of the RNAV pilots' response times to the runway blunder event. These times averaged approximately 12 seconds. The means and standard deviations for Captain acting as PF and for First Officer acting as PF do not show a significant difference. These times are consistent with those times recorded in the loss of sight event. However, the point at which the ILS aircraft disappeared in the loss of visual scenario was defined; the point where the flight crew executed a missed approach in the runway alignment blunder event was not as well defined due to uncertainty as to the ILS aircraft's intentions.

The runway alignment blunder event response times also affected the CPA between the two aircraft as shown in Figure 10. In general, early recognition of the event resulted in a larger CPA.

Table 10: Runway Alignment Blunder Event Response Times (Seconds)

Scenario Event	Mean	Minimum	Maximum	Standard Deviation
Blunder Day	13.09	1.09	26.11	6.97
Blunder Night	12.12	0.44	35.05	10.26
Blunder - Captain as PF	11.89	3.64	26.11	8.22
Blunder - First Officer as PF	12.76	0.44	35.05	9.17

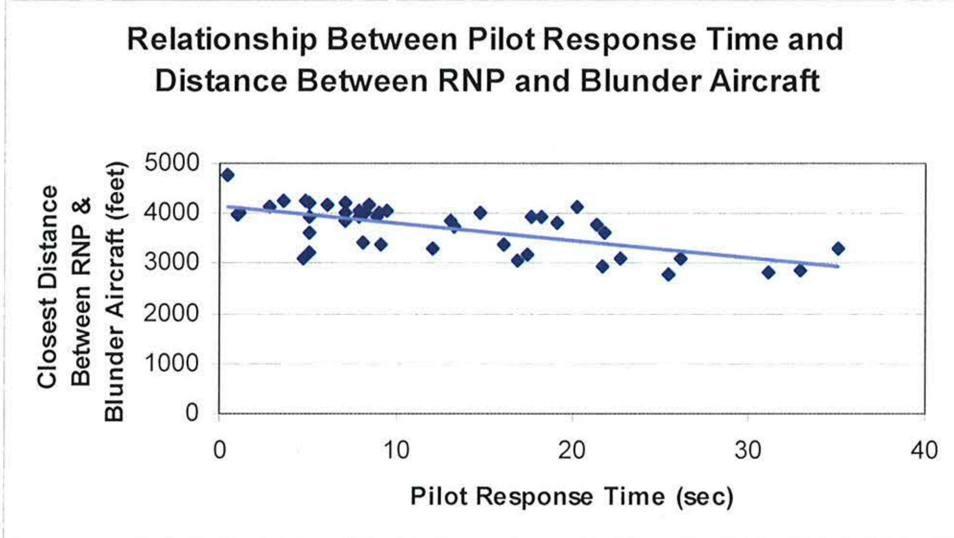

Figure 10: Runway Alignment Blunder Event Response Time vs. CPA

All the runway alignment blunder events resulted in missed approaches except when a single right seat RNAV pilot elected to switch runways and land on 28L. That data was not used in this analysis.

Effect of RNP Navigation System Error (NSE). The RNP NSE particularly that represented by the RNP 0.3R approach, had a pronounced effect on flight crew performance. During the NSE RNP 0.3R approach early recognition of the NSE was an important factor in maintaining a stabilized approach.

With late recognition, the distance needed to correct back to the runway 28R extended centerline required bank angles and descent rates which exceeded the stabilized flight criteria as described in section 3.1.1. Figure 11 shows several representative runs. The RNP 0.3R approaches exceeded the stabilized flight criteria an average duration of 9-12 seconds, with recorded bank angles up to 10 degrees below 500 feet AGL. As noted earlier the RNP 0.3L and 0.3R approaches were meant to provide a conservative assessment of the flyablility of the RNAV approach with NSE set at the ostensive 95% limit. However, with GPS part of the navigation solution as required for the approach, 0.3 NM does not represent a 95% NSE. A more realistic 95% NSE with GPS is on the order of 0.06 NM. It is recommended that future evaluations of this type use the 0.06 NM figure to simulate a 95% NSE when using GPS.

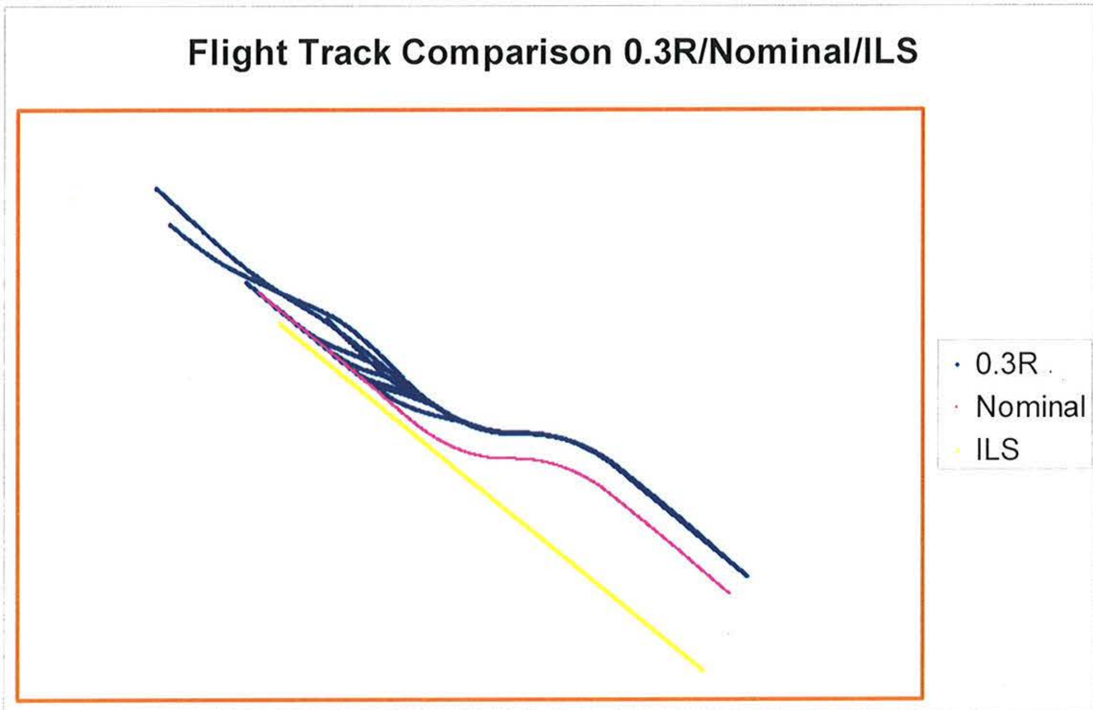

Figure 11: RNP 0.3R Tracks

3.2. Human Factors Analysis

3.2.1. Post Run Questionnaire Analysis

The tabulated results are shown in Figures 12 - 17, respectively, for each of the six post run questions.

1. In general, compare the visual segment of this RPAT procedure to other approaches that you perform (overall level of effort).

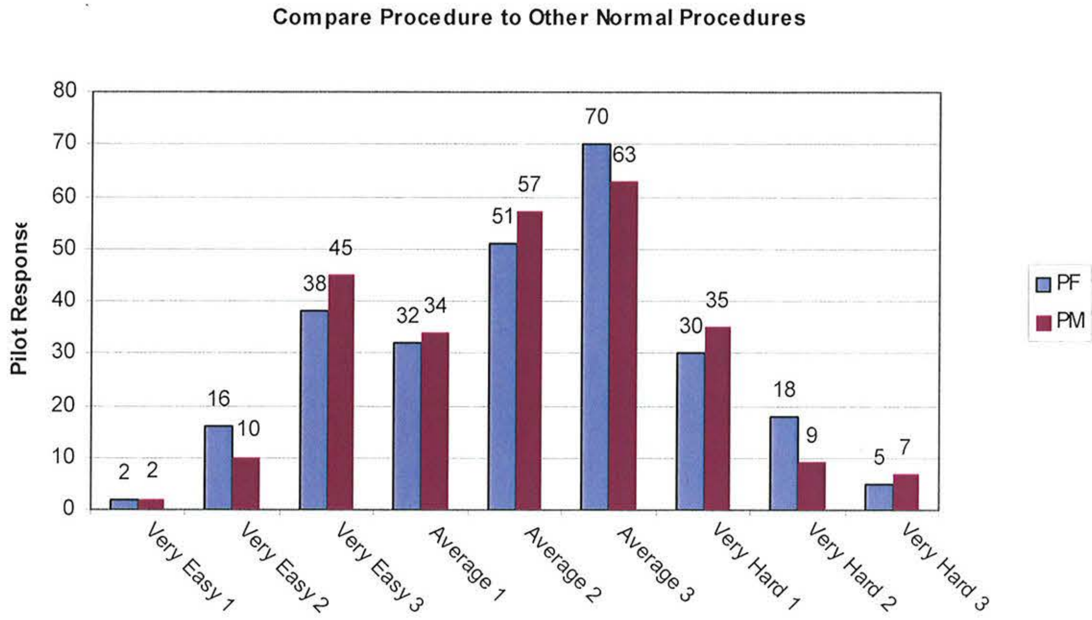

Figure 12: Post Run Questionnaire - Question 1 Responses

As Figure 12 indicates, a total of 524 responses to question 1 were obtained from the PF and Pilot Monitoring (PM). Of this total, 21% (113/524) were in the Very Easy range, 59% (307/524) were in the Average range and 20% (104/524) were in the Very Hard range. In summary, 80% of the responses were in the Very Easy or Average range. Thus, the vast majority of flight crews considered the level of effort during the visual portion of the RNAV approach to be on par with or easier than that of other approaches.

2. Rate your comfort level with this RPAT approach procedure given the proximity of the parallel traffic.

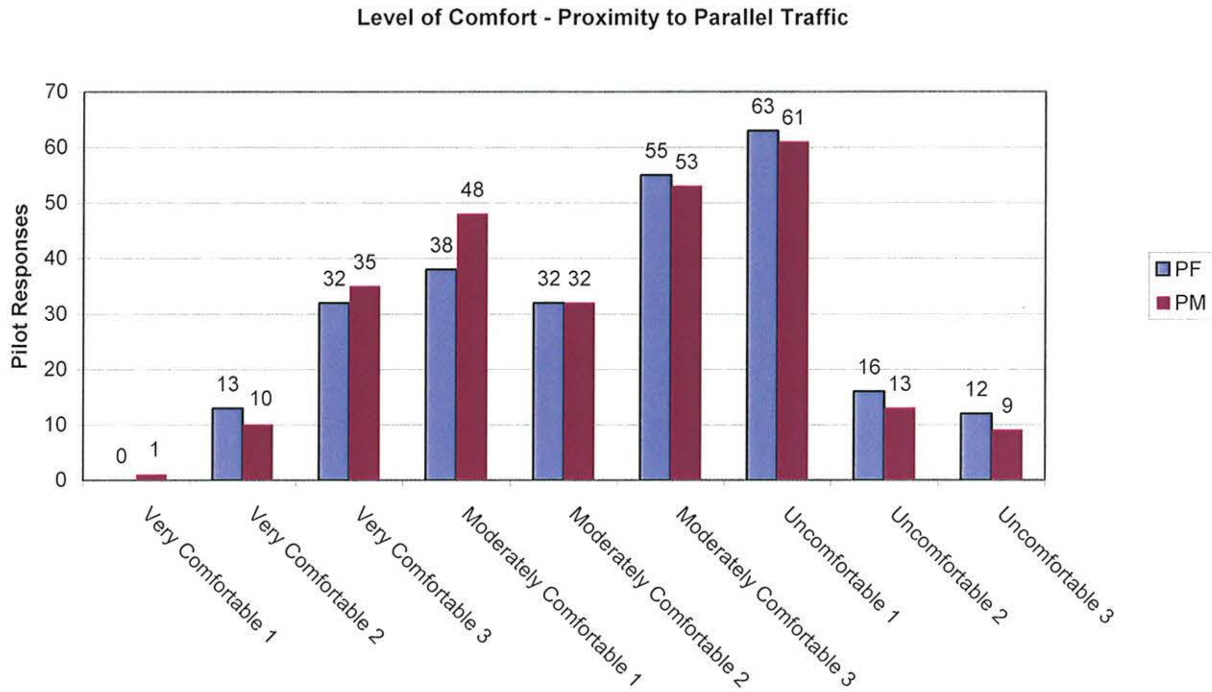

Figure 13: Post Run Questionnaire - Question 2 Responses

As Figure 13 indicates, a total of 523 responses to question 2 were obtained from the PF and PM. Of this total, 17% (91/523) were in the Very Comfortable range, 49% (258/523) were in the Moderately Comfortable range and 33% (174/523) were in the Uncomfortable range. The results show that over half (54%) of the respondents ranked their proximity to parallel traffic comfort level in the 4 highest categories, i.e. Moderately Comfortable 3 or Uncomfortable. Thus, over half of the respondents felt discomfort with the closeness of the parallel traffic during the evaluation.

3. Rate your level of aircraft stabilization for the visual segment portion of this approach based upon your organization's guidance for a stabilized approach.

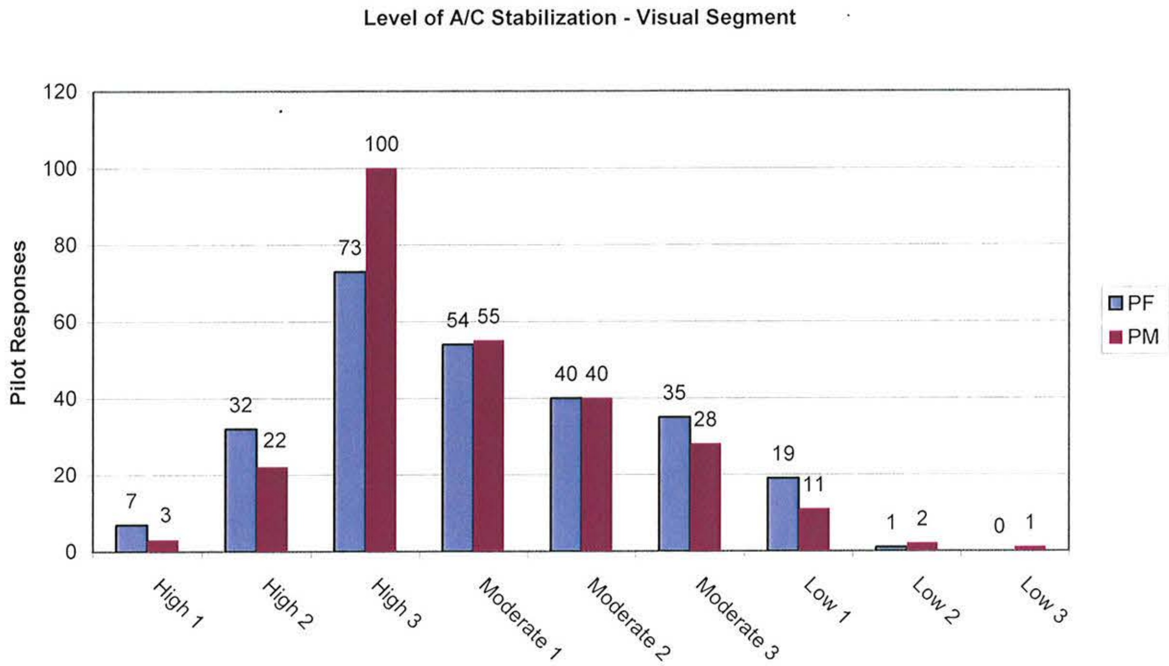

Figure 14: Post Run Questionnaire - Question 3 Responses

As Figure 14 shows, a total of 523 responses to question 3 were obtained from the PF and PM. Of this total, 45% (237/523) were in the High range, 48% (252/523) were in the Moderate range and 7% (34/523) were in the Low range. In summary, flight crews seem to be satisfied with the degree of aircraft stability during the visual segment of the RNAV approach.

4. Rate your perceived level of physical workload (e.g. head movement, switchology, controls) while flying this approach.

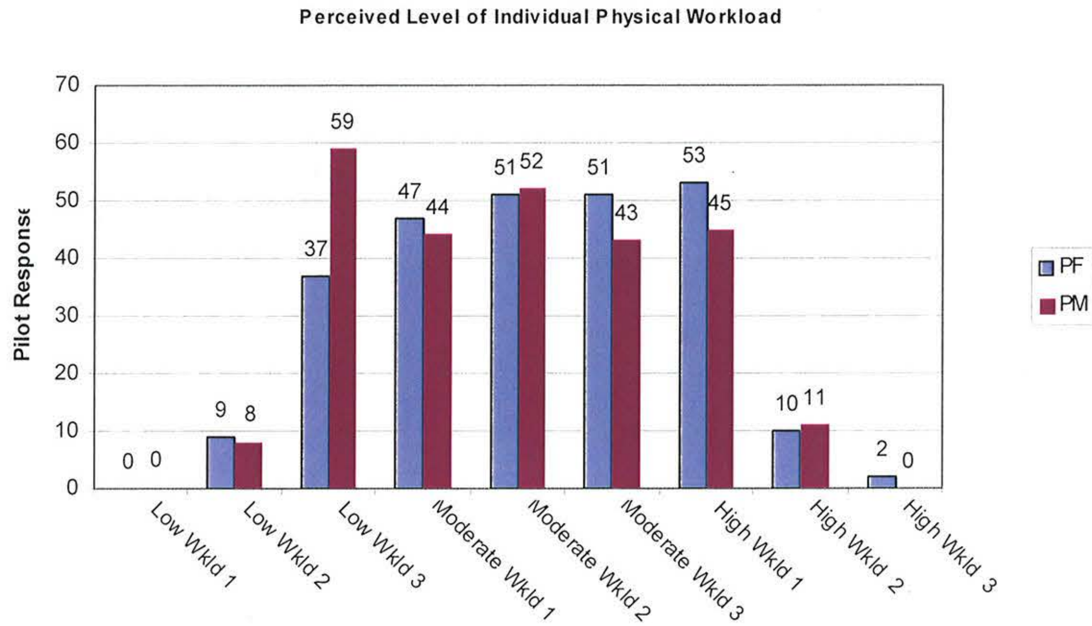

Figure 15: Post Run Questionnaire - Question 4 Responses

A total of 522 responses were received for question 4. The response breakdown is shown in Figure 15. As shown, 22% (113/522) of the responses fell in the Low Workload range, 55% (288/522) fell in the Moderate Workload range and 23% (121/522) were marked in the High Workload range. In general, the responses to question 4 do not indicate an inordinate amount of physical workload perceived on the approach.

5. Rate your perceived level of mental workload (e.g. searching, thinking, deciding, calculating) while flying this approach.

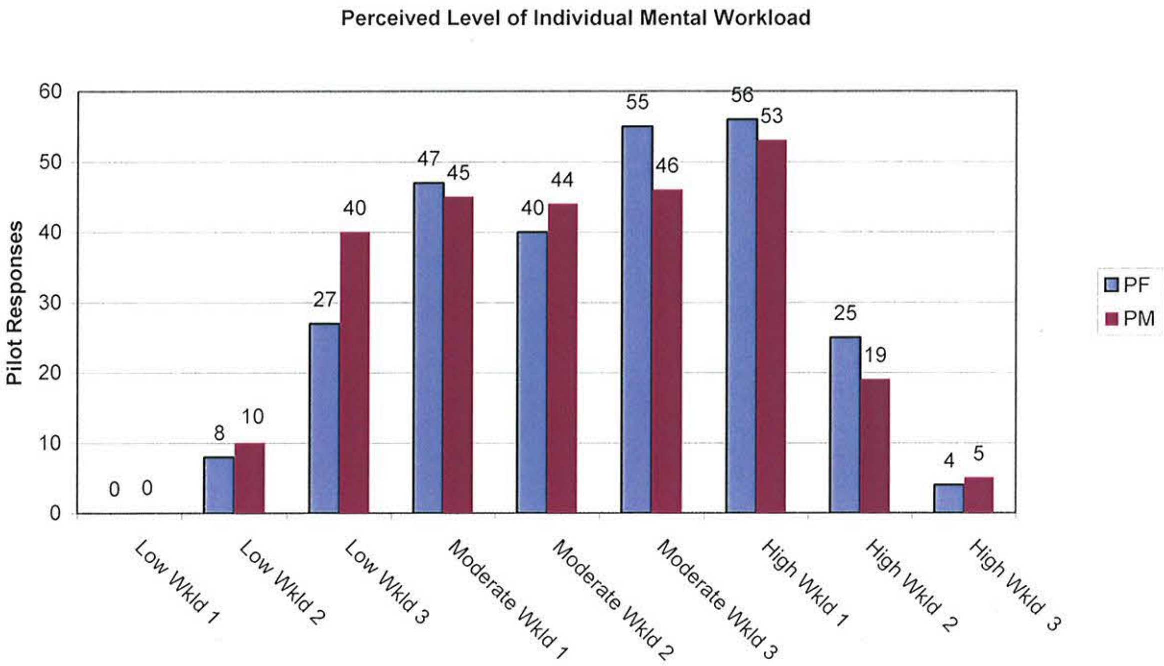

Figure 16: Post Run Questionnaire - Question 5 Responses

A total of 524 responses were received for question 5. The response breakdown is shown in Figure 16. As shown, 16% (85/524) of the responses fell in the Low Workload range, 53% (277/524) fell in the Moderate Workload range and 31% (162/524) were marked in the High Workload range. The results indicate that half (263/524) of the respondents ranked the perceived mental workload in the 4 highest categories, i.e. Moderate Workload 3 or High Workload. Thus, one out of every two participants perceived an elevated level of mental workload on the RNAV approach.

6. Rate your perceived level of crew workload while flying this approach (e.g. thinking, coordinating, searching, communicating, etc.).

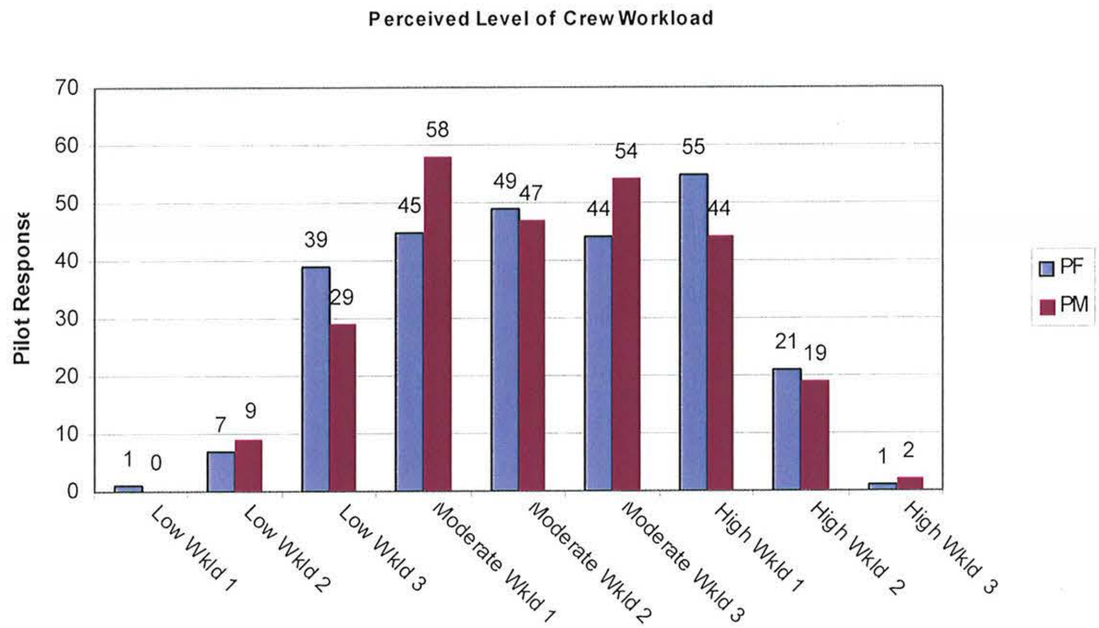

Figure 17: Post Run Questionnaire - Question 6 Responses

A total of 524 responses were received for question 6. The response breakdown is shown in Figure 17. As shown, 16% (85/524) of the responses fell in the Low Workload range, 57% (297/524) fell in the Moderate Workload range and 27% (142/524) were marked in the High Workload range. The results indicate that almost half (46%) of the respondents ranked the perceived crew workload in the 4 highest categories, i.e. Moderate Workload 3 or High Workload. Thus, almost one out of two participants perceived an elevated level of crew workload on the RNAV approach.

4.0. Test Director/Observer/Subject Pilot Observations

In general, during the first one-third of the test runs, pilots verbally expressed uncertainty with the RNAV approach and RPAT operation, primarily the curved path and rate of closure on the ILS aircraft. As the number of test run attempts increased, pilots communicated a more positive view of the RNAV approach and RPAT operation, especially during those scenarios using autopilot and auto-throttles. This is supported by the synopsis of the post simulator debriefing contained in Appendix A. Appendix A comments along with Test Director/Observer observations revealed the following five major areas of interest.

Night RPAT Operations. The pilots' written responses for the night scenarios reported that maneuvering in close proximity to the ILS aircraft at night was more difficult than day scenarios due to visual acuity. All the flight crews expressed concern with lateral distance, judging closure rate and monitoring the ILS aircraft during night RPAT operations. Pilots also stated they experienced some level of mental and/or physical workload increase.

In the night RPAT scenarios, judging closure rate with the ILS aircraft during the approach curved path segments was especially challenging, particularly while attempting to simultaneously monitor airspeed, altitude, course track, and the runway environment. In addition, the Observers noted and video playback supports increased head movements by the pilots. Because pilots must use very different monocular cues at night to achieve adequate depth perception, directional information and a sense of closure rate, flight crews appeared to place a higher emphasis on the TCAS and map display for aircraft separation during the night scenarios. It should be noted though that in all simulators, the visual screens represent a 2-dimensional world. This is especially true during night-simulated conditions. As such, the assumptions and assertions made from this study with regard to 2-dimensional versus 3-dimensional representations and the use of visual cues during the day and night may not be completely transferable to the real world. Clearly, there were visual acuity challenges with the RPAT operation and those challenges are magnified under night conditions. In addition to these visual acuity challenges, increased potential for vertigo and spatial disorientation exists when in "close proximity" to other aircraft at night.

Use of Autopilot and Auto-throttles. The last four test runs in each simulator session were conducted without the use of autopilot and auto-throttles. Each Captain and First Officer made a day and night run without autopilot and auto-throttles. The flight crews did continue to have a flight director with command steering bars available. The pilots' written responses indicated a significant workload level increase during these scenarios. In addition, the Observer noted the PF fixated on the command steering bars to maintain the lateral and vertical paths, thus greatly reducing the time devoted to visual monitoring of the ILS aircraft. The command steering bars fixation resulted in a slow crosscheck of airspeed and consequently, the aircraft speed on average exceeded the ILS aircraft speed by 5-10 knots.

TCAS RA. In every nominal (5000 feet parallel offset) case, the design of this RNAV approach resulted in TCAS RAs when flown as an RPAT operation. Figure 18 gives a pictorial representation of the general TCAS design.

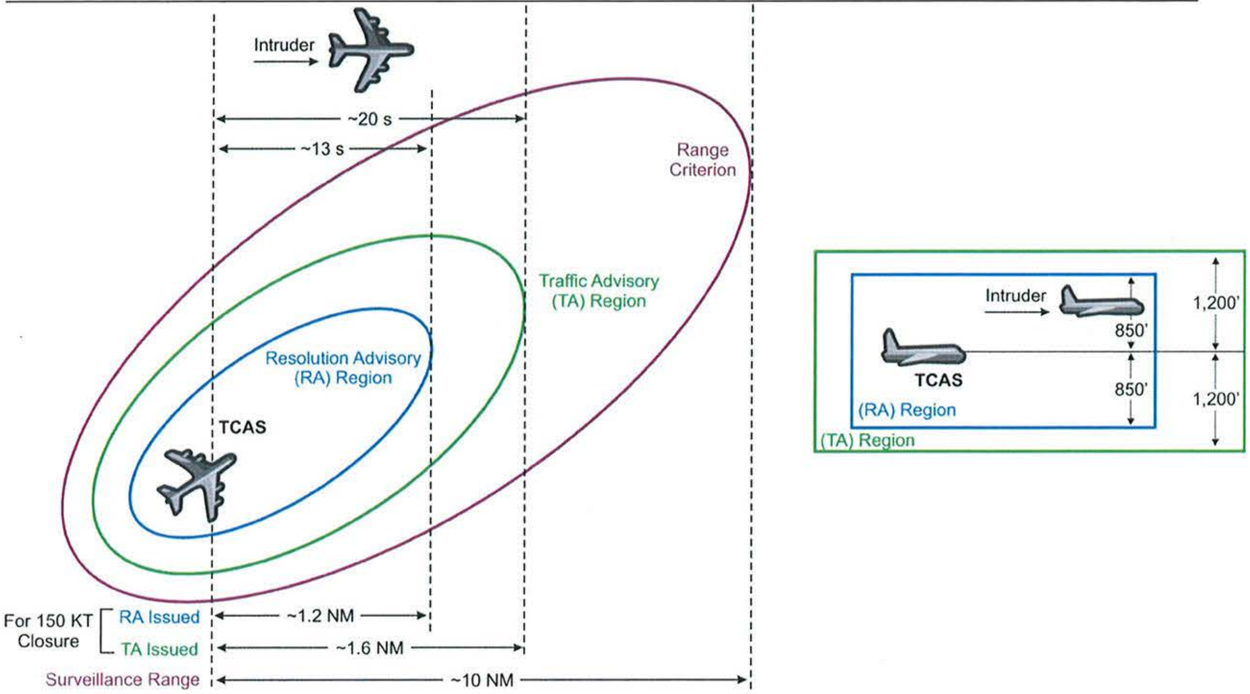

Figure 18: TCAS Design Concept

Closure rate between aircraft is the most important variable that determines TCAS RA alerts. Flight crews are trained to react to TCAS RA alerts and if necessary, take corrective actions by following the audio and display instructions. These instructions are usually an audio "climb" or "descend" (TCAS only provides vertical resolution of conflicts) and a visual cue to "avoid" red warning areas on the cockpit displays. Some airline companies make it mandatory for flight crews to follow RA instructions. In general, the RNAV aircraft's closure rate on the ILS aircraft while in the curved path segment triggered the TCAS RA audio and display alerts. During the test runs, however, most flight crews chose to disregard the TCAS warnings and continue with the RNAV approach. This was in keeping with their company guidance, based on being able to maintain visual separation from the ILS aircraft. Some flight crews did query the Test Director on whether to continue the approach or follow the TCAS RA guidance. In such cases, the Test Director recommended to continue the approach for data collection consistency.

The workload and stress level noticeably increased when the flight crews chose to disregard the TCAS RA warnings. During their feedback sessions, many flight crews specifically mentioned that the RA warnings were the "most disconcerting" aspect of the RNAV approach. This was especially true during night scenarios. In addition, it can reasonably be assumed that if the RNAV aircraft was experiencing TCAS warnings during the simulator scenarios, then the ILS aircraft would also be experiencing TCAS warnings during a real world approach. This situation could result in simultaneous avoidance maneuvers (one climb and one descent) by the two RPAT aircraft while in a busy airport terminal area. TCAS is designed to inhibit RAs when below 1000 feet AGL. Since the TCAS warnings were occurring at 1200 feet AGL, this may require an approach redesign to eliminate TCAS RA warnings or the RNAV approach could be flown in the "TA-only" mode.

Missed Approach in the Curved Path. Pilot written responses for the blunder and lost sight scenarios indicate high workloads and aircraft separation safety concerns. Flight crews were instructed to maintain the RNAV course while climbing to the missed approach altitude when executing a missed approach instead of turning away from the conflicting aircraft. At times during the missed approach sequence, the TCAS indicated the RNAV aircraft was flying virtually directly overhead of the ILS aircraft. In addition, without a redesign of the missed approach procedure, simultaneous missed approaches by both aircraft could potentially have catastrophic results. The missed approach procedure used for the RNAV approach was specifically designed to accommodate SFO airspace restrictions and was not in keeping with current FAA divergent course criteria for simultaneous approach operations.

Crew coordination. The Observers noted and pilots commented that crew coordination was lacking for RPAT operations. Communication was minimal between flight crewmembers and there appeared to be no clear division of responsibilities. As this was a first-look procedure, and no training programs have been established, lack of disciplined crew coordination was expected. Additionally, a number of First Officers noted that during the last portion of the curved path segment, the RNAV aircraft's glare shield blocked the First Officer's field of view. The Captains reported no difficulties with field of view. Pilot written responses also indicated that the PM should be the seat on the RNAV aircraft's side that the ILS aircraft is flying, i.e., left or Captain's side in this case. Pilots wrote that the Captain was better able to assess any traffic conflicts.

5.0. Recommendations

The following recommendations are made concerning the SFO RPAT operation to runways 28L and 28R. Some of the recommendations may also be applicable to RPAT operations in general.

1. Design the missed approach procedure for RPAT operations to include an immediate turn to a heading that will provide course divergence from the ILS final approach course. A turning missed approach will have the following advantages: 1) will create the quickest separation from the ILS aircraft, 2) will simplify the missed approach procedure for flight crews by allowing the missed approach heading to be pre-set in the navigation system, and 3) can be utilized anywhere along the RNAV approach, including the curved path segment. The missed approach procedure must meet current simultaneous approach criteria found in FAA Order 8260.3B.

2. Develop a training program to describe and explain RPAT operations and crew coordination issues. Specifically, an Internet-based video training program for flight crews might alleviate concerns with closure rates and close proximity flying, particularly at night, in RPAT scenarios.

3. Require the use of the autopilot by the RNAV aircraft until established on the straight portion of short final approach.

4. Redesign the SFO RNAV approach to mitigate TCAS RAs.

6.0. References

1. Lankford, D. N., McCartor, G., Hasman, F., Greene, G. C., Yates, J., Ladecky, S. and Templeton, D., "San Francisco International Airport Simultaneous Offset Instrument Approach Procedures (SOIA), Volume I," DOT-FAA-AFS-420-84, March 2000.

2. Lankford, David, et al, "Safety Study Report on San Francisco International Airport Simultaneous Offset Instrument Approach (SOIA) Wake Vortex Re-evaluation", DOT-FAA-AFS-440-8, April 2005.

Appendix A:
Post Simulator Debriefing Synopsis

1. Overall, did you feel comfortable with this approach, based upon your experience with all other approaches that you perform? Why or why not?

Crew #1:

a. Very comfortable.
b. Challenging due to close proximity to other aircraft.

Crew #2:

a. Somewhat comfortable…disorienting at night with marginal visibility, especially during blunders.
b. Yes…after 4-5 approaches, much easier.

Crew #3:

a. Yes…required more SA and division of attention.
b. Reasonably comfortable…night more difficult.

Crew #4:

a. Yes…if both aircraft are aware and practice.
b. Got better as seen more…autopilot a must.

Crew #5:

a. With experience, OK under normal conditions…would be very uncomfortable with new crew, low visibility, blundering, and system error.
b. Comfortable with all except for the right turn to final from the right seat…lose sight as aircraft drops below glare shield.

Crew #6:

a. No. Concern over what the aircraft might do is high (i.e., Nav error etc.) Actual line experience might result in a high degree of confidence. (ALPA)
b. Compared to other closely spaced parallel runways, it was slightly more difficult due to the turn in required.

Crew #7:

a. Visibility and TCAS play important role as to the difficulty of the approach (headwork).
b. Comfortable. The traffic is closer than we normally experience, but not unsafe.

Crew #8:

a. Yes, but a huge demonstration of CRM.
b. Comfortable with the approach, but NOT the close proximity with the parallel aircraft.

2. At rollout for alignment with the runway centerline, were you in an acceptable position to complete a landing in keeping with your company's standards? Why or why not?

Crew #1:

a. Yes-stabilized by 500 feet.
b. Yes…but a lot of trust with other aircraft.

Crew #2:

a. Yes…no problem.
b. Yes…safe transitions.

Crew #3:

a. Yes…no extreme turns or banks were required to land.
b. Yes…rollout allowed plenty of time for safe alignment.

Crew #4:

a. Yes…we met criteria.
b. Yes when rolling out lined up…no when angling due to system error.

Crew #5:

a. Yes, but would prefer to be further after of traffic.
b. Yes.

Crew #6:

a. Yes.
b. Yes if the Nav display was accurate.

Crew #7:

a. Yes…500 AGL is the limit.
b. Yes, LNAV/VNAV made the transition smooth, even in crosswinds.

Crew #8:

a. Yes, but didn't understand the approach that was too far left…
b. Yes, transition was fine.

3. What additional mental or physical requirements, if any, were imposed on you during this approach?

Crew #1:

a. Overshooting winds, thorough pre-brief.

Crew #2:

a. None really…some indecision trying to decide how far/close the traffic was.
b. With Autopilot, very manageable. Maintain visual was the hard part.

Crew #3:

a. More attention to other aircraft and his actions.
b. Judgment was very important...especially with blunders and lost sight.

Crew #4:

a. Watching the other A/C and being prepared for a missed approach on short notice.
b. Marginal WX…my concentration split 3 ways…gages, runway, and traffic.

Crew #5:

a. None.
b. Need good visibility to determine if traffic is lining up on the right runway.

Crew #6:

a. Trying to watch the other aircraft is the real problem. The actual aircraft alignment maneuver is nice.
b. Traffic monitoring was an additional work load.

Crew #7:

a. FO bank angle blocked other aircraft…did not see the NSEs.
b. Traffic awareness, convergence acquisition of the runway complicated the crosscheck scan, much higher workload.

Crew #8:

a. No real mental/physical. More effort in CRM.
b. More mental to evaluate other aircrafts position and path, physical required to monitor and crosscheck rwy, app, and power.

4. Would you consider this approach to be stabilized based upon your company's/organization's guidelines for a "stabilized approach"? Why or why not?

Crew #1:

a. Yes.
b. Very small margin of error.

Crew #2:

a. Yes.
b. Yes.

Crew #3:

a. Yes…no radical turns required to line up with runway.
b. Yes…1000 feet limit.

Crew #4:

a. Yes.
b. Yes if no system error…1000 feet limit.

Crew #5:

a. Yes…preferred the offset system error that was right of course.
b. Yes as long as traffic was visible.

Crew #6:

a. Yes, except when Nav error occurs.
b. Yes.

Crew #7:

a. Yes.
b. Yes, 500 feet is used.

Crew #8:

a. Yes.
b. Yes.

5. Did you have any difficulty monitoring the parallel traffic while flying this RNAV approach? Explain why or why not?

Crew #1:

a. Right seat—yes during the turns.
b. No…PM did a good job monitoring.

Crew #2:

a. Sometimes…right seat during banks.
b. Yes…periods of low visibility, difficult.

Crew #3:

a. Sometimes at night and during low visibility, unable to tell blunders.
b. Bit at night and in the haze.

Crew #4:

a. Not a problem with full system…harder when hand flown.
b. Difficult to monitor traffic from FO seat; closer, the easier it was to monitor.

Crew #5:

a. Only in low visibility/night prevented quick detection of the other A/C moves.
b. Right seat loses sight…but no problems, same as a circle.

Crew #6:

a. As FO, could not see other traffic very well and had to depend on Capt's assessment
b. At times in low visibility or if we got ahead of the traffic

Crew #7:

a. Yes, visibility and bank angles critical for this approach.

b. No, but requires higher skills not normally required…closure rate etc.

Crew #8:

a. No, only in IMC.

b. Yes, with parallel, requirement for extreme head movement over just eye movement.

6. What impacted your performance most, i.e. monitoring the parallel traffic, flying the RNAV approach, transitioning to the runway environment /lining up with the runway centerline, descent rate to the TDZ?

Crew #1:

a. Monitoring the traffic and not overshoot the centerline.

Crew #2:

a. All of the above…especially night and overshooting crosswinds.

b. Hardest…monitoring the parallel traffic.

Crew #3:

a. Monitoring parallel traffic.

b. Monitoring the parallel traffic and watching the instruments.

Crew #4:

a. Monitoring the traffic.

b. Harder with haze and without autopilot.

Crew #5:

a. Monitoring traffic had a tendency to mess up my crosscheck…even slight glances away could be hazardous.

b. Transitioning to runway environment while monitoring winds and traffic.

Crew #6:

a. Monitoring parallel traffic and dealing w/ TCAS RA's that we ignored.

b. Monitoring the traffic.

Crew #7:

a. Monitoring the traffic…unpredictability with other traffic…stress level higher.

b. Monitoring parallel traffic…but not unmanageable.

Crew #8:

a. Weather…on a clear day a pilot could recognize slight deviations.

b. Monitoring the parallel traffic required the most workload…so close.

7. Based on your experience, do you think these RPAT approaches are viable and safe? Why or why not?

Crew #1:

a. Yes, with training.
b. Viable if needed.

Crew #2:

a. Day VFR good, night marginal…RA very distracting, noise. Viable-yes, Safe-yes, smart-no.
b. Yes…much easier with autopilot.

Crew #3:

a. Yes…minimal training required.
b. Yes…with appropriate training.

Crew #4:

a. Yes…with full systems, training, and WX criteria.
b. Viable in great WX and full up system with autopilot.

Crew #5:

a. Day VFR with experienced crews.
b. Possible if WX and visibility is good day and night.

Crew #6:

a. No, not w/TCAS and not at Night. Day ok with experience.
b. I think they are viable, but TCAS must be required and RA's can't be. ignored on the assumption that you have the traffic.

Crew #7:

a. Not sure purpose…why not stagger ILS approaches.
b. Viable and safe…GPS works.

Crew #8:

a. Safe for experienced crews.
b. Safe, but more an issue of risk…to much risk to manage for this approach.

8. Any closing comments to the effectiveness of these RPAT approaches?

Crew #1:

a. TCAS needs to be in TA only. Pilot with best view needs to monitor and other pilot fly the approach.

Crew #2:

a. Passengers would be outraged/scared.
b. Need to increase task saturation by adding Emergencies and checklists.

Crew #3:

a. TCAS…major distraction, TA only.
b. Approach works well…careful during night operations.

Crew #4:

a. Works under tight A/C, crew, WX and ATC controls.
b. Would help with flow, but need good WX.

Crew #5:

a. More nose/tail spacing.

Crew #6:

a. Must deal w/TCAS. Ignoring RA's is unacceptable. Capt told me his company policy is to follow every RA…then proceeded to ignore every one
b. If TCAS RA's can be resolved…it is viable.

Crew #7:

a. What does the lead ILS aircraft do when his TCAS activates?
b. Pilots should receive simulation training before conducting.

Crew #8:

a. Visibility a key factor and RPAT aircraft not overtake the ILS aircraft.
b. Designed for efficiency, but the risks are too great (converging, go-arounds while converging, TCAS RAs etc.).