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Flight Procedure Standards Branch
Flight Technologies and Procedures Division
Flight Standards Service

250-KNOT SPEED RESTRICTION EVALUATION

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12. Abstract

In June 1997, the FAA initiated a field test, conducted by Houston Intercontinental Terminal Radar Approach Control, of a proposed increase of the 250 KT speed restriction for aircraft operating below 10,000 feet within Class B airspace. A 1997 MITRE report concluded that there was an apparent increase in the number of aircraft that appeared to exit the side of the Class B airspace below 10,000 feet at speeds greater than 250 KT. Since the MITRE study did not address the underlying causes of the increased exit rate, the FAA Flight Procedure Standards Branch was tasked to determine the conditions or performance limitations that might cause an unintentional exit of the Class B airspace below 10,000 feet at speeds greater than 250 KT. The evaluation was divided into two principal efforts. The first activity was an in-depth analysis of the data that initiated the MITRE conclusion. The second effort involved the design and performance of a flight test utilizing a Boeing B-727-200 level C simulator. The analysis of radar tracks revealed 28 instances where the aircraft unintentionally exited Class B airspace prior to reaching 10,000 feet altitude. Eighteen of the instances were attributed to older generation aircraft. In the second effort, two visual locales for the simulation were chosen, a sea level locale and a high altitude (5,431 feet) locale. Test departures were flown straight away on runway heading at constant airspeeds ranging from 250 KT increasing decimally to a maximum of 310 KT with an ambient temperature of 95° F and a heavy take-off weight. Fifty-five flights were conducted at the low altitude airport and 25 flights were conducted at the high altitude airport. Thirty-three of the low altitude flights reached 10,000 feet and all 25 of the high altitude flights reached 12,000 feet within Class B airspace. It was found that the pilots of the successful flights used significantly higher power settings, reconfigured their aircraft, and accelerated to their climb speed in a more expeditious manner than the pilots of the unsuccessful flights. Five recommendations were presented that could eliminate exits from Class B airspace below 10,000 feet.

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EXECUTIVE SUMMARY

In 1995 an RTCA Task Force recommended to the Federal Aviation Administration (FAA) that a study of the 250 KT speed restriction for aircraft operating below 10,000 feet within Class B airspace be conducted to determine whether the speed restriction can be increased or eliminated. In response, the FAA initiated a field test of the proposed change conducted by Houston Intercontinental Terminal Radar Approach Control (TRACON) beginning June 26, 1997. In December 1997, the MITRE Center for Advanced Aviation System Development (CAASD) published a preliminary evaluation of that field study. The most significant effect of the increase in the speed limit, reported by MITRE, was the apparent increase in the number of aircraft that appeared to exit the side of the class B airspace below 10,000 feet at speeds greater than 250 knots (KT). The MITRE study did not include an in-depth analysis of the underlying causes of the increased exit rate, but this conclusion fostered the perception that the level of collision risk with uncontrolled traffic passing just outside the class B airspace may be increased with the increase in the speed limit. As a consequence, the FAA Flight Procedure Standards Branch (AFS-420) was tasked to determine the conditions or performance limitations that might cause an unintentional exit of the class B airspace below 10,000 feet at speeds greater than 250 KT.

The evaluation was divided into two principal efforts. The first activity was an in-depth analysis of the data that initiated the report by MITRE that the rate of unintentional exit of aircraft exceeding 250 KT from class B airspace below 10,000 feet had increased. In order to conduct this analysis, the AFS-420 Airspace Simulation and Analysis for TERPS (ASAT) computer system was modified to manage the large amount of data contained in each data set and to facilitate analysis on a track by track basis. The ASAT modification permitted the analysis of the radar tracks in two different ways. The first method consisted of plotting each of the two data sets in its entirety and comparing the overall characteristics of each set. The second method consisted of examining each track representing an unintentional exit for the underlying causes of the exit.

The radar tracks recorded by the Houston TRACON during the period June 26, 1997 to August 6, 1997, and initially investigated by MITRE, were analyzed using the ASAT computer system. The analysis revealed 38 instances where the aircraft exited class B airspace prior to reaching 10,000 feet altitude. The analysis indicated that 10 of the 38 instances were induced by air traffic control action. The remaining 28 were all attributed to four types of older generation aircraft, the DC-9, the B-727, the MD-80, and the B-737. Only 10 Class B Exits (CBEs) were attributed to the MD-80 and B-737. No newer generation aircraft such as the B-767, B-747, or MD-11 exited class B airspace prior to reaching 10,000 feet during the recording period.

The second effort involved the design and performance of a flight test utilizing the Boeing B-727-200 level C simulator located at the Mike Monroney Aeronautical Center in Oklahoma City, Oklahoma. The objective was to design and perform departure routings in order to collect flight tracks for comparison to the radar track data collected at Houston. The Boeing B-727 simulator was chosen because it represents a typical lower performance older generation aircraft.

Current pilots, qualified in the B-727-200, were enlisted to fly the flight simulator. Fourteen FAA flight crews and one flight crew from Continental Airlines were briefed and familiarized with the simulator prior to data acquisition runs. Two visual locales for the simulation were chosen, a sea level locale and a high altitude (5,431 feet) locale. Test departures were flown straight away on runway heading at various speeds starting at 250 knots indicated airspeed (KIAS) and increased in steps of 10 KIAS to a maximum of 310 KIAS. The selected speed remained the target speed throughout each departure. The B-727-200 take-off weight was 183,000 pounds for the low altitude airport and 163,000 pounds for the high altitude airport. The ambient temperature was 95° Fahrenheit with an altimeter setting of 29.92 inches of mercury. Pilots were briefed to maintain take-off power to 3,000 feet and then to maintain 92% power (N 1) during the climb. The flight simulator used for the study was updated with Dash 15 engines and FAA mandated hush kits. The hush kit on the B-727-200 is the United Airlines configuration, which results in very little degradation in performance.

Fifty-five flights were conducted at the low altitude airport and 25 flights were conducted at the high altitude airport. All flights were performed at high (95° F) temperatures. No exits from class B airspace prior to reaching 12,000 feet were recorded for the high altitude airport flights; however, 22 of the low altitude airport flights resulted in exits from class B airspace prior to reaching 10,000 feet.

Analysis of the low altitude flights revealed the B-727 is capable of successfully reaching 10,000 feet prior to exiting class B airspace at speeds up to 300 KT with an air temperature of 95° F and a gross take-off weight of 183,000 pounds, if appropriate piloting techniques are employed. Thirty-eight of the 55 flights were successful in reaching10,000 feet prior to exiting class B airspace. It was found that the successful flights used higher power settings than the unsuccessful flights. Additionally, the pilots of the successful flights reconfigured their aircraft and accelerated to their climb speed in an expeditious manner.

In order to insure aircraft reach 10,000 feet before exiting class B airspace, it is recommended that:

a. Pilots should be informed, in some appropriate manner, of the need to perform the departure climb in the most expeditious and efficient manner prior to being issued clearance for high speed climb profiles.

b. Maximum take-off thrust should be maintained to 3,000 feet. The aircraft should be reconfigured for climb with maximum climb power appropriate for the atmospheric conditions which should be maintained until 10,000 feet is reached.

c. Consideration should be given to the establishment of climb corridors in high density traffic areas.

d. Consideration should be given to the addition of an annotation to Standard Instrument Departures (SIDs) indicating the aircraft must reach 10,000 feet altitude prior to reaching 30 NM DME.

e. Consideration should be given to the addition of climb profiles to SIDs that provide a description of the requirements to reach 10,000 feet prior to reaching 30 NM DME.

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250-KNOT SPEED RESTRICTION EVALUATION

1.0 INTRODUCTION

In 1995 an RTCA Task Force recommended to the Federal Aviation Administration (FAA) that a study of the 250 KT speed restriction for aircraft operating below 10,000 feet within Class B airspace be conducted to determine whether the speed restriction can be increased or eliminated. In response, the FAA initiated a field test of the proposed change conducted by Houston Intercontinental Terminal Radar Approach Control (TRACON) beginning June 26, 1997. In December 1997, the MITRE Center for Advanced Aviation System Development (CAASD) published a preliminary evaluation (see Spelman, et al) of that study. Although the primary purpose of the study was to assess the impact on air traffic controllers, flight crew, and the surrounding population, the study also included a comparison of flight tracks before initiation of the field test and during the field test based on Automated Radar Terminal System (ARTS) data. The first set of radar track data was collected from April 8, 1997 to May 18, 1997. The second set of data was collected from June 26, 1997 to August 6, 1997. The high air temperatures present during the second time period were ideal for the evaluation of the effects of the lifting of the 250 KT speed limit.

The most significant effect of the increase in the speed limit, reported by MITRE, was the apparent increase in the number of aircraft that appeared to exit the side of the Class B airspace below 10,000 feet at speeds greater than 250 KT. The MITRE report states "... there is a noticeable shift outward of the point at which aircraft reach 10,000 feet. That in itself is unremarkable, as it was expected that most aircraft would climb somewhat slower when allowed to accelerate to higher forward speeds. However, the results also indicate that there is an apparent increase in the number of aircraft exiting the side of Class B, below 10,000 feet, at speeds in excess of 250 knots, during the field test."

The MITRE report concluded that "... there seems to be a direct correlation between the higher authorized speeds and the number of aircraft outside of the Class B lateral limits at speeds greater than 250 knots." The MITRE study did not include an in-depth analysis of the underlying causes of the increased exit rate, but this conclusion fostered the perception that the level of collision risk with uncontrolled traffic passing just outside the Class B airspace may be increased with the increase in the speed limit. As a consequence, the FAA Flight Procedure Standards Branch (AFS-420) was tasked to determine the conditions or performance limitations that might cause an unintentional exit of the Class B airspace below 10,000 feet at speeds greater than 250 KT.

2.0 EVALUATION DESCRIPTION

The evaluation was divided into two principal efforts. The first activity was an in-depth analysis of the data that initiated the report by MITRE that the rate of unintentional exit of aircraft exceeding 250 KT from Class B airspace below 10,000 feet had increased. In order to conduct this analysis, the AFS-420 Airspace Simulation and Analysis for TERPS (ASAT) computer system was modified to manage the large amount of data contained in each data set and to facilitate analysis on a track by track basis. The ASAT modification permitted the analysis of the radar tracks in two different ways. The first method consisted of plotting each of the two data sets in its entirety and comparing the overall characteristics of each set. The second method consisted of examining each track representing an unintentional exit for the underlying causes of the exit. An unintentional exit of Class B airspace below 10,000 feet will be referred to as a Class B Exit (CBE). A CBE can be caused by a variety of circumstances such as aircraft type, piloting techniques, or air traffic control procedures.

The second effort involved the design and performance of a flight test utilizing the Boeing B-727-200 level C simulator located at the Mike Monroney Aeronautical Center in Oklahoma City, Oklahoma. The objective was to design and perform departure routings in order to collect flight tracks for comparison to the radar track data collected at Houston. The Boeing B-727 simulator was chosen because it represents a typical lower performance older generation aircraft.

Current pilots, qualified in the B-727-200, were enlisted to fly the flight simulator. Fourteen FAA flight crews and one flight crew from Continental Airlines were briefed and familiarized with the simulator prior to data acquisition runs. Differences in simulator equipment were identified for the participating crews.

Two visual locales for the simulation were chosen. The first locale was the San Francisco International Airport (SFO), which was chosen to be representative of sea level airports such as George Bush Intercontinental Airport (IAH) at Houston, Texas. The second was the Denver International Airport (DEN), which was chosen to be representative of high altitude airports. In either case, the choice of visual location is unimportant. The important factors in the simulation are: density altitude, aircraft weight and performance, air traffic control procedures, and piloting techniques.

Test departures were flown straight away on runway heading at various speeds starting at 250 knots indicated airspeed (KIAS) and increased in steps of 10 KIAS to a maximum of 310 KIAS. The selected speed remained the target speed throughout each departure. Some of the departures included a level off for one minute at 4,000 feet AGL with a target speed of 250 KIAS. Some scenarios were altered by personnel from the Houston Departure Control facility to simulate operational procedures; however, these were for a comparison to the planned scenarios and only eight were flown.

The B-727-200 take-off weight was 183,000 pounds for the low altitude airport and 163,000 pounds for the high altitude airport. The ambient temperature was 95° Fahrenheit with an altimeter setting of 29.92 inches of mercury. Pilots were briefed to maintain take-off power to 3,000 feet and then to maintain 92% power (N 1) during the climb. The flight simulator used for the study was updated with Dash 15 engines and FAA mandated hush kits. Most hush kits reduce climb performance which is offset by reduced operation weights. The hush kit on the B-727-200 is the United Airlines configuration, which results in very little degradation in performance.

3.0 RADAR TRACK ANALYSIS

Figure 3.1 is a plot of the first set of radar tracks collected while the 250 KT speed limit was still in effect. Figure 3.2 is a plot of the second set of radar tracks collected during the field test. In each graph the green ring represents the boundary of the Class B airspace. The red segments represent the portions of the tracks below 10,000 feet.

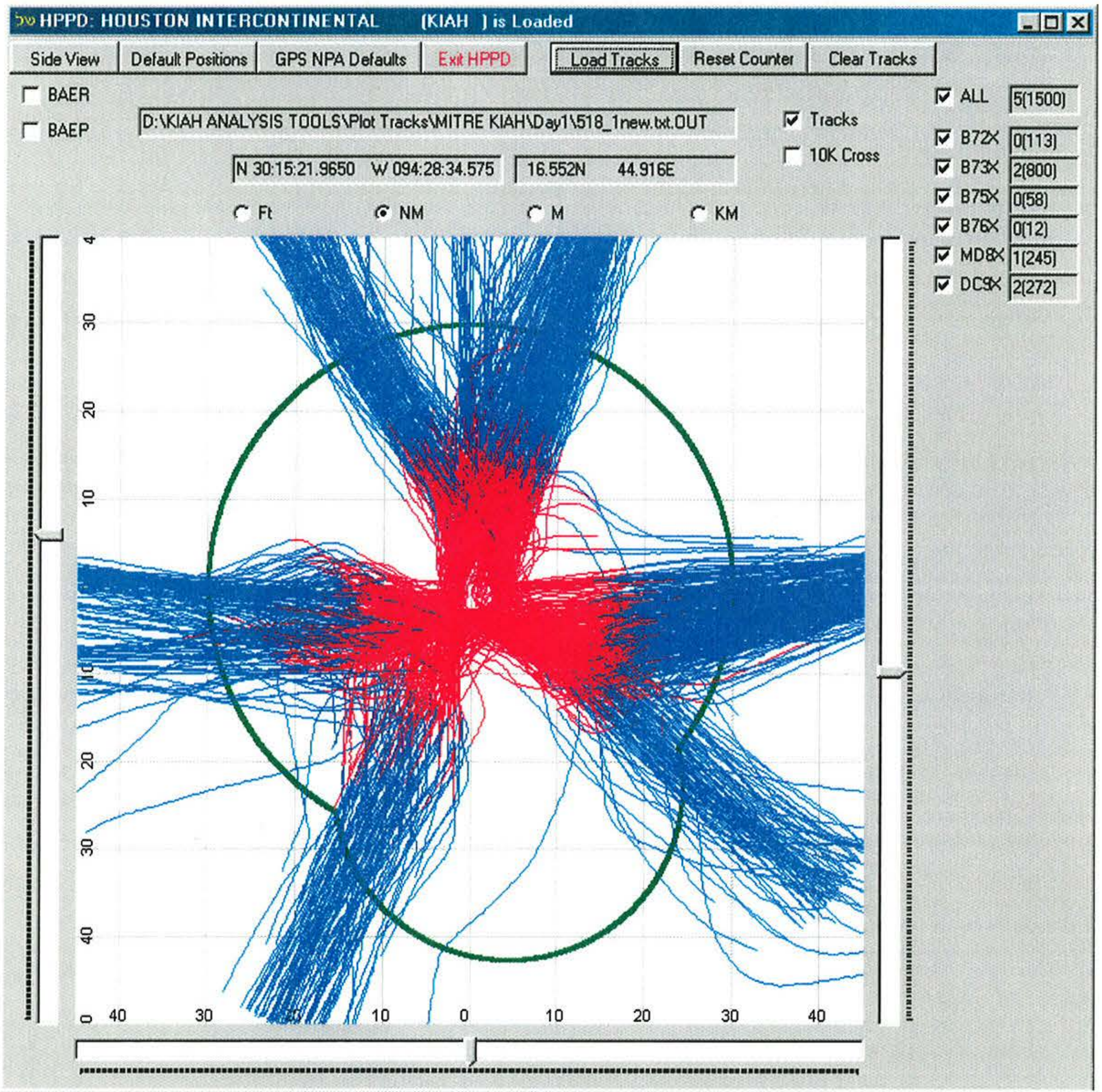


Figure 3.1: RADAR TRACKS WITH 250 KT SPEED LIMIT

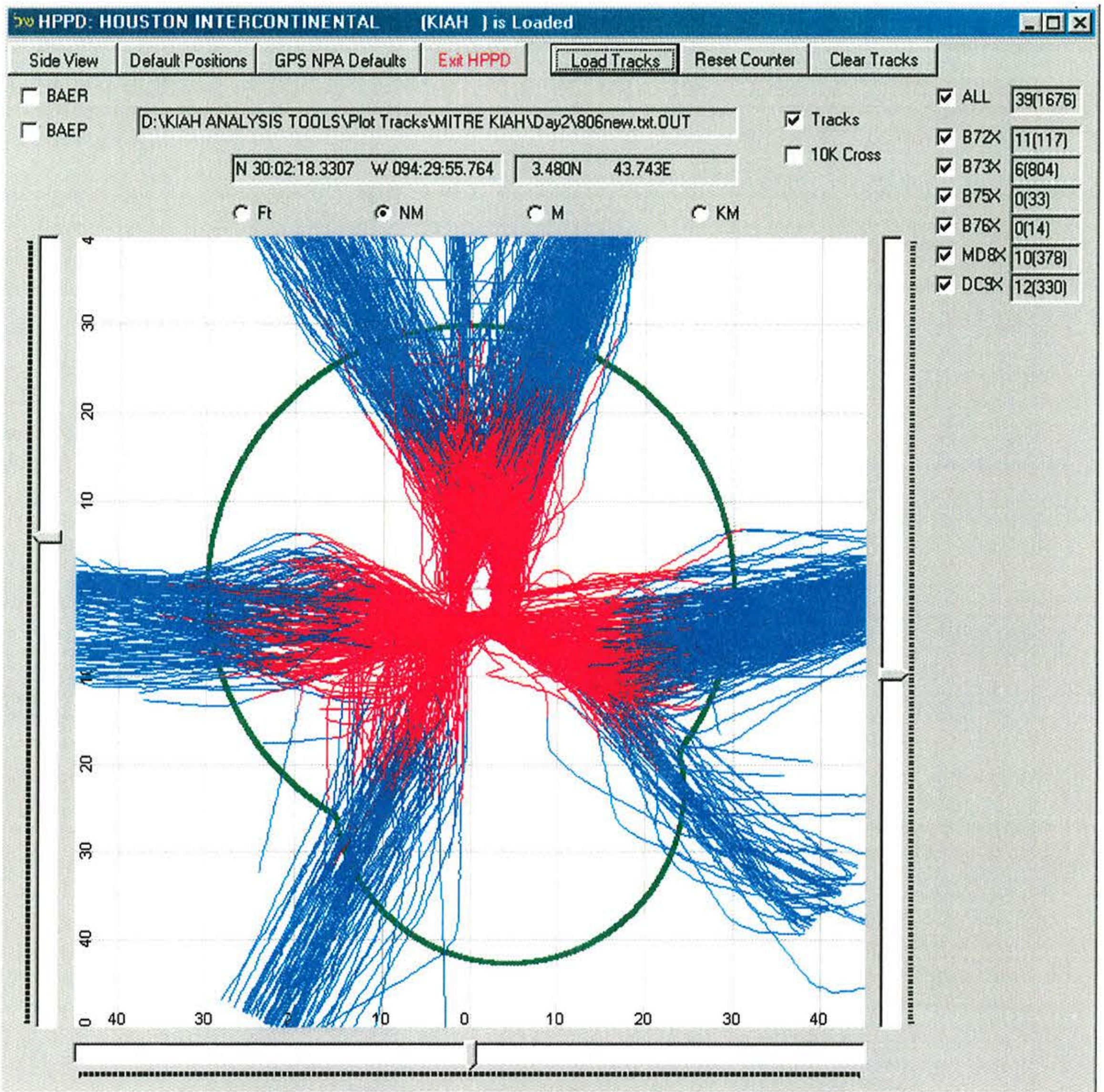


Figure 3.2: RADAR TRACKS DURING FIELD TRIAL

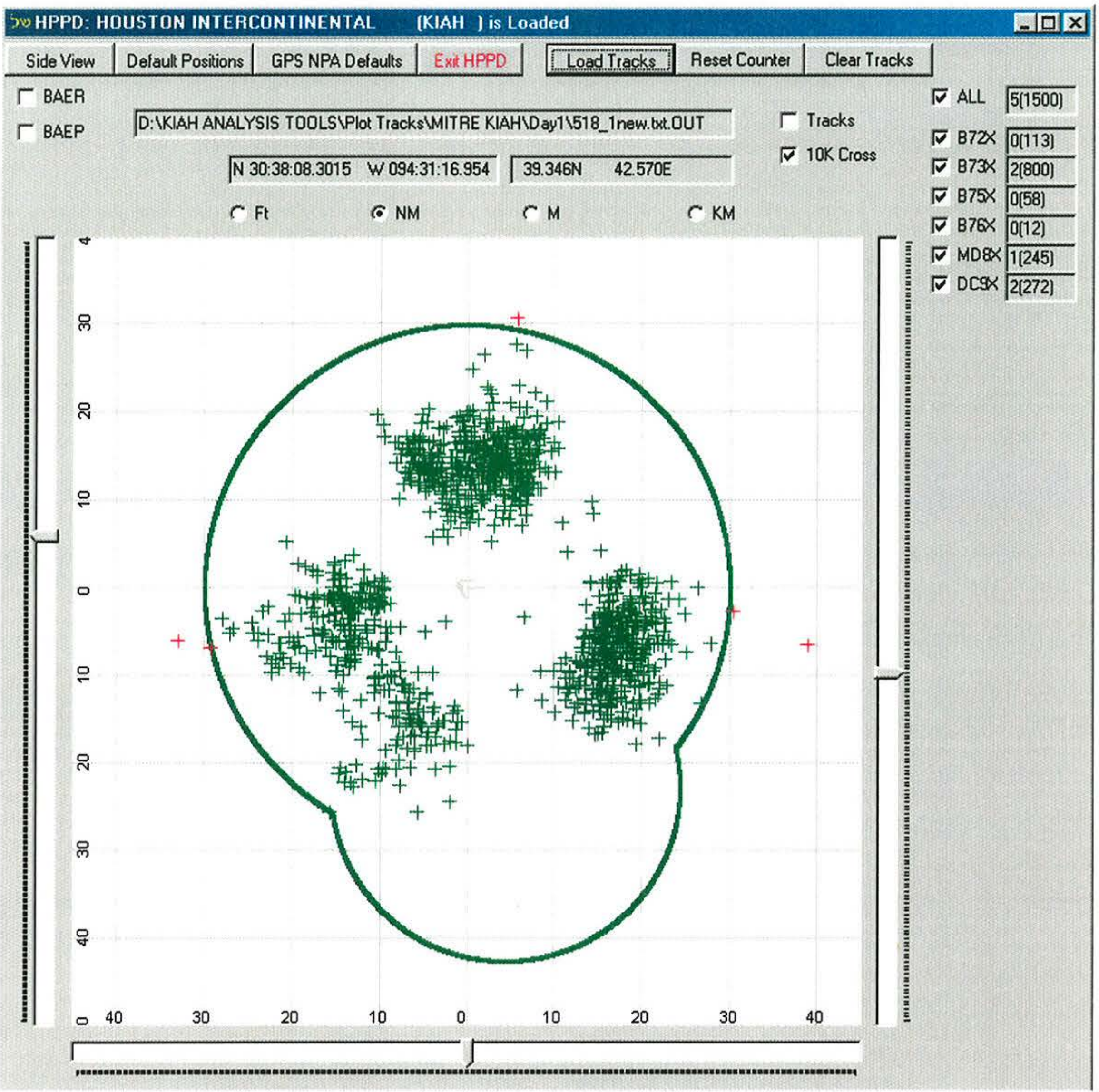


Figure 3.3: LOCATION OF AIRCRAFT CROSSING 10,000 FEET WITH 250 KT SPEED LIMIT

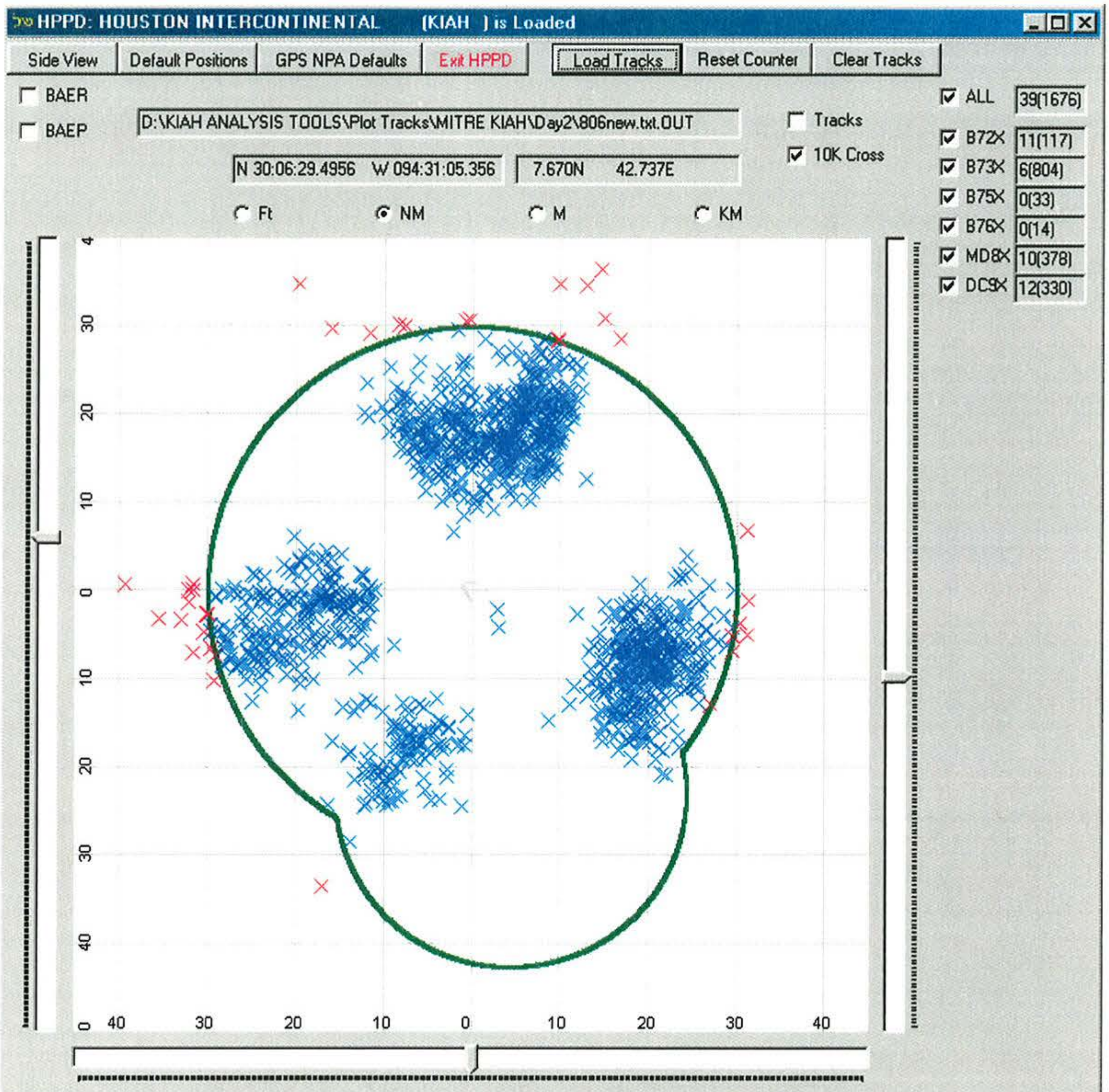


Figure 3.4: LOCATION OF AIRCRAFT CROSSING 10,000 FEET DURING FIELD TRIAL

The blue segments represent the portions of the tracks above 10,000 feet. A visual comparison of the two graphs indicates the aircraft seem to be reaching, on average, 10,000 feet somewhat nearer the Class B airspace boundary in figure 3.2 than in figure 3.1.

Figure 3.3 is a plot of the points where the aircraft reached 10,000 feet from the data set collected while the 250 knot speed limit was in effect. The points are plotted as plus signs. The green plus signs are inside Class B airspace and the red plus signs are outside. Figure 3.4 is a plot of the points where the aircraft reached 10,000 feet from the data set recorded during the field test. From figures 3.3 and 3.4 there is an obvious increase in the number of aircraft exiting Class B airspace before 10,000 feet altitude is attained.

There were 38 CBEs found in the second data set recorded during the field test. Of these, 10 CBEs were found to have speeds below 250 KT or were the result of air traffic control (ATC) action; e.g., the aircraft were obviously leveled for a period of time. Therefore, 28 CBEs had speeds exceeding 250 KT and were not the result of ATC action. Since there were 1,676 radar tracks, the CBE rate was only about 1.7 percent.

An example of a CBE that was leveled for a period of time is shown in figure 3.5. The upper half of figure 3.5 is a plan view of the flight track. The segment of the track where the aircraft is below 10,000 feet is drawn in red. The segment of the track where the aircraft is above 10,000 feet is drawn in blue. The lower half of figure 3.5 is a profile view of the track with a plot of the indicated airspeed. Figure 3.5 indicates that the aircraft flew level at 5000 feet from 10 NM to 25 NM at an IAS of about 350 KT. The aircraft exited Class B airspace at about 8,000 feet altitude. The level flight is likely the result of an ATC instruction.

Some of the CBEs were the result of high speed during the climb that resulted in a low climb gradient. An example of a CBE that was caused by a high speed climb is shown in figure 3.6. The aircraft is in a steady climb while accelerating to a speed of about 380 KT and exits Class B airspace at about 8,000 feet.

Many of the CBEs occurred at altitudes very near 10,000 feet. Table 3.1 lists CBEs versus altitude. The other entries in the table represent the number of aircraft at the given altitude that had speeds between 250 and 300 KT, labeled 250+, and the number exceeding 300 KT, labeled 300+. The average altitude of the CBEs was 9,332 feet. Aircraft altitude is measured by an encoding altimeter and transmitted to the ASR-9 radar via the aircraft transponder. The signal is processed by a mode-C interrogator for presentation on the radar screen or digital recording. Because of altimeter and latency errors, the total error could be in the 200-300 feet range. Therefore, as many as 14 of the CBEs listed in table 3.1 may not be actual CBEs.

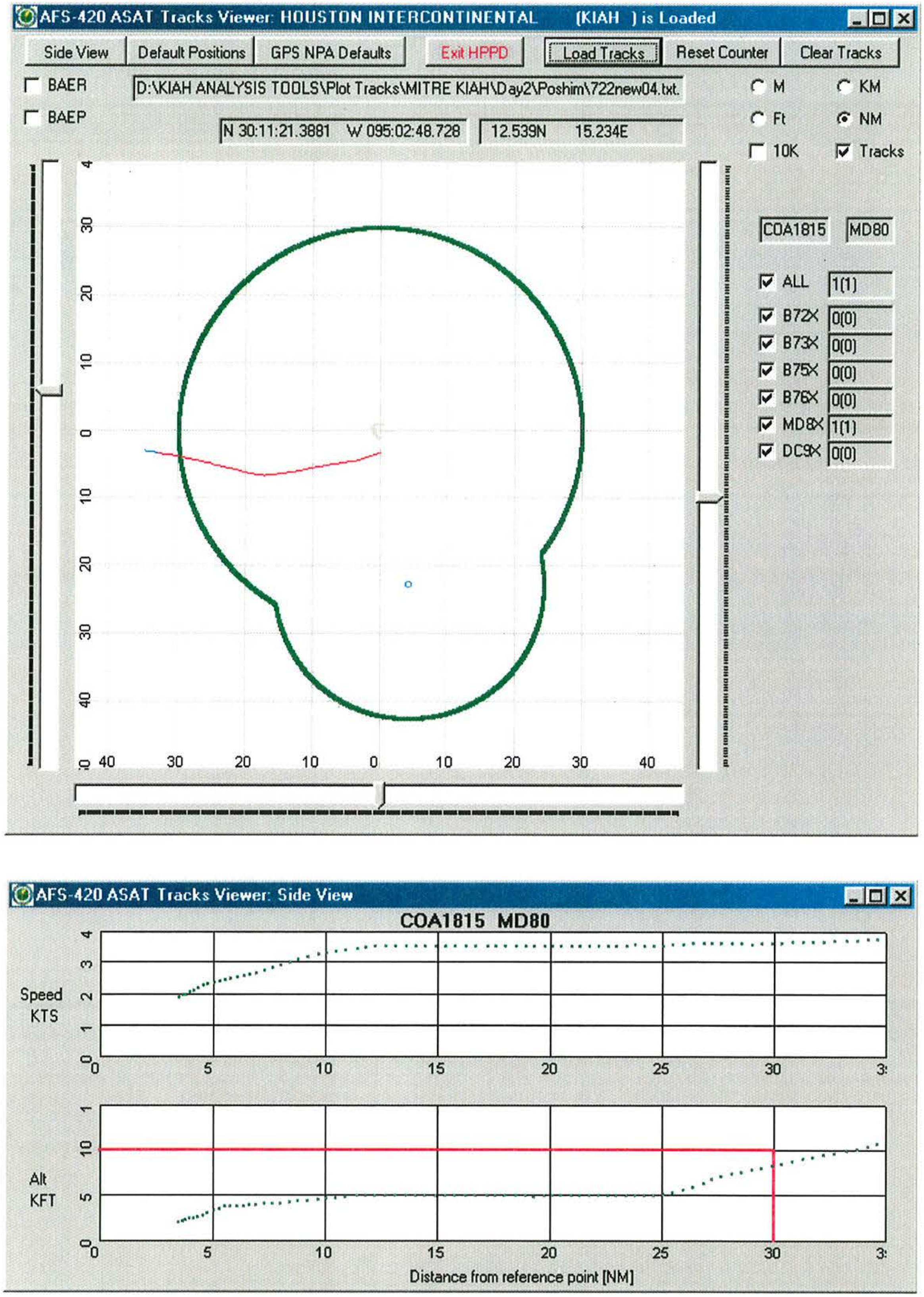


Figure 3.5: PLAN AND PROFILE VIEW OF A CBE DUE TO LEVEL FLIGHT

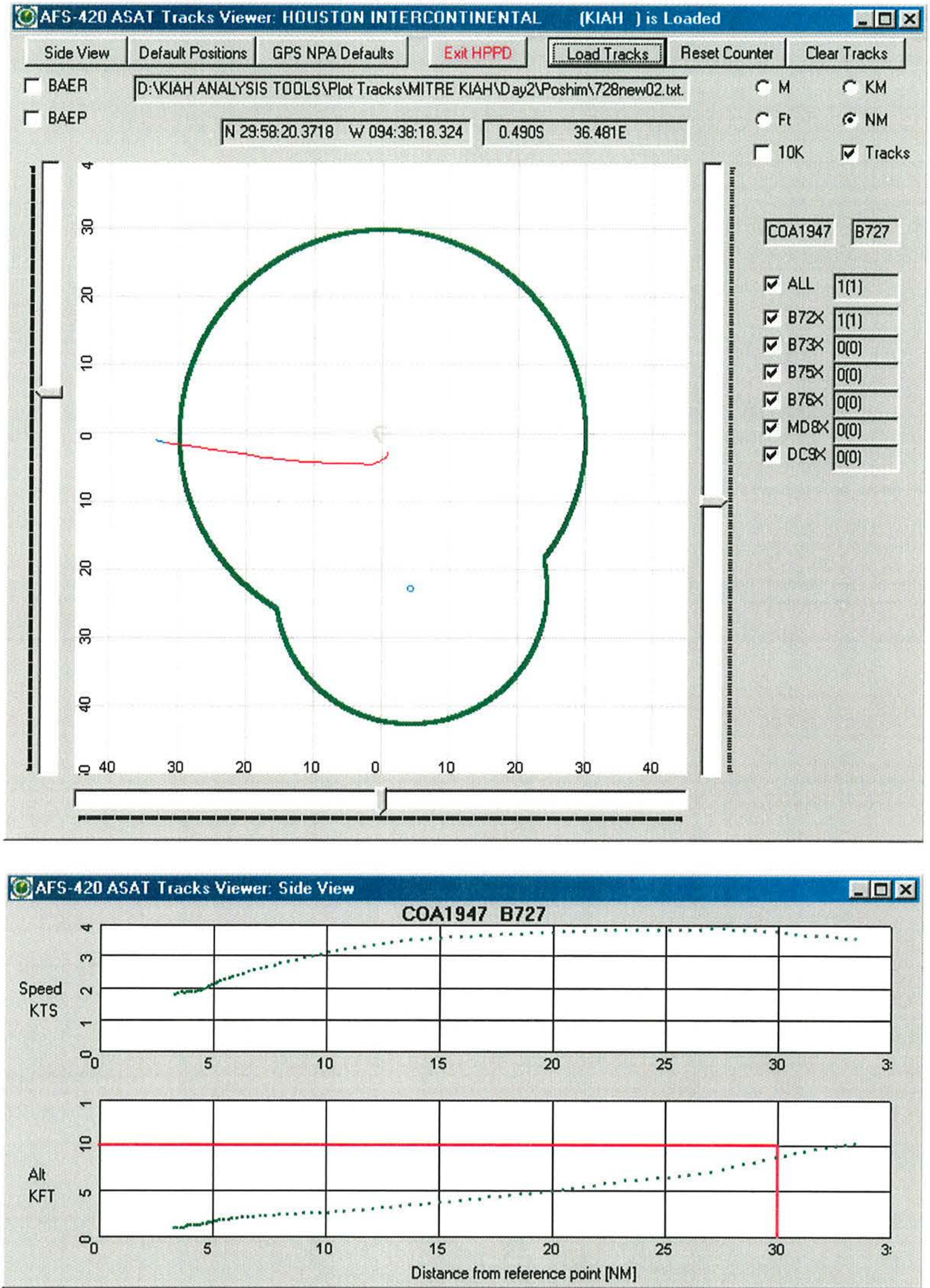
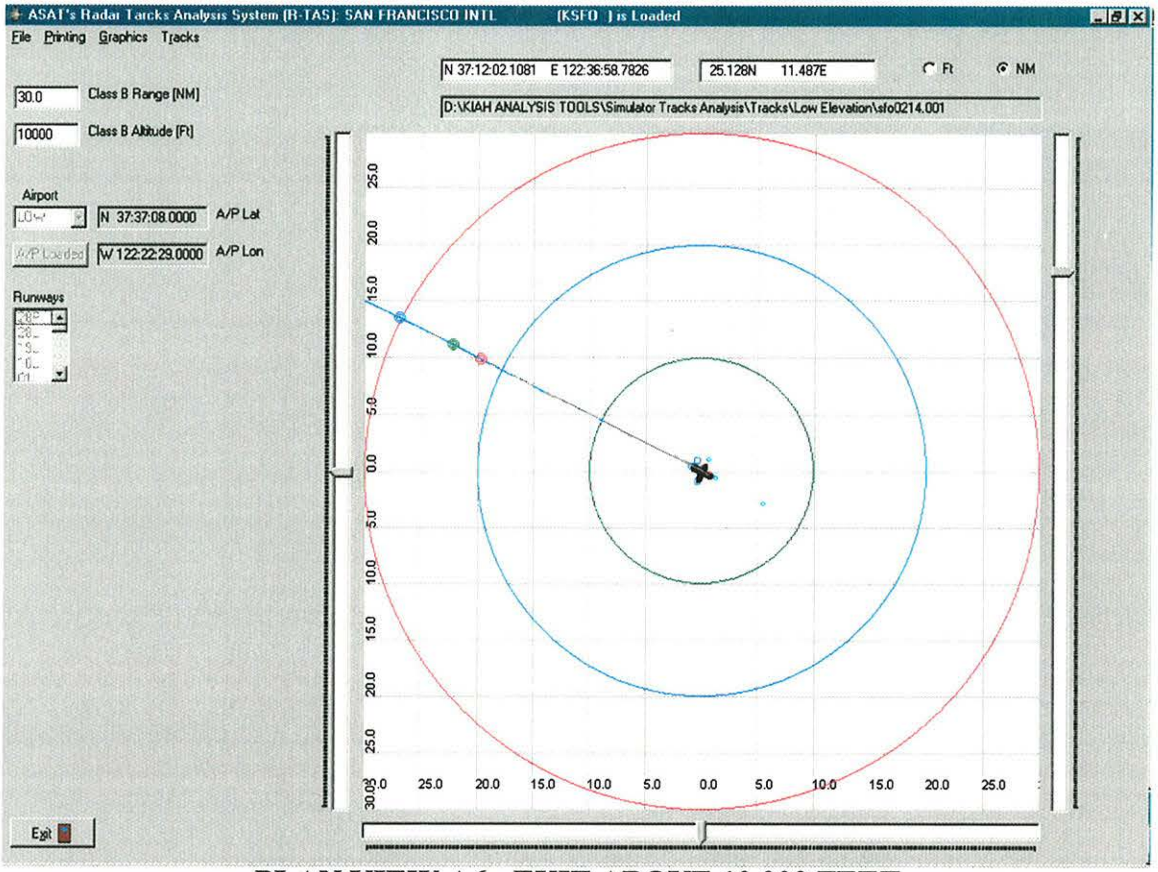


Figure 3.6: PLAN AND PROFILE VIEW OF A CBE DUE TO HIGH SPEED CLIMB

Altitude	250+	300+	Total
9900	5	1	6
9800	2	1	3
9700	3	2	5
9600	0	0	0
9500	1	0	1
9400	3	0	3
9300	1	0	1
9200	1	0	1
9100	1	0	1
9000	0	0	0
8900	1	0	1
8800	1	0	1
8700	1	0	1
8600	2	0	2
8100	1	0	1
7000	1	0	1
Totals	24	4	28

Table 3.1: CBEs BY ALTITUDE AND SPEED

Further analysis indicated only four different types of aircraft were responsible for all the CBEs. In addition, only 14 different airline flight numbers were responsible for all the CBEs. One flight number, flying a Boeing 727 was responsible for 5 CBEs. Another flight number, flying a MD-80 was responsible for 4 CBEs. Table 3.2 details the number of CBEs by aircraft and flight number. The actual airline flight number is not used. The flights are given numbers ranging from 1 to 14.



PLAN VIEW A6: EXIT ABOVE 10,000 FEET

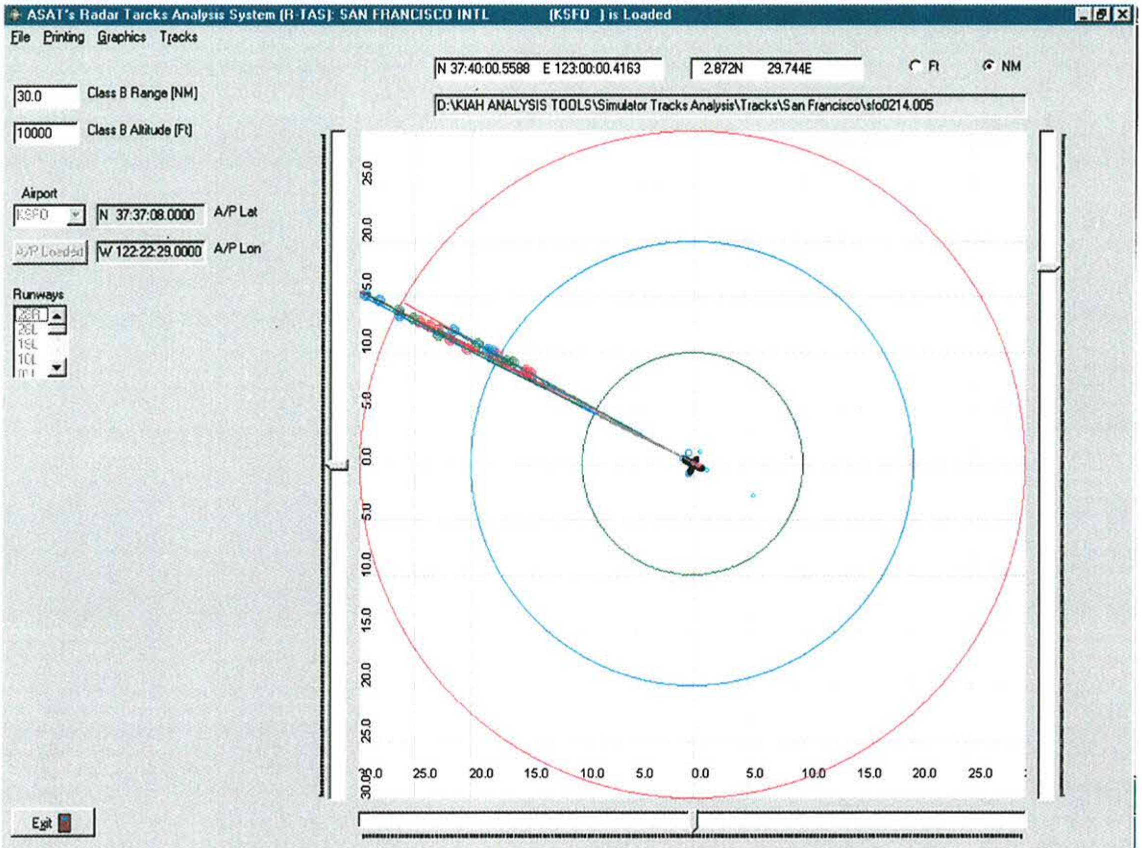


Figure 4.1: PLAN VIEW OF SELECTED FLIGHT SIMULATOR TRACKS

In figure 4.1, the tracks are color coded to indicate the speed of the simulator. Gray indicates the speed is less than or equal to 250 KIAS. Blue indicates the speed is greater than 250 KIAS and less than or equal to 275 KIAS. Green indicates the speed is greater than 275 KIAS and less than or equal to 300 KIAS. Red indicates the speed is greater than 300 KIAS. The large circles indicate distances from the VOR. The green circle represents 10 NM, the blue circle represents 20 NM, and the red circle represents 30 NM. The small circles on the tracks mark the position at which certain altitudes were achieved. The small red circle indicates where the track passes 8,000 feet, the small green circle marks the 9,000 foot point, and the blue circle represents the 10,000 foot point.

Figure 4.2 provides a profile view of the tracks shown in figure 4.1. The figure displays plots of engine pressure ratio (EPR), climb rate, indicated airspeed (IAS), and altitude. The colors represent speeds in the same manner as figure 4.1.

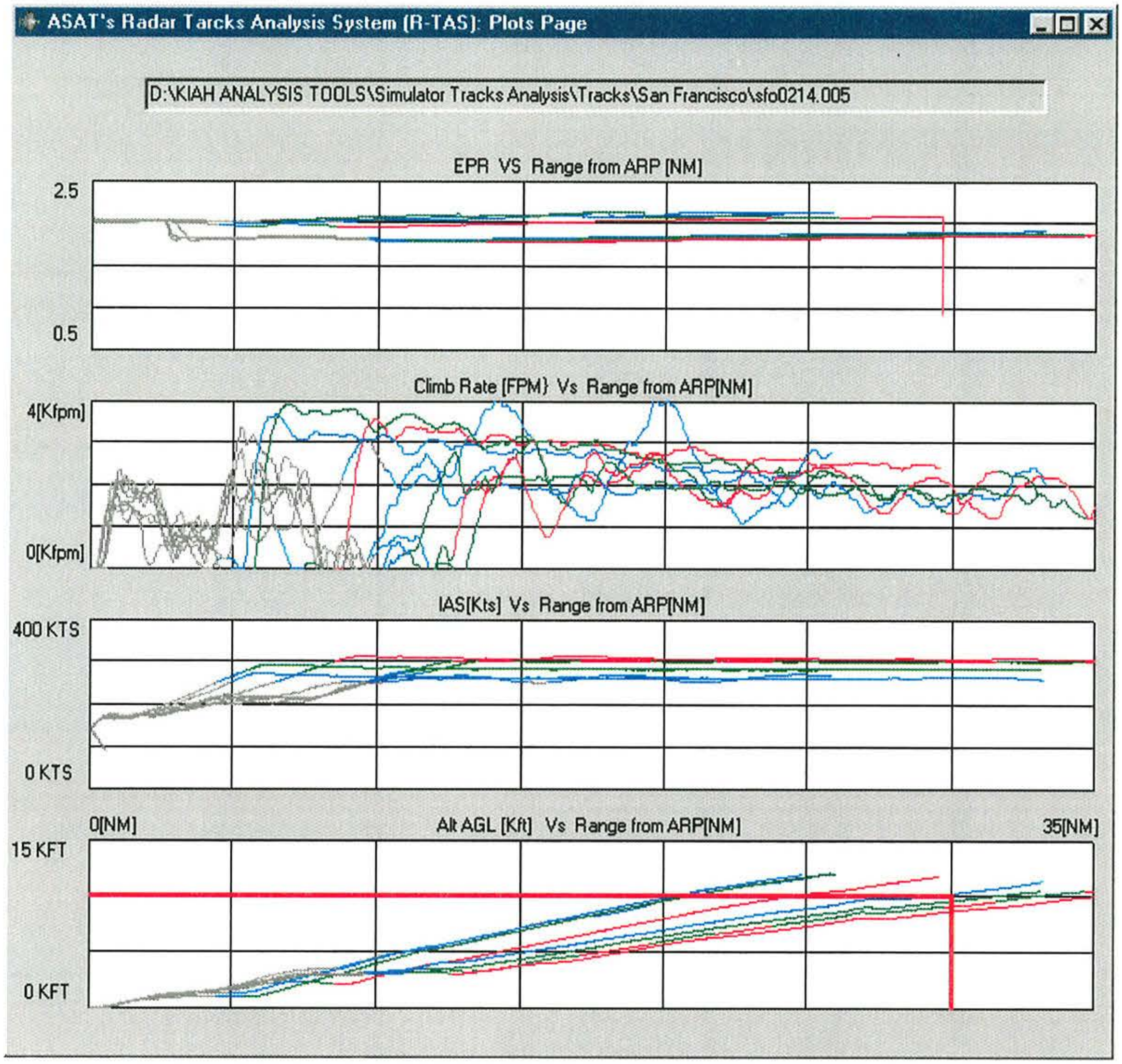


Figure 4.2: PROFILE VIEW OF SELECTED FLIGHT SIMULATOR TRACKS

4.1 ANALYSIS OF HIGH ALTITUDE SIMULATOR TRACKS

The field elevation of the high altitude airport is 5,431 feet while the ceiling of the Class B airspace is 12,000 feet mean sea level (MSL). Thus the aircraft are only required to climb 6,569 feet before reaching 30 NM from the VOR and they are less heavily loaded at 163,000 pounds. The analysis indicated that none of the high altitude flight simulator tracks resulted in a CBE. Average IAS were computed for each aircraft while it climbed from 8,000 to 12,000 feet or from 8,000 feet until it exited Class B airspace. In a similar fashion, average EPR was computed for each aircraft. Standard statistics of the average indicated airspeed and EPR are shown in table 4.1. The table indicates the aircraft flew at an average speed of 279 KT, with a minimum speed of 250 KT and a maximum speed of 311 KT. The EPR was 1.91, with a minimum of 1.79 and a is less than 6,600 feet, the aircraft can easily attain 12,000 feet without exiting through the side of the Class B airspace.

	Average IAS	Average EPR
Mean	279.3	1.91
Standard Deviation	22.228	0.087
Minimum	249.86	1.79
Maximum	311.15	2.07
Count	25	25

Table 4.1: AVERAGE IAS AND EPR AT DENVER

4.2 ANALYSIS OF LOW ALTITUDE AIRPORT SIMULATOR TRACKS

The field elevation of the low altitude airport is only 11 feet, while the ceiling of the Class B airspace is 10,000 feet. Thus, the aircraft are effectively required to climb 10,000 feet before exiting the Class B airspace with a load of 183,000 pounds. The analysis indicated that 17 of the 55 simulator tracks exited Class B airspace below 10,000 feet. Four of the flights with ATC interaction exited Class B airspace below 10,000 feet. Average IAS were computed for each aircraft while it climbed from 4,000 to 10,000 feet or from 4,000 feet until it exited Class B airspace. In a similar fashion, average EPR was computed for each aircraft. Standard statistics of the average indicated airspeed are shown in table 4.2. The table indicates the aircraft flew at an average speed of 280.6 KT, with a minimum speed of 238.6 KT and a maximum speed of 317.2 KT. The table also indicates the average EPR was 1.87, with a minimum EPR of 1.75 and a maximum EPR of 2.09.

	IAS	EPR
Mean	280.6195	1.870182
Standard Deviation	20.74806	0.073924
Minimum	238.64	1.75
Maximum	317.2	2.09
Count	55	55

Table 4.2: STANDARD STATISTICS OF IAS AND EPR FOR ALL FLIGHTS

The flight simulator tracks were separated into two sets, the set of tracks that did not exhibit a CBE and the set of tracks that did exhibit a CBE. Each set was sorted by average IAS. The number of CBEs was determined for speed intervals as shown in table 4.3. Table 4.3 indicates there were no CBEs for IAS less than 265 KT. Between 266 and 285 KT, there were 4 CBEs versus 10 non-CBEs. From 286 to 305 KT there were 9 CBEs and 10 non-CBEs. Above 305 KT there were 4 CBEs and 2 non-CBEs. The table indicates the Boeing 727 is capable of reaching 10,000 feet before exiting Class B airspace at speeds over 300 KT. Since all other factors, such as atmospheric conditions and aircraft weight, are constant for all flights, the failure of several aircraft to reach 10,000 feet must be attributed to pilot techniques.

IAS Range		**CBE**	**Non-CBE**
Minimum	Maximum		
	255	0	8
256	265	0	8
266	275	3	4
276	285	1	6
286	295	4	4
296	305	5	6
306	315	4	2
Totals		17	38

Table 4.3: NUMBER OF CBEs BY IAS RANGE

4.3 ANALYSIS OF PILOT TECHNIQUES

Table 4.3 indicates 17 flights committed a CBE while flying in the speed range, 266 to 315 KT. However, 22 flights successfully exited Class B airspace at 10,000 feet or more while flying in the same speed range. Therefore, the Boeing 727 is capable of reaching 10,000 feet before exiting Class B airspace, which implies the success or failure of a particular flight hinges upon pilot technique.

In table 4.4 standard statistics of IAS are presented for those simulator flights with average IAS above 265 KT. The table indicates the speeds are nearly equal, with the average speed of the group committing CBEs being about 7.4 KT faster than the average speed of the group that did not commit a CBE. A T-test was performed to determine if a significant difference was present. The result of the T-test is shown in table 4.5. The null hypothesis of the test is the difference between the means is zero. The computed T-statistic is –1.42797 with a p-value of 0.081814. Therefore, the T-test indicated no significant difference at the 5% level. This implies the difference in means is likely the result of chance alone. Therefore, the two groups of pilots flew at the same average speed after reaching 4,000 feet.

IAS	Non-CBE Group (KT)	CBE Group (KT)
Mean	289.1405	295.0376
Standard Deviation	11.05825	13.98006
Range	32.1	47.96
Minimum	274.4	269.24
Maximum	306.5	317.2
Count	22	17

Table 4.4: STANDARD STATISTICS OF IAS IN THE RANGE 265 KT TO 315 KT

IAS	Non-CBE Group (KT)	CBE Group (KT)
Mean	289.1405	295.0376
Variance	122.285	195.442
Observations	22	17
Hypothesized Mean Difference	0	
t Statistic	-1.42797	
P(T<=t) one-tail	0.081814	
t Critical one-tail	1.69726	

Table 4.5: T-TEST OF IAS FOR 265 KT TO 315 KT

In table 4.6 standard statistics of EPR are presented for those simulator flights with average IAS above 265 KT. The table indicates the EPR values of the non-CBE group are larger than those of the CBE group. The average EPR of the group committing CBEs is about 0.062112 larger than the average EPR of the group that did not commit a CBE. A T-test was performed to determine if a significant difference was present. The result of the T-test is shown in table 4.7. The null hypothesis of the test is the difference between the means is zero. The computed T-statistic is 3.137094 with a p-value of 0.001947. Therefore, the T-test indicated a highly significant difference at the 5% level. This implies the difference in means is likely the result of differences in piloting technique. Therefore, the group of pilots that did not commit a CBE used a significantly higher power setting for the same IAS than the group that committed a CBE.

EPR	Non-CBE Group	CBE Group
Mean	1.886818	1.824706
Standard Deviation	0.084368	0.034117
Range	0.32	0.12
Minimum	1.77	1.75
Maximum	2.09	1.87
Count	22	17

Table 4.6: STANDARD STATISTICS OF EPR FOR IAS FROM 265 KT TO 315 KT

EPR	Non-CBE Group	CBE Group
Mean	1.886818	1.824706
Variance	0.007118	0.001164
Observations	22	17
Hypothesized Mean Difference	0	
t Statistic	3.137094	
P(T<=t) one-tail	0.001947	
t Critical one-tail	1.699127	

Table 4.7: T-TEST OF EPR FOR IAS FROM 265 KT TO 315 KT

Other differences in piloting technique that contribute to the success or failure of the flight to exit Class B airspace at or above 10,000 feet can be deduced by examination of the simulator flight track plots. Figures 4.3 and 4.4 illustrate critical piloting techniques. In figure 4.3, the flight committed a CBE, but in figure 4.4 a CBE was not committed. From the plots of IAS, both flights flew at 300 KT, but the EPR in figure 4.4 is about 2.0, while the EPR in figure 4.3 is about 1.8. Another very important difference is indicated by the plots of altitude versus range. In each plot the segment of each flight where the aircraft was reconfigured following take-off for the climb is clearly visible as the segment where the aircraft briefly leveled. In figure 4.3 the aircraft is reconfigured at about 3,000 feet AGL. The level segment is about 7 NM long and starts about 7 NM from the VOR. In figure 4.4 the aircraft is reconfigured at about 1,500 feet AGL. The level segment is about 5 NM long and starts about 2 NM from the VOR. The plots also indicate the aircraft of figure 4.4 reached its climb speed of 300 KT about 7 NM from the VOR, while the aircraft of figure 4.3 reached its climb speed of 300 KT at about 13 NM from the VOR. Therefore, the pilot of the aircraft of figure 4.4 was able to successfully reach 10,000 feet before exiting Class B airspace through the use of a higher power setting and by aggressively reconfiguring the aircraft and accelerating to the final climb speed.

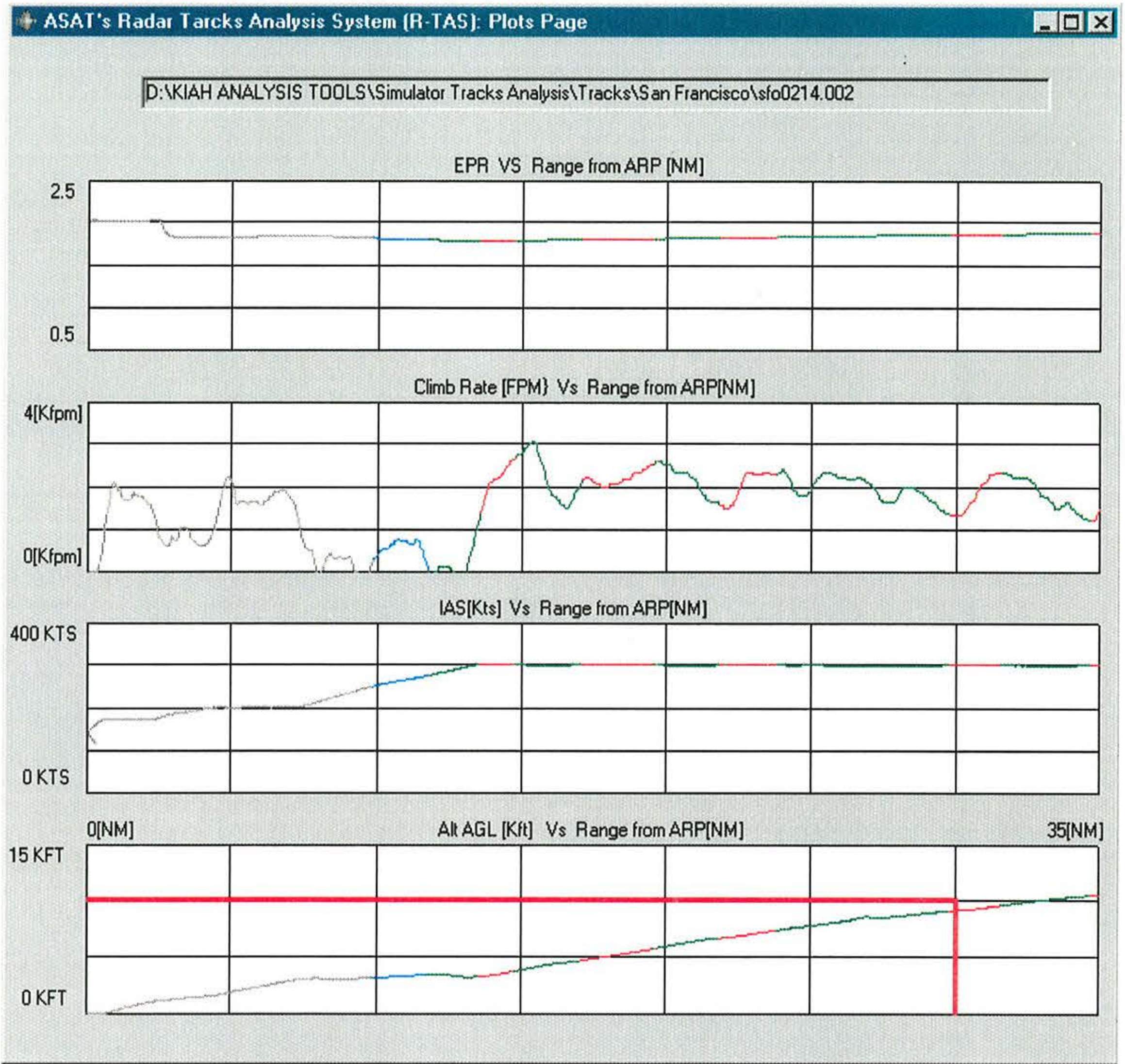


Figure 4.3: PROFILE PLOTS OF A CBE

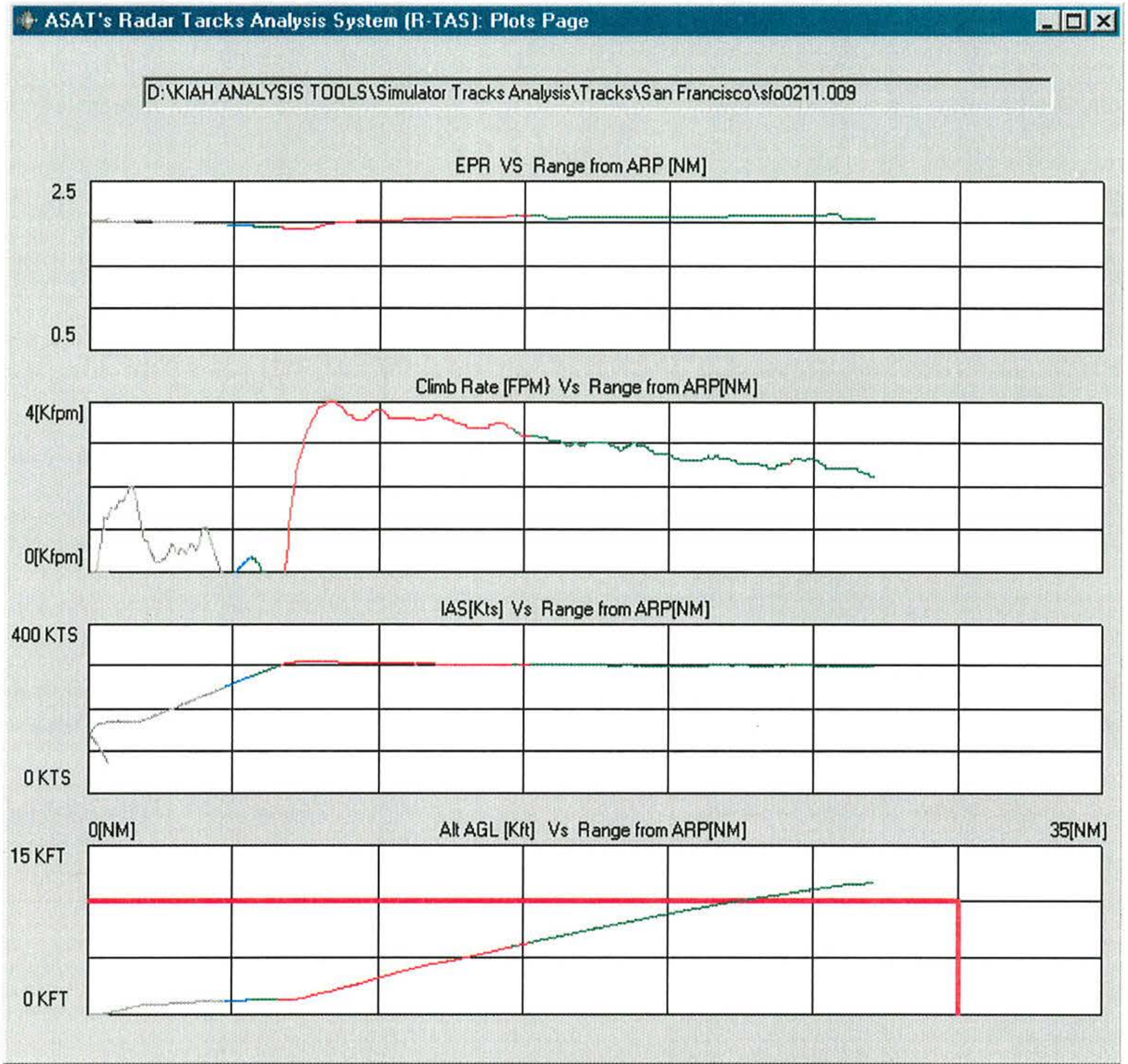


Figure 4.4: PROFILE PLOTS OF A NON-CBE

5.0 SUMMARY AND RECOMMENDATIONS

Radar tracks recorded by the Houston TRACON during the period June 26, 1997 to August 6, 1997 were analyzed using the ASAT computer system. The analysis revealed 38 instances where the aircraft exited Class B airspace prior to reaching 10,000 feet altitude. The analysis indicated that 10 of the 38 instances were induced by ATC action. The remaining 28 were all attributed to four types of aircraft, the DC-9, the B-727, the MD-80, and the B-737. The first two aircraft listed are lower performance older generation aircraft. Only 10 CBEs were attributed to the MD-80 and B-737. No newer generation aircraft such as the B-767, B-747, or MD-11 exited Class B airspace prior to reaching 10,000 feet during the recording period.

In order to test the ability of an older generation aircraft to successfully exit Class B airspace at or above 10,000 feet, a simulator flight test was conducted using the FAA Boeing 727 flight simulator located in Oklahoma City, Oklahoma. Pilots, current and qualified in the B-727-200 were enlisted to fly the flight simulator. Two visual locales for the simulation were chosen, a low altitude sea level airport, and a high altitude (5,431 feet) airport. Fifty-five flights were conducted at the low altitude airport and 25 flights were conducted at the high altitude airport. All flights were performed at high (95° F) temperatures. No exits from Class B airspace prior to reaching 10,000 feet were recorded for the high altitude airport flights; however, 22 of the low altitude airport flights resulted in exits from Class B airspace prior to reaching 10,000 feet.

Analysis of the low altitude flights revealed that the B-727 is capable of successfully reaching 10,000 feet prior to exiting Class B airspace at speeds up to 300 KT with an air temperature of 95° F and a gross take-off weight of 183,000 pounds, if appropriate piloting techniques are employed. Thirty-eight of the 55 flights were successful in reaching 10,000 feet prior to exiting Class B airspace. It was found the successful flights used higher power settings than the unsuccessful flights. Additionally the pilots of the successful flights reconfigured their aircraft and accelerated to their climb speed in an expeditious manner.

In order to insure aircraft reach 10,000 feet before exiting Class B airspace, it is recommended that:

a. Pilots should be informed, in some appropriate manner, of the need to perform the departure climb in the most expeditious and efficient manner prior to being issued clearance for high speed climb profiles.

b. Maximum take-off thrust should be maintained to 3,000 feet and then the aircraft should be reconfigured for climb with maximum climb power appropriate for the atmospheric conditions which should be maintained until 10,000 feet is reached.

c. Consideration should be given to the establishment of climb corridors in high density traffic areas.

d. Consideration should be given to the addition of an annotation to Standard Instrument Departures (SID) indicating the aircraft must reach 10,000 feet altitude prior to reaching 30 NM DME.

e. Consideration should be given to the addition of climb profiles to SIDs that provide a description of the minimum requirements to reach 10,000 feet prior to 30 NM DME.

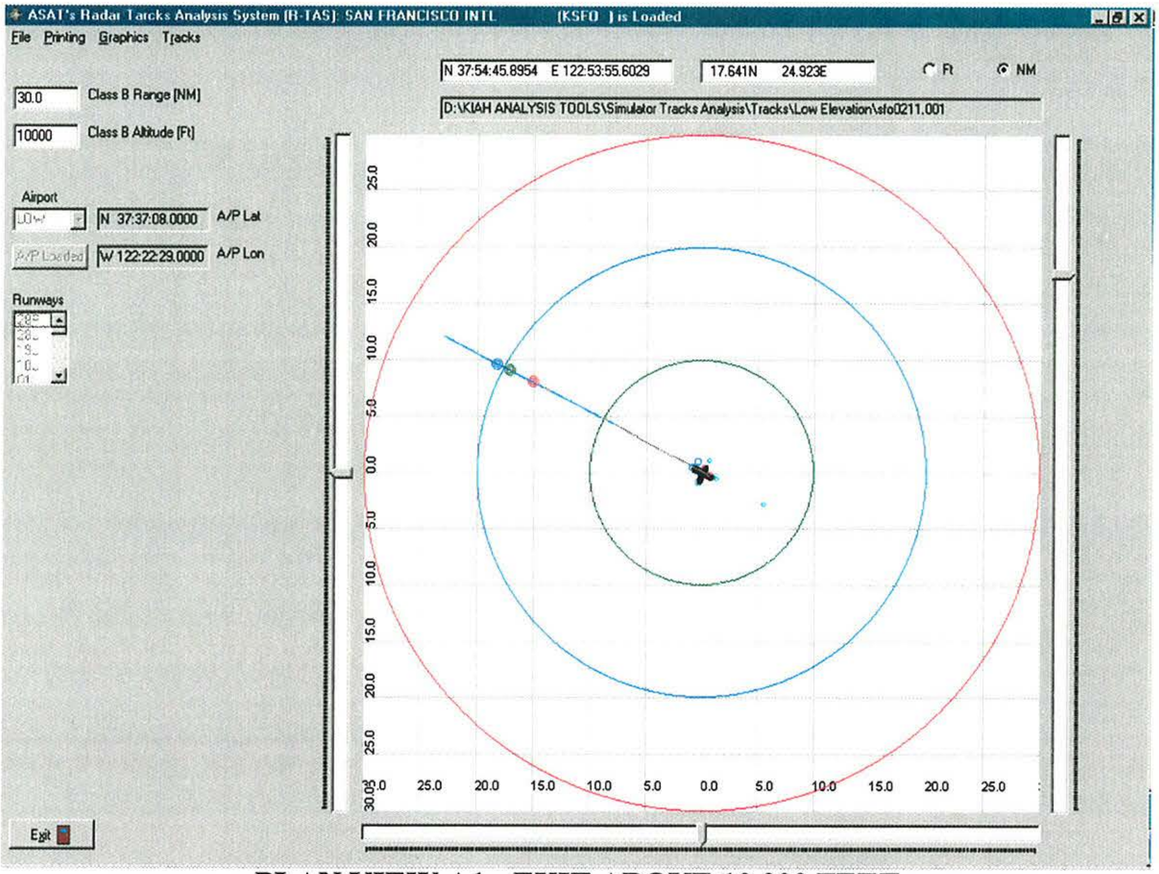
BIBLIOGRAPHY

Spelman, J., Maroney, D., Simmons, B., 250 Knot Speed Restriction Study, MTR 97W0000145R1, MITRE Center for Advanced Aviation System Development, McLean, VA, December 1997.

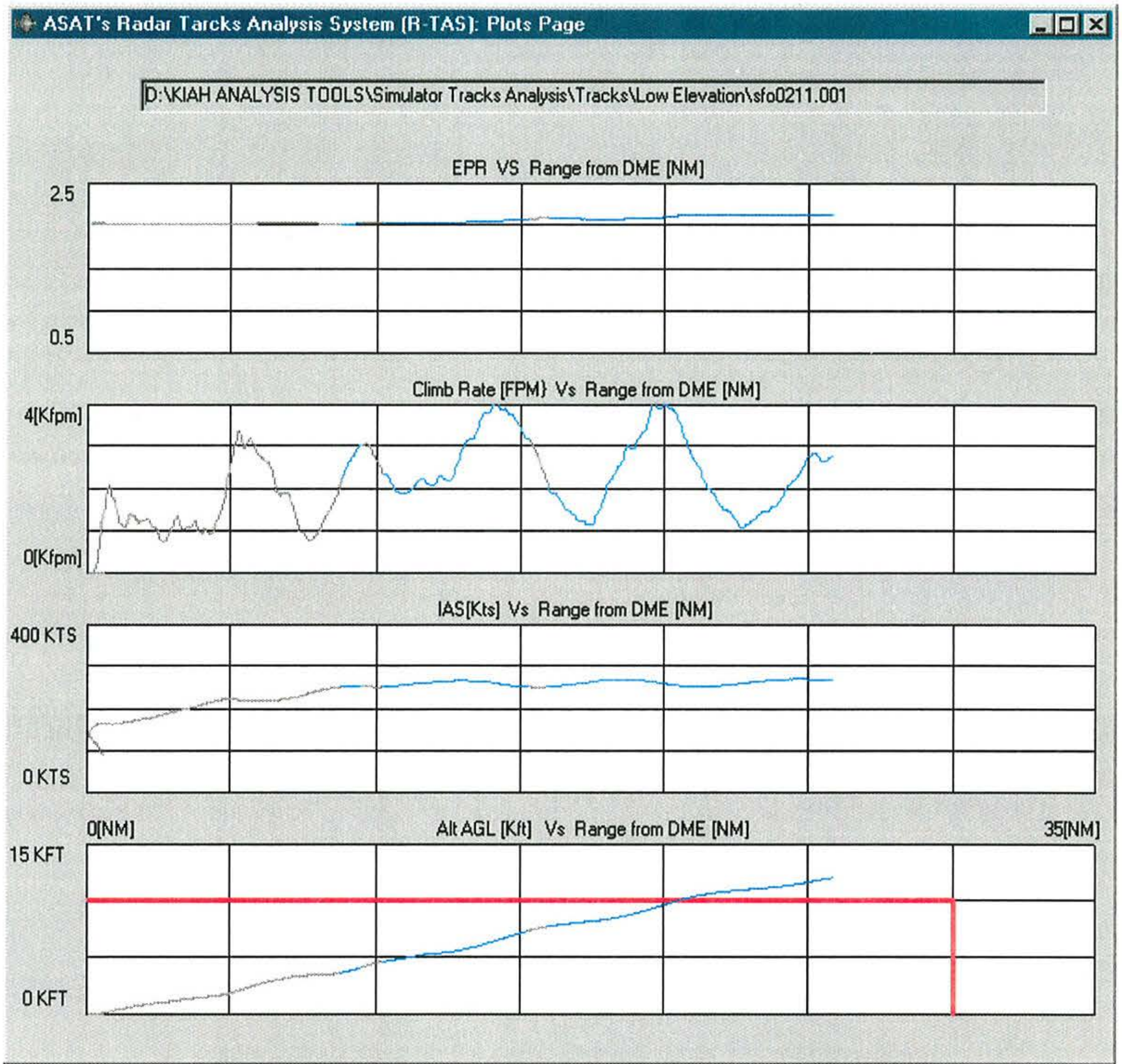
APPENDIX A

SIM PLOTS LOW ELEVATION*

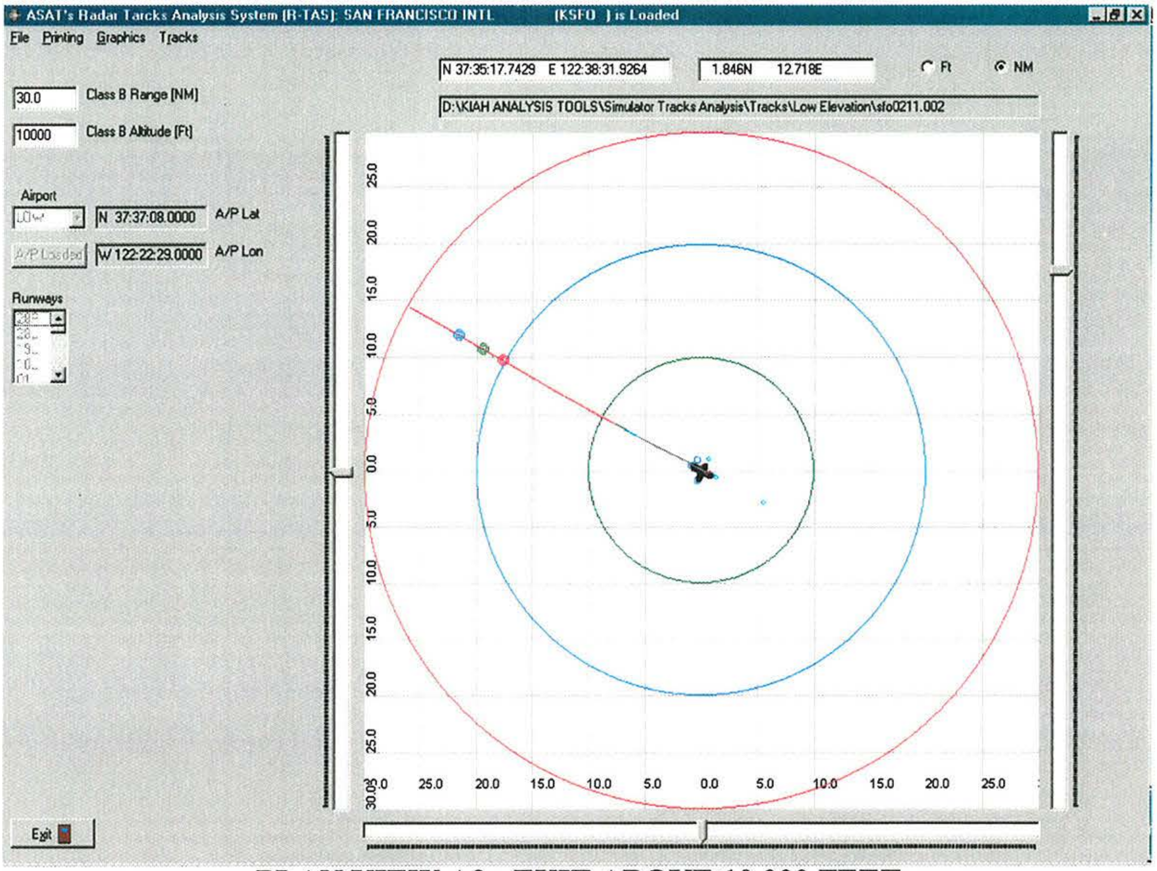
*Refer to section 4.0 for an explanation of the color coding used in the figures.



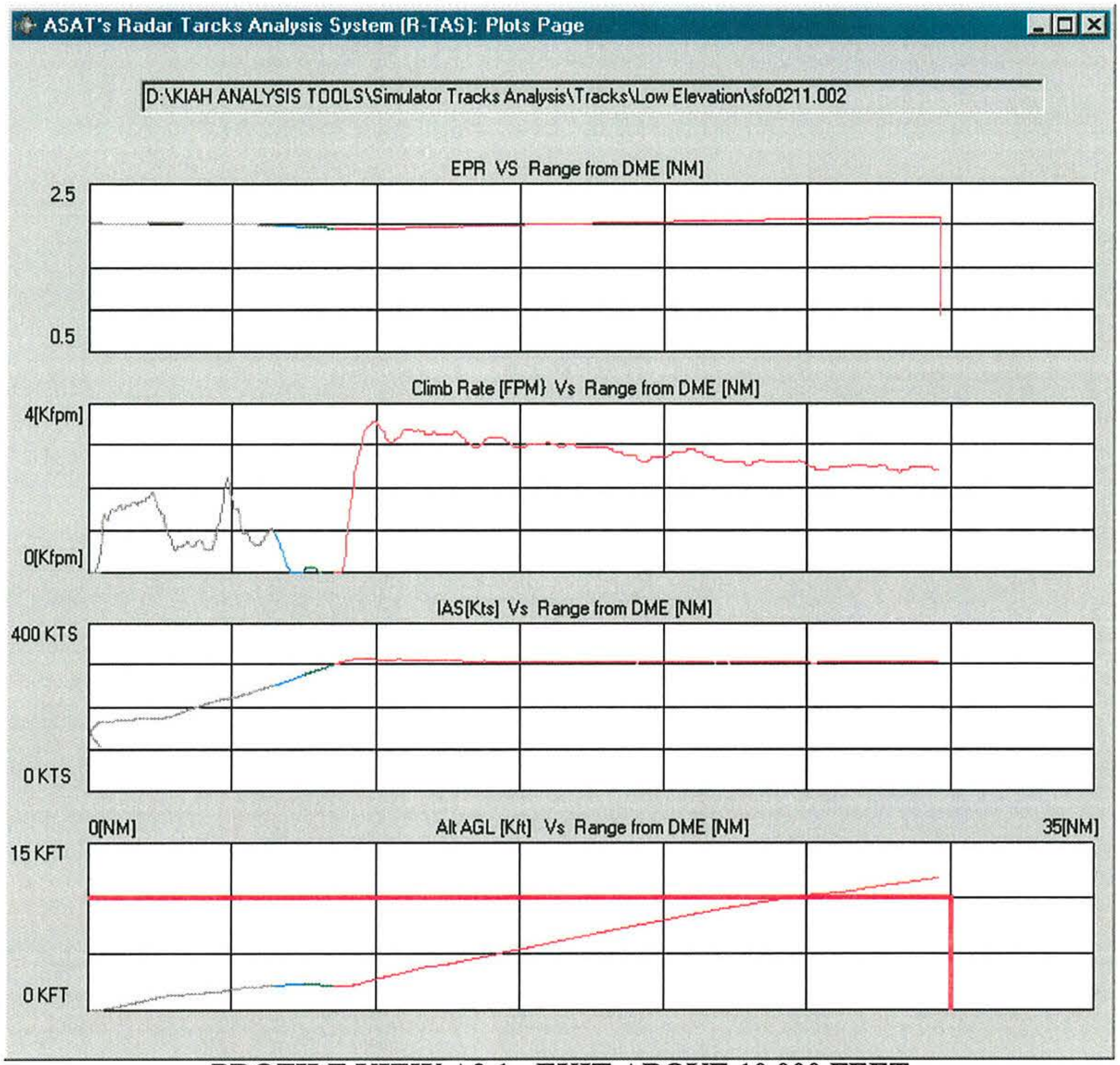
PLAN VIEW A1: EXIT ABOVE 10,000 FEET



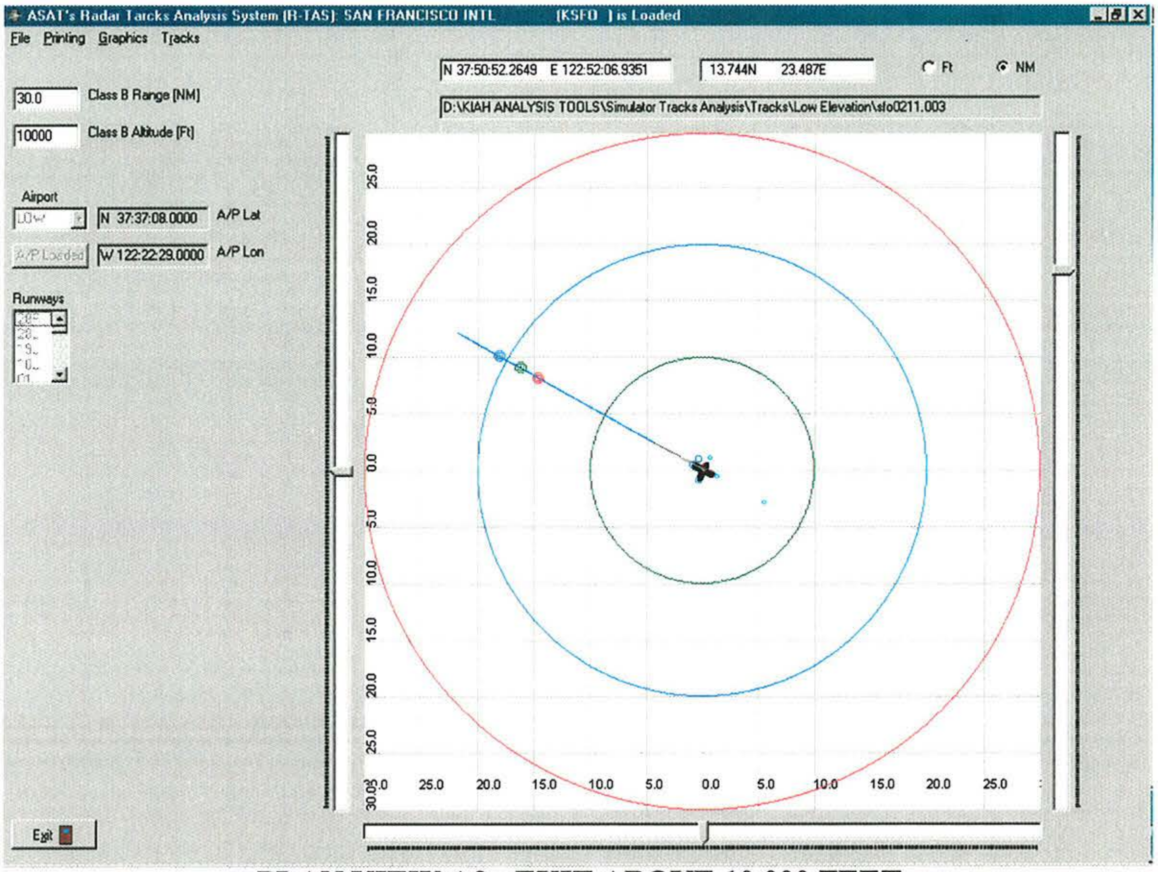
PROFILE VIEW A1.1: EXIT ABOVE 10,000 FEET



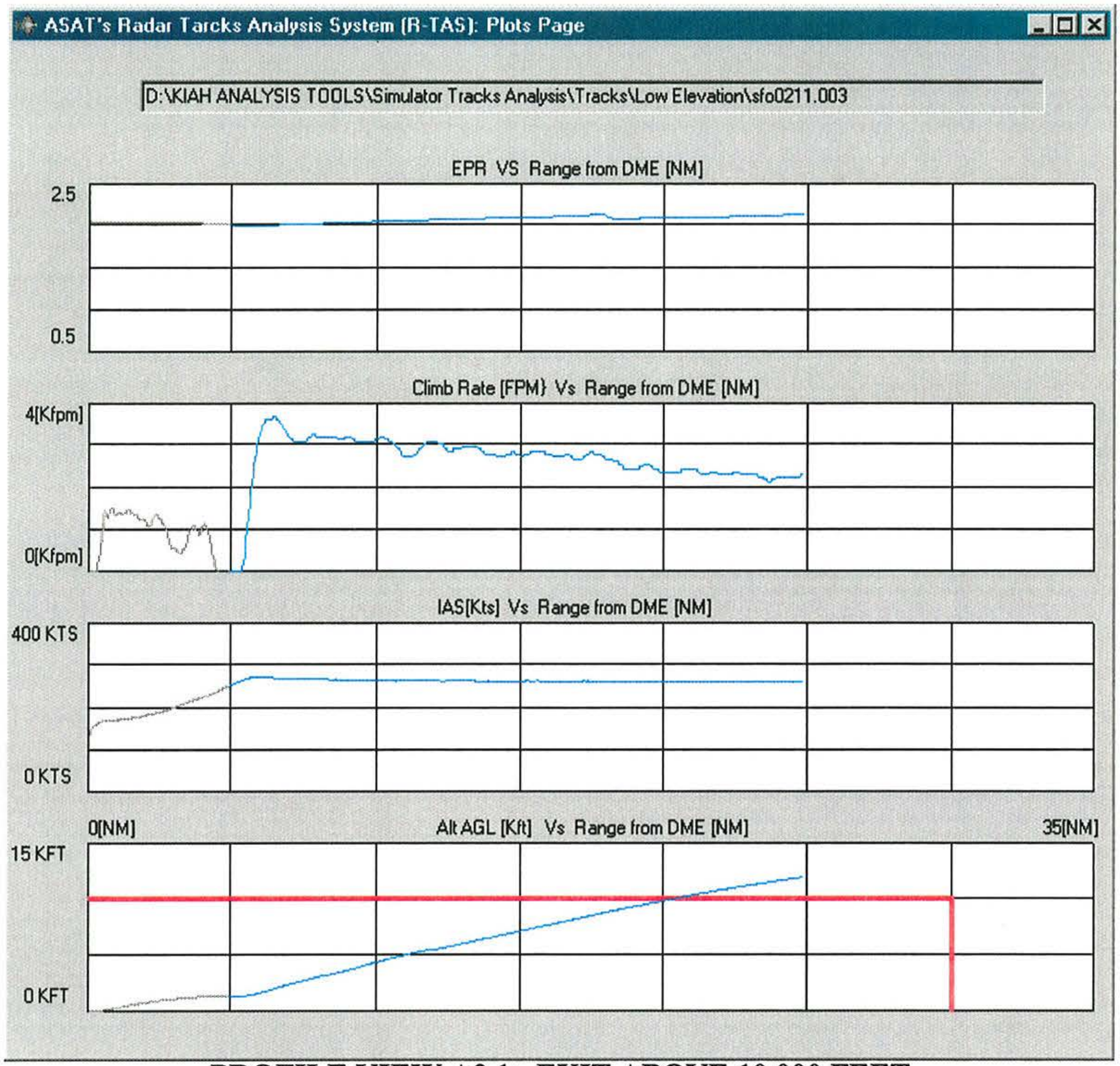
PLAN VIEW A2: EXIT ABOVE 10,000 FEET



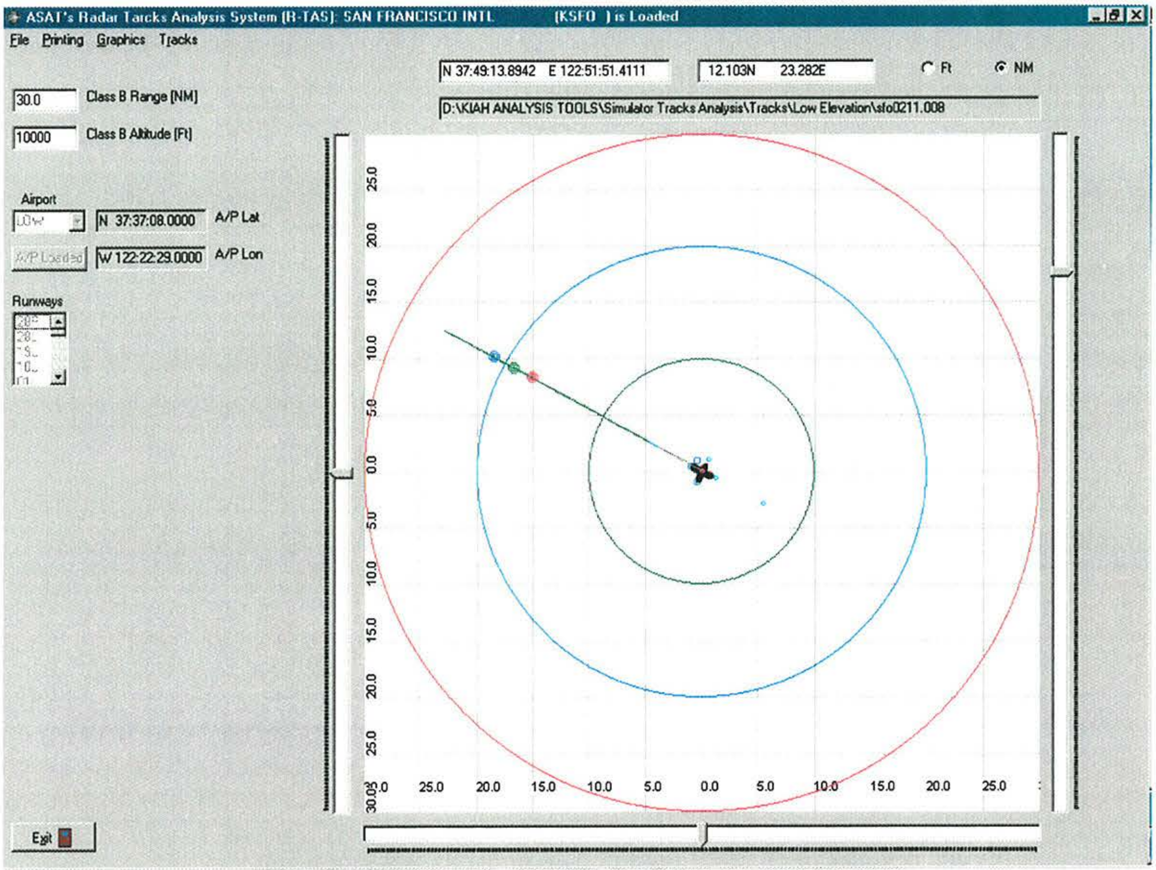
PROFILE VIEW A2.1: EXIT ABOVE 10,000 FEET



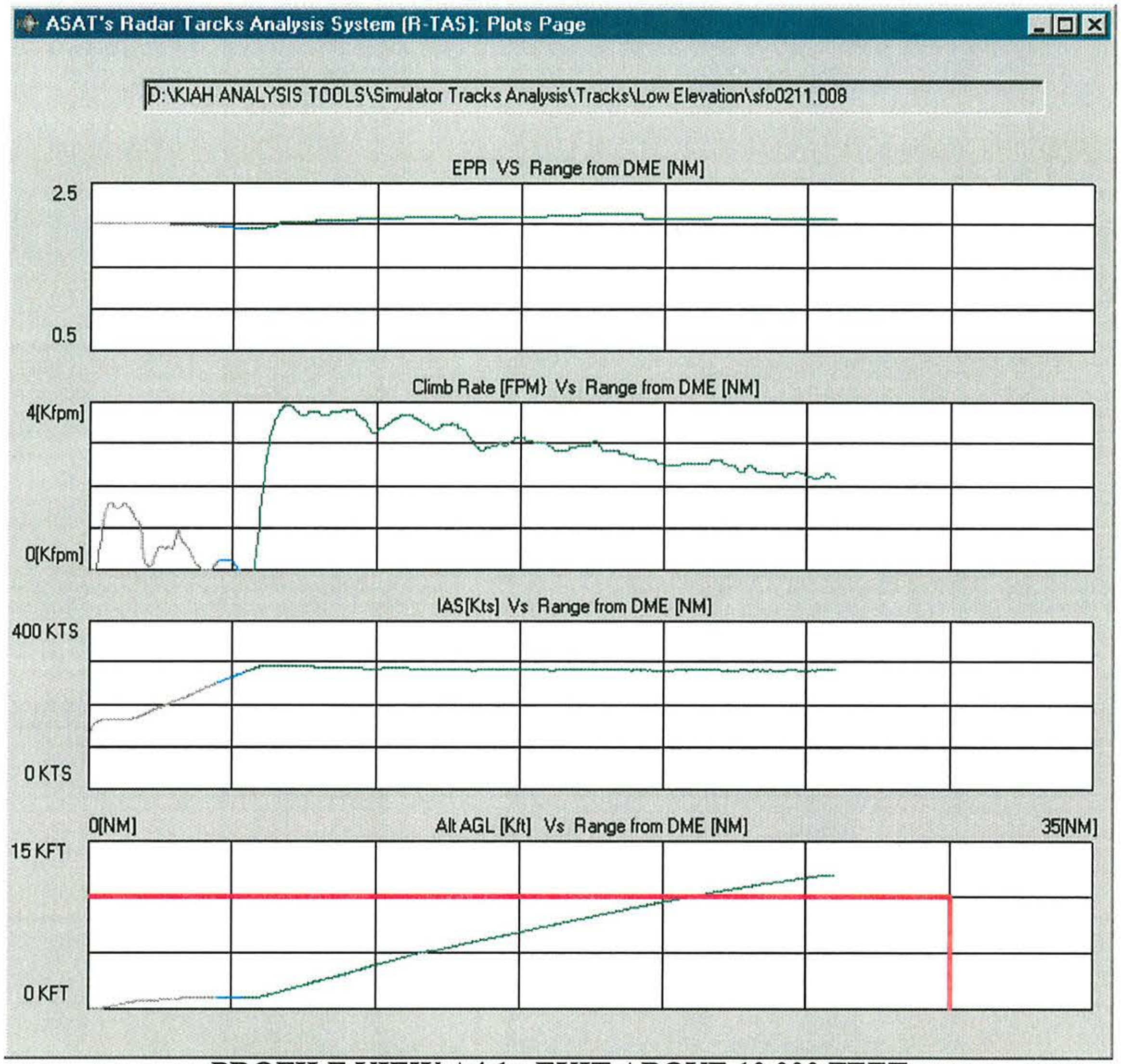
PLAN VIEW A3: EXIT ABOVE 10,000 FEET



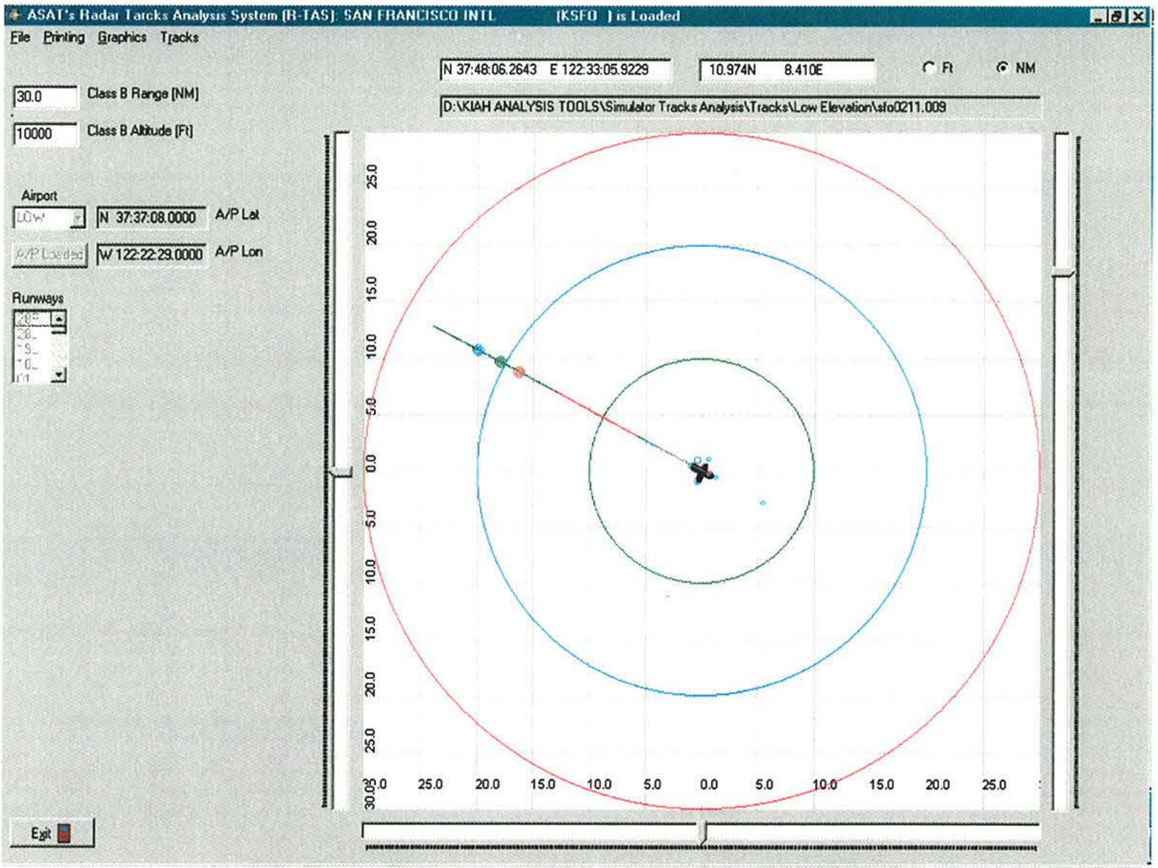
PROFILE VIEW A3.1: EXIT ABOVE 10,000 FEET



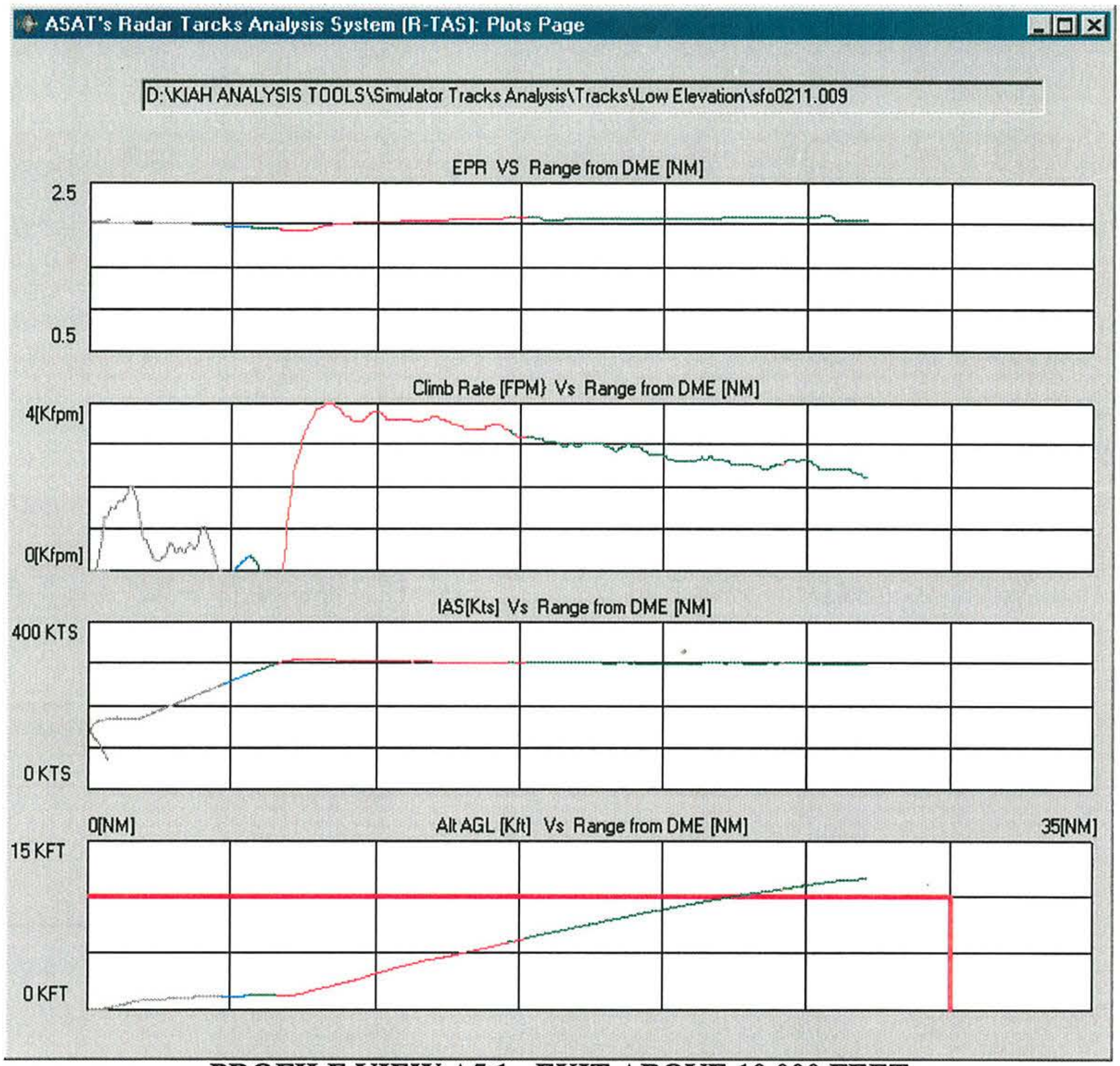
PLAN VIEW A4: EXIT ABOVE 10,000 FEET



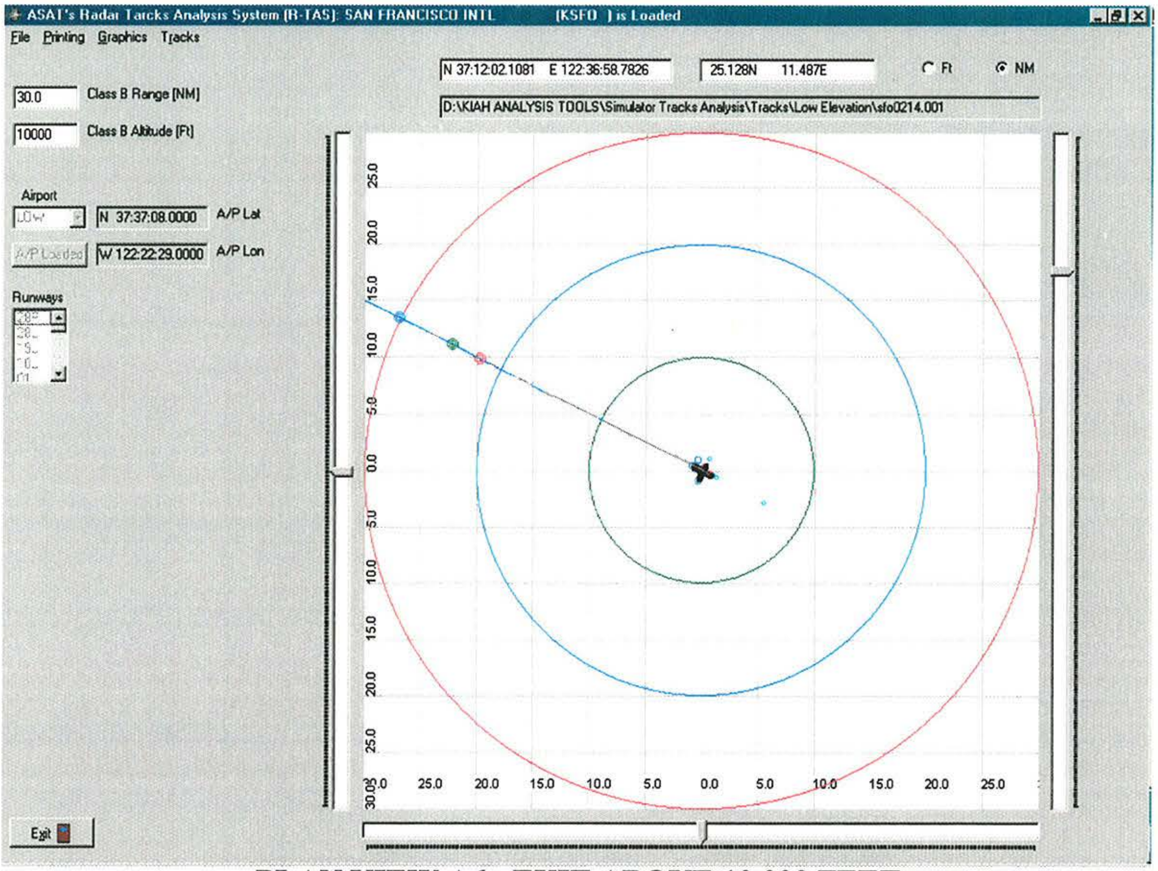
PROFILE VIEW A4.1: EXIT ABOVE 10,000 FEET



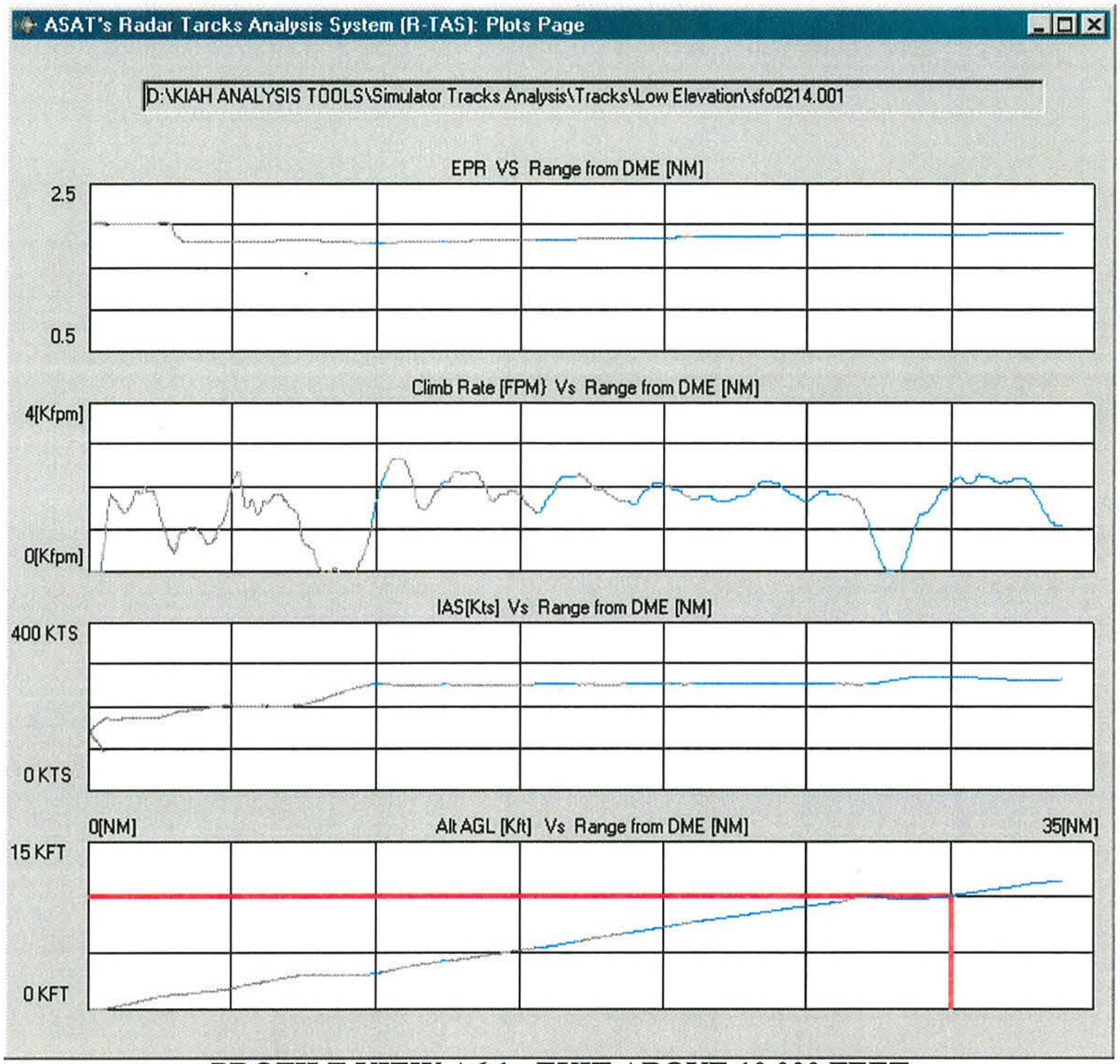
PLAN VIEW A5: EXIT ABOVE 10,000 FEET



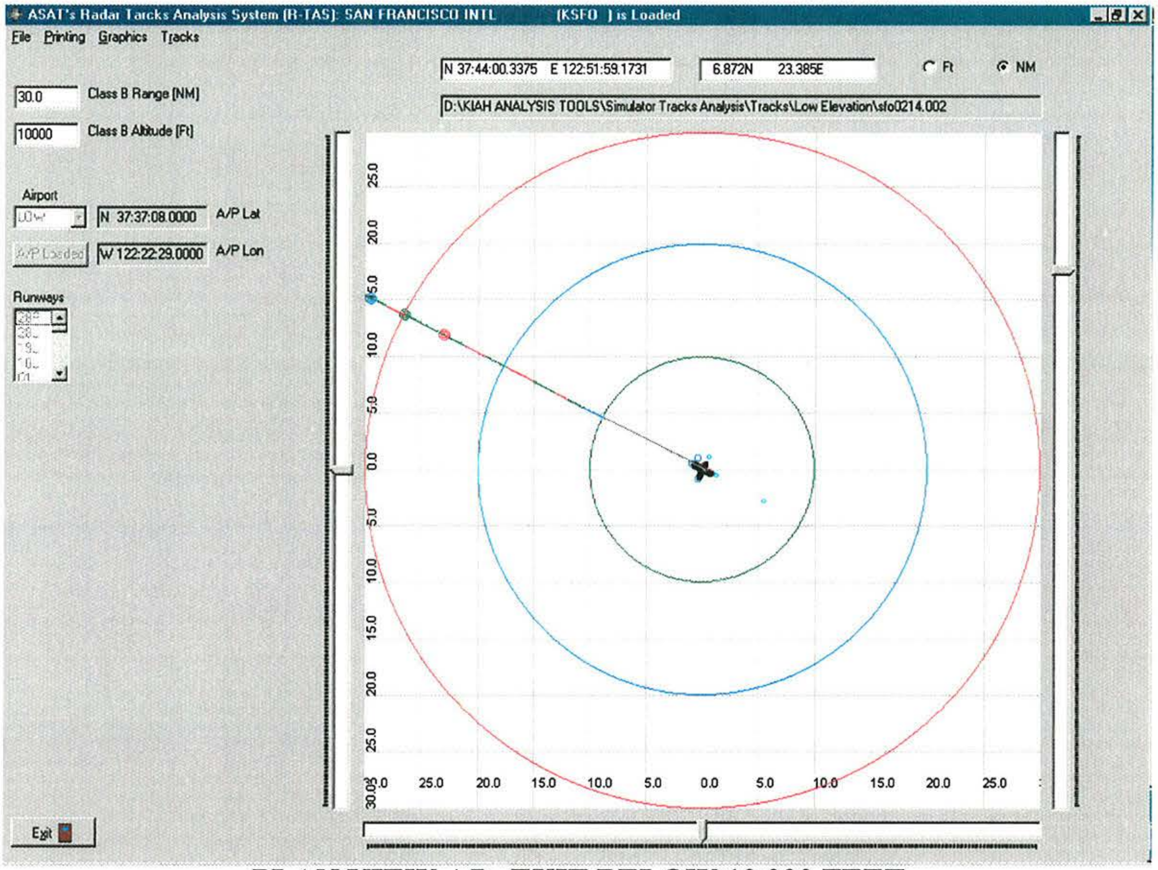
PROFILE VIEW A5.1: EXIT ABOVE 10,000 FEET



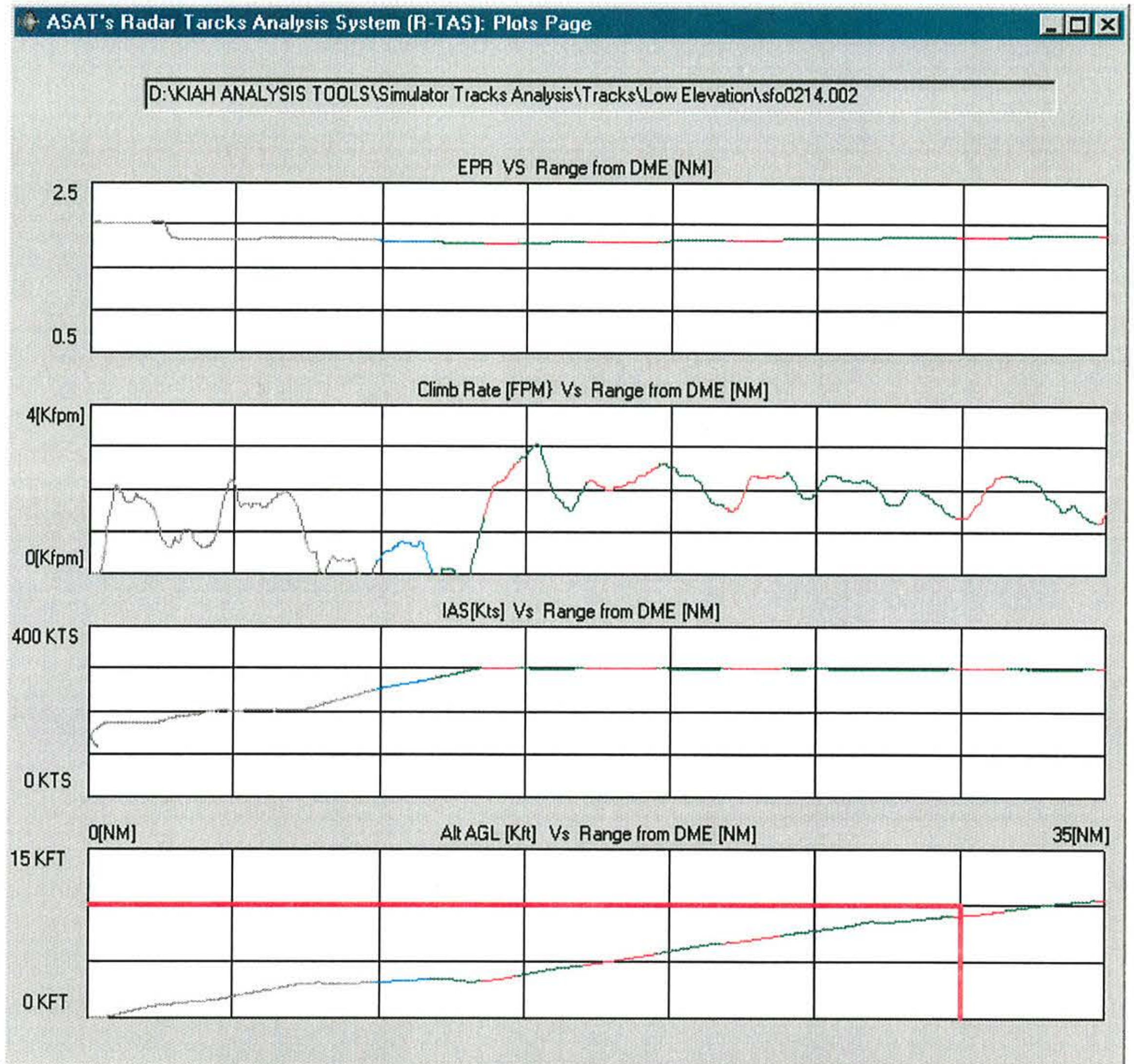
PLAN VIEW A6: EXIT ABOVE 10,000 FEET



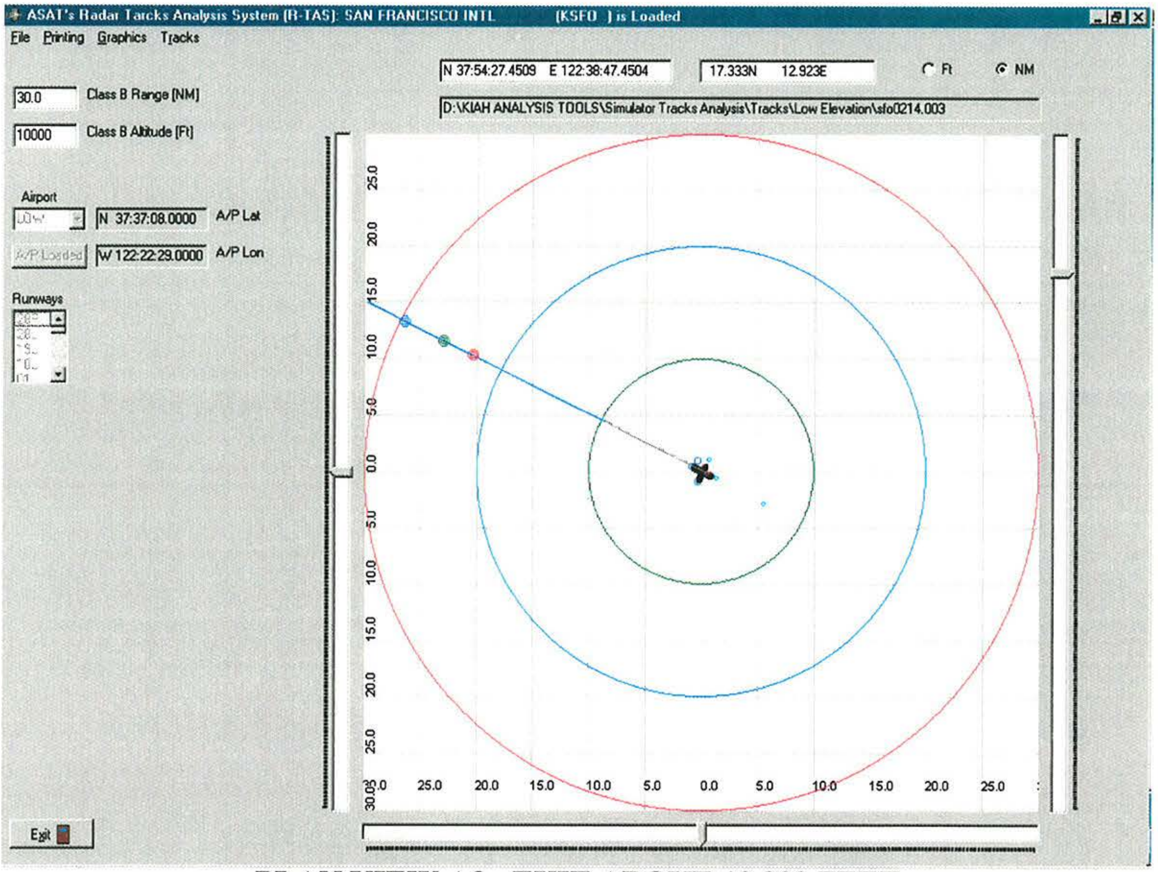
PROFILE VIEW A6.1: EXIT ABOVE 10,000 FEET



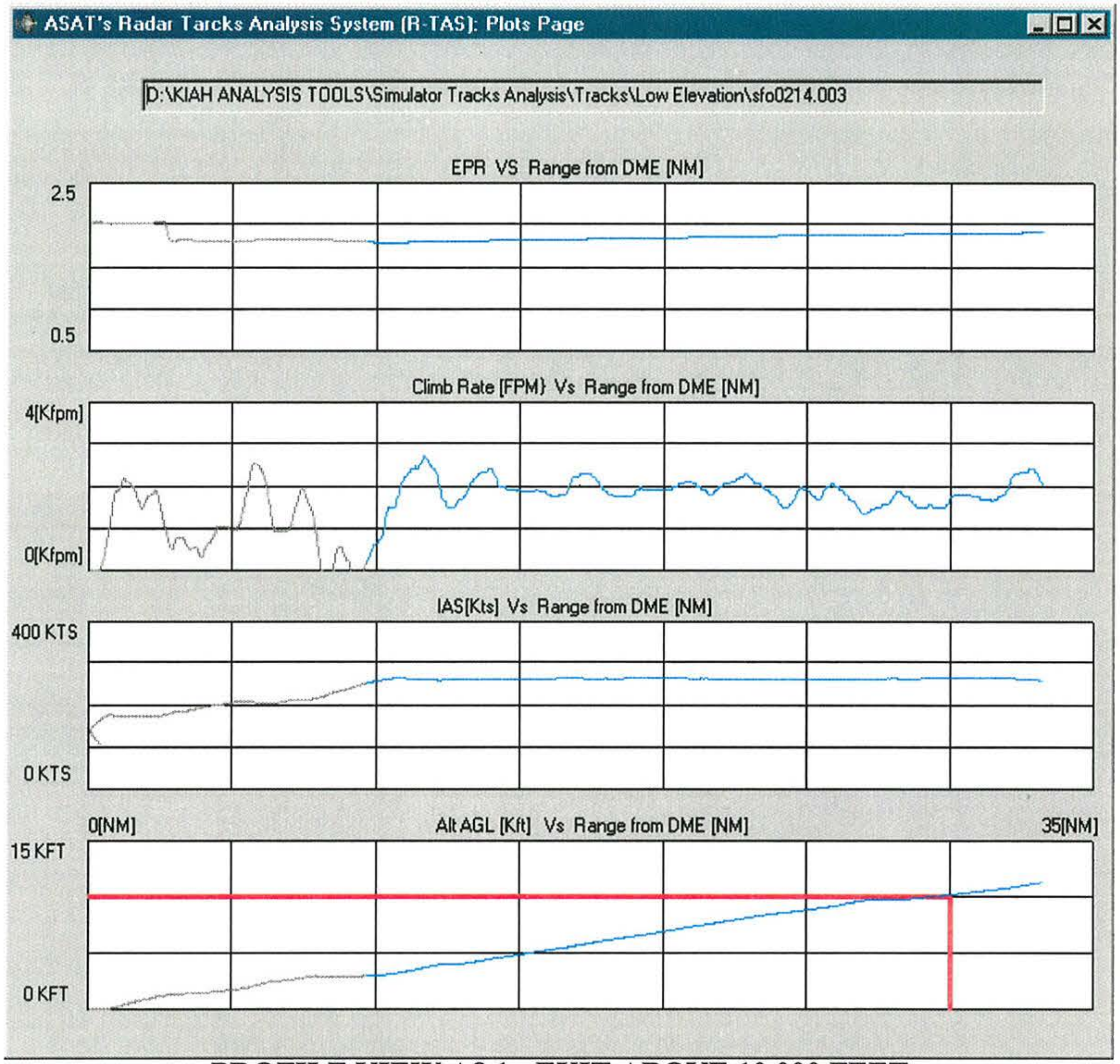
PLAN VIEW A7: EXIT BELOW 10,000 FEET



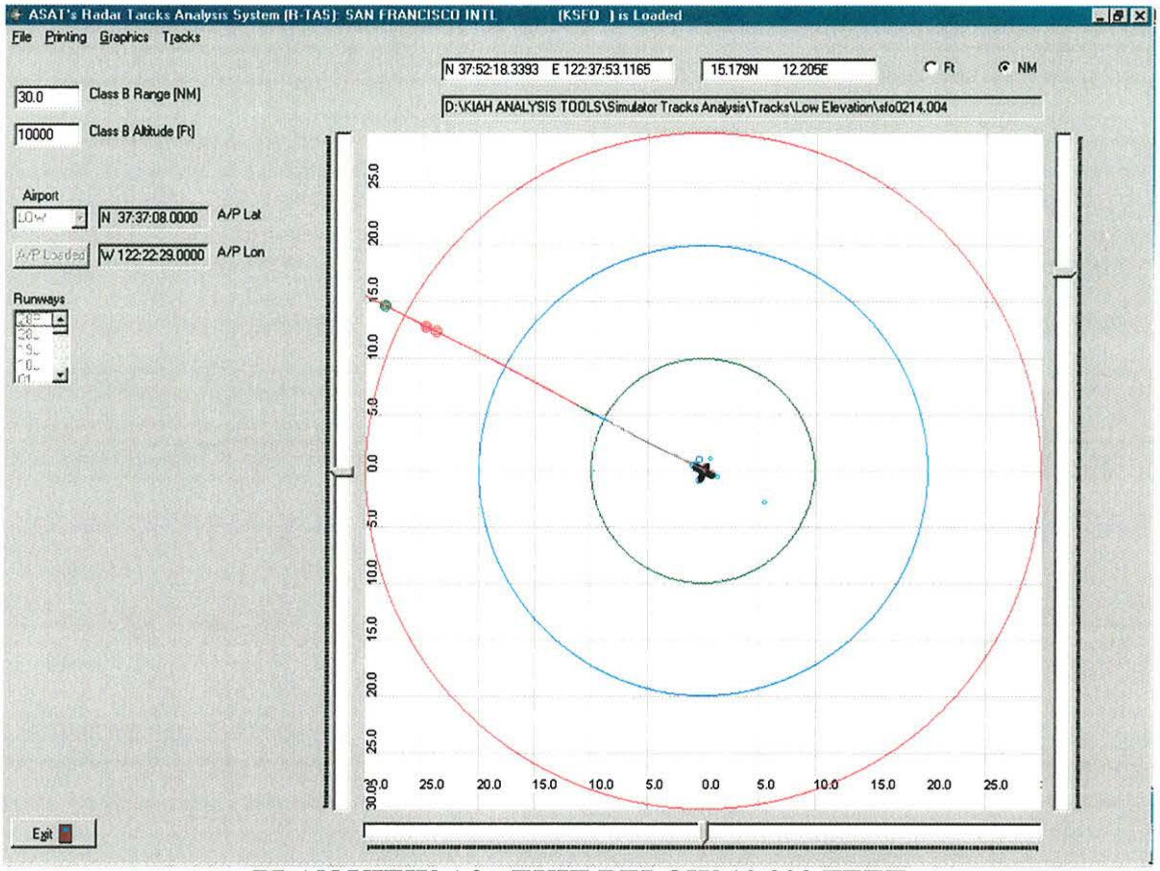
PROFILE VIEW A7.1: EXIT BELOW 10,000 FEET



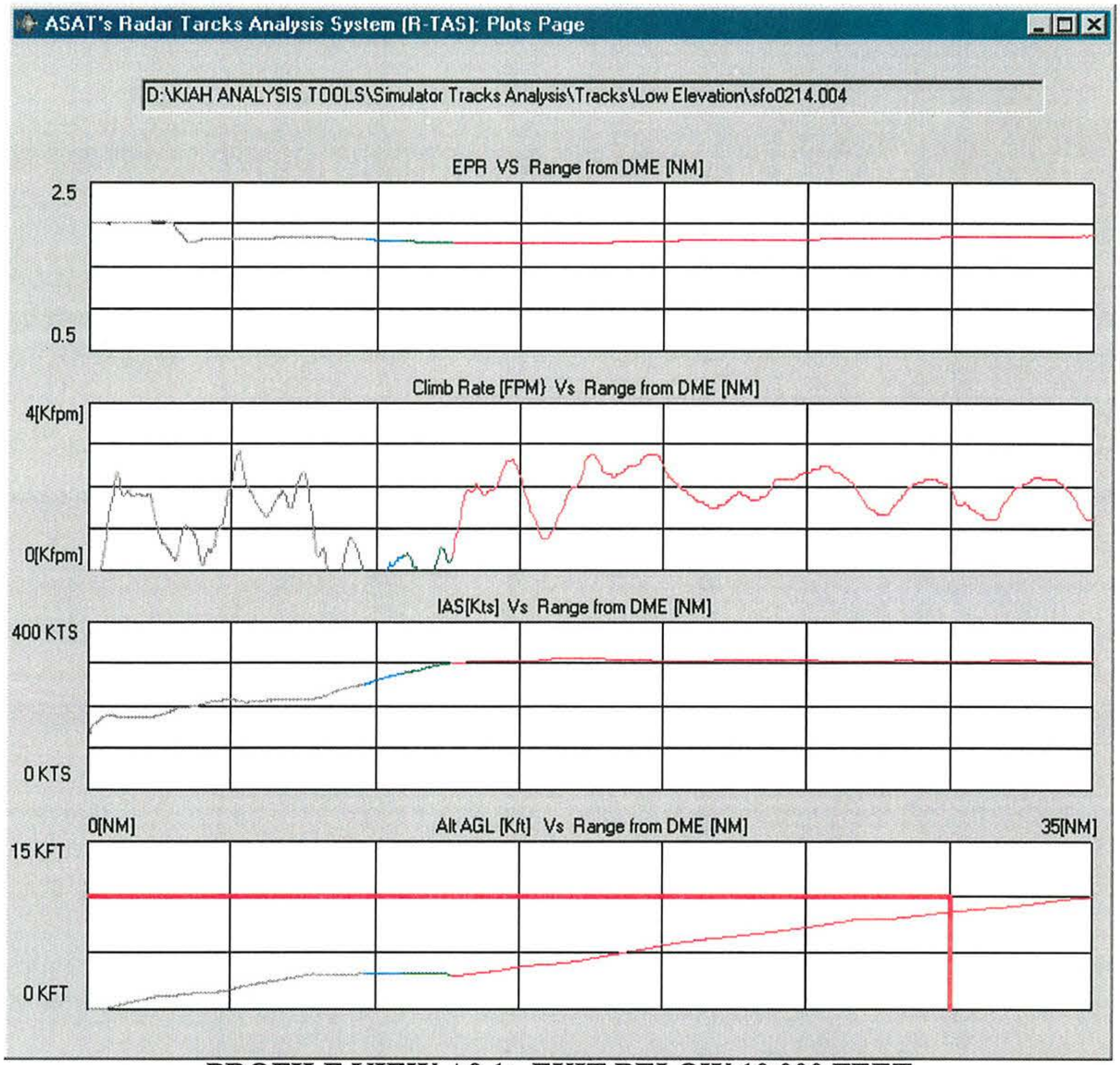
PLAN VIEW A8: EXIT ABOVE 10,000 FEET



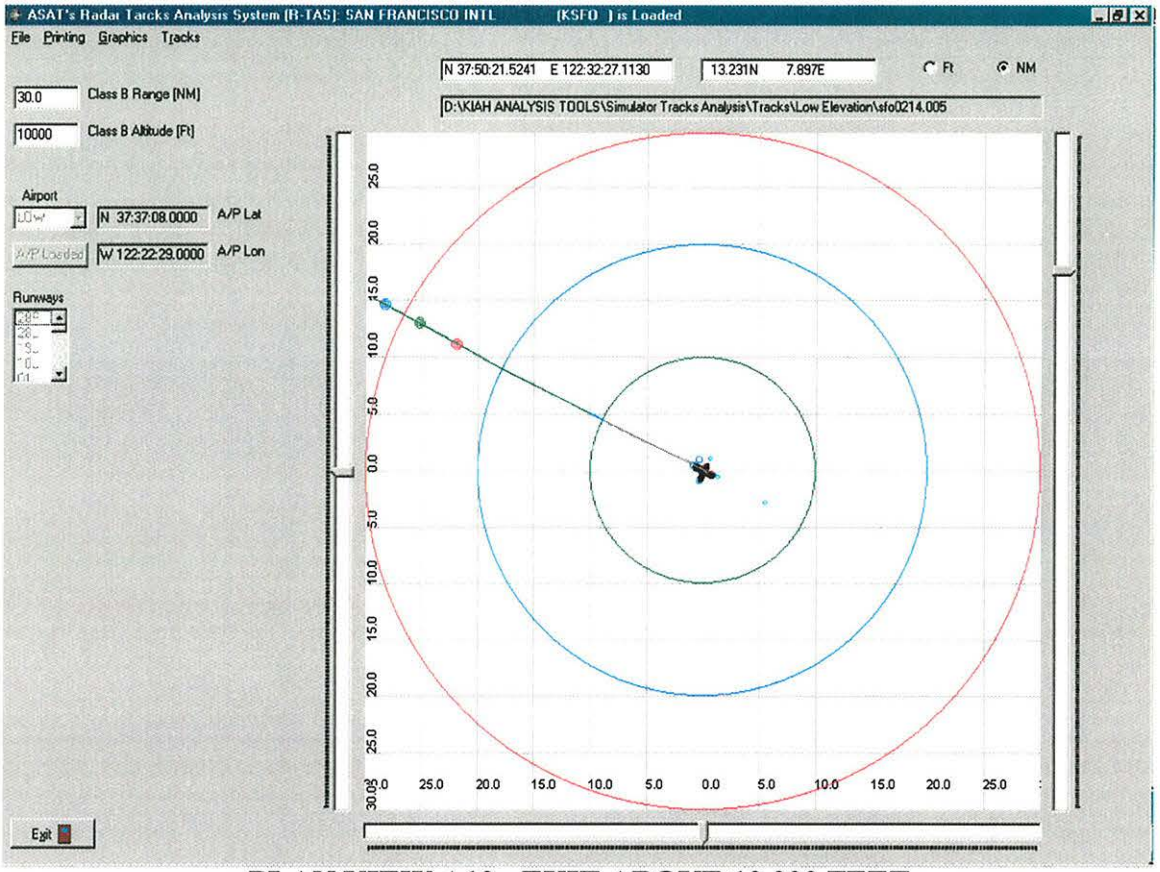
PROFILE VIEW A8.1: EXIT ABOVE 10,000 FEET



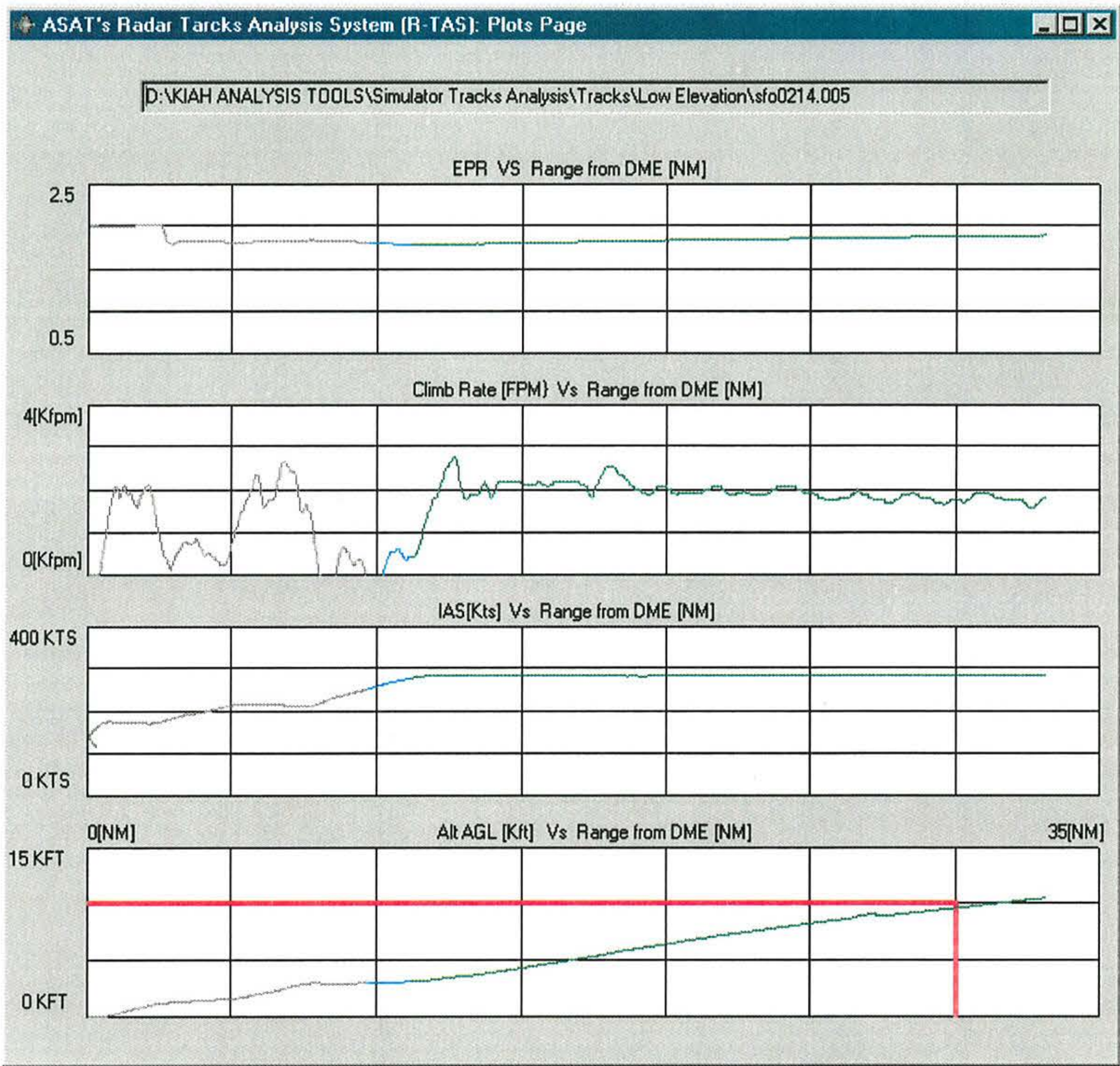
PLAN VIEW A9: EXIT BELOW 10,000 FEET



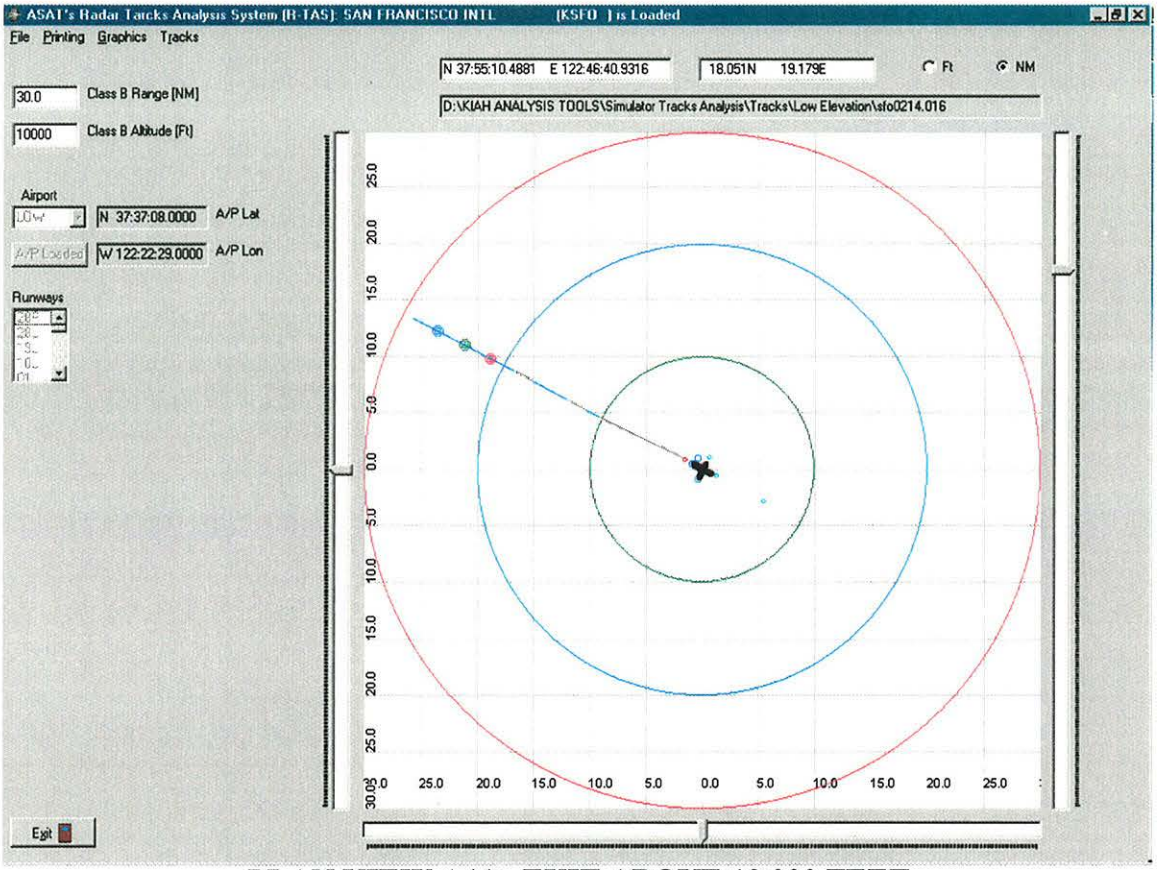
PROFILE VIEW A9.1: EXIT BELOW 10,000 FEET



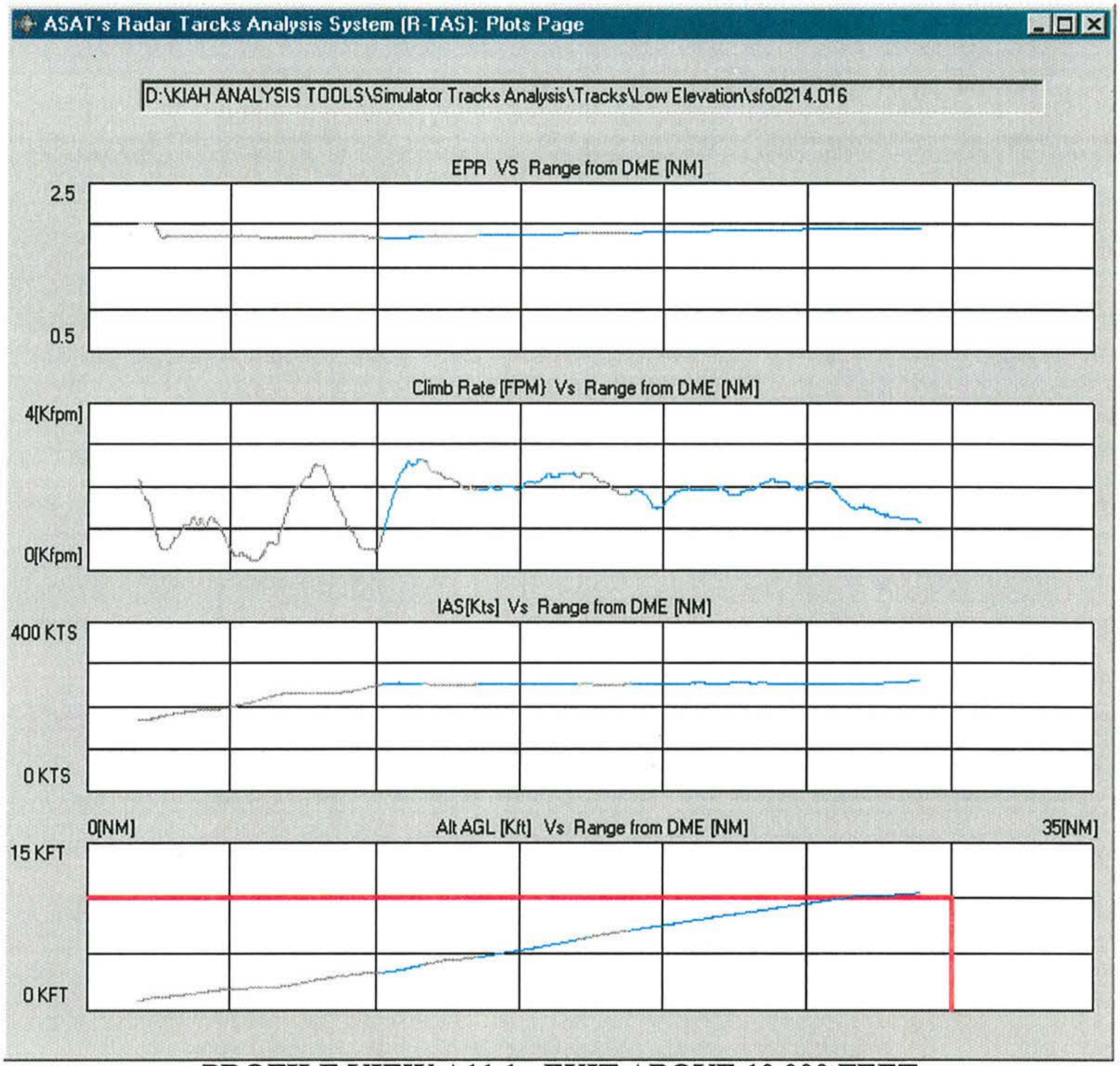
PLAN VIEW A10: EXIT ABOVE 10,000 FEET



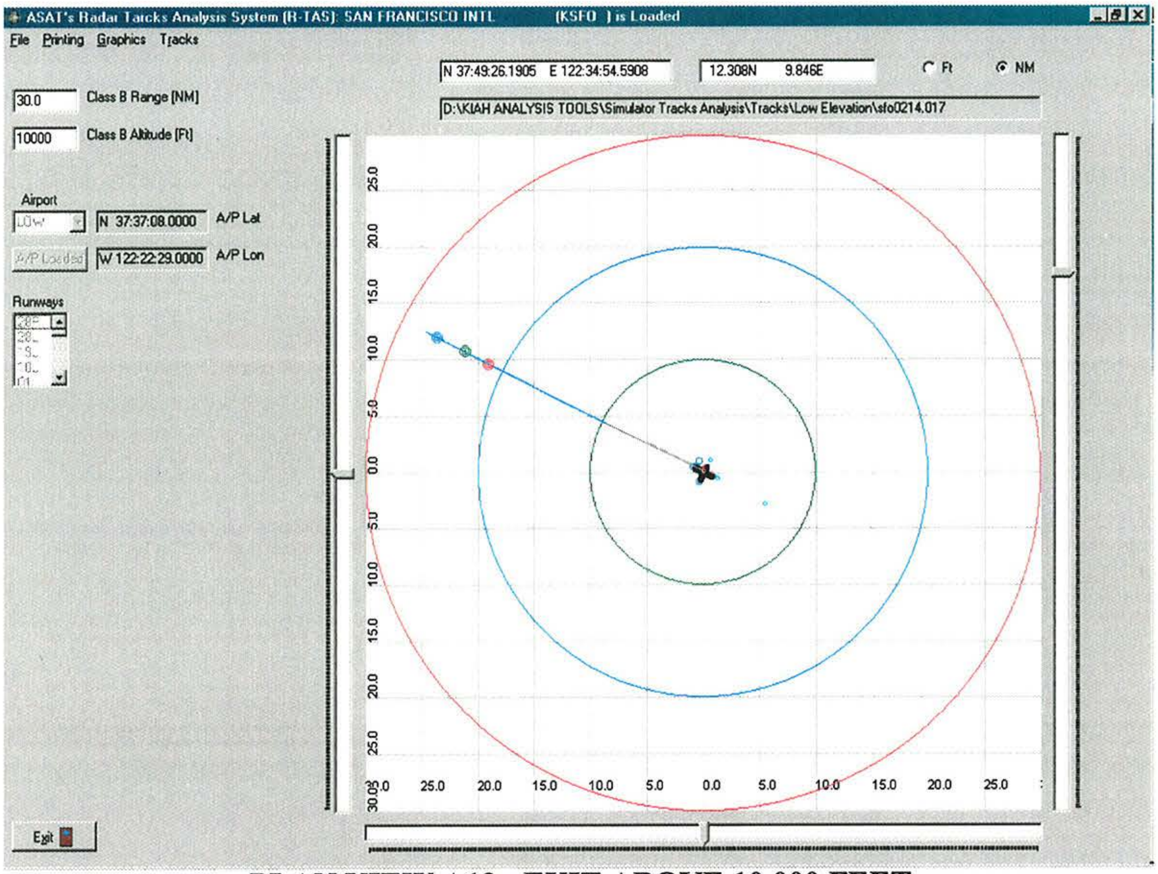
PROFILE VIEW A10.1: EXIT ABOVE 10,000 FEET



PLAN VIEW A11: EXIT ABOVE 10,000 FEET



PROFILE VIEW A11.1: EXIT ABOVE 10,000 FEET



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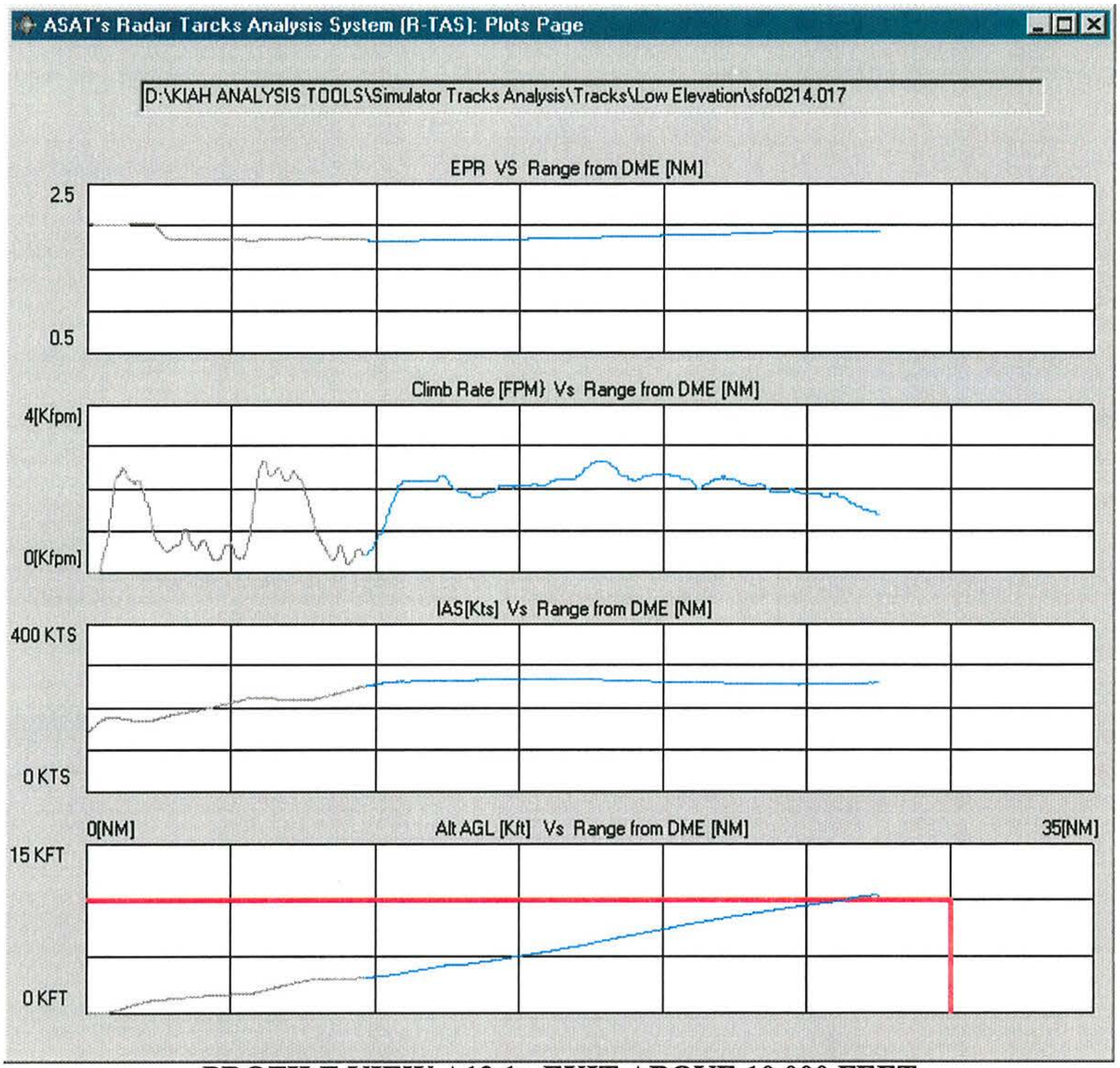
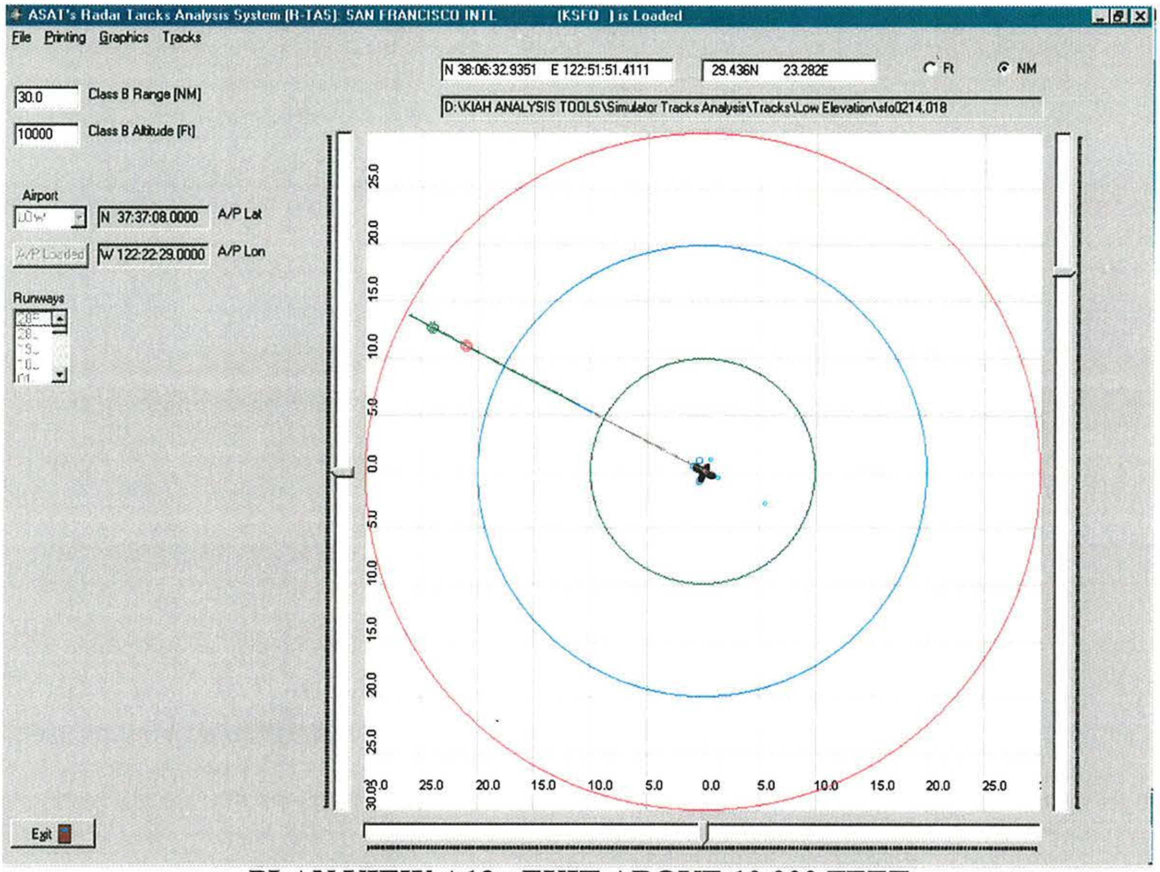


PROFILE VIEW A12.1: EXIT ABOVE 10,000 FEET



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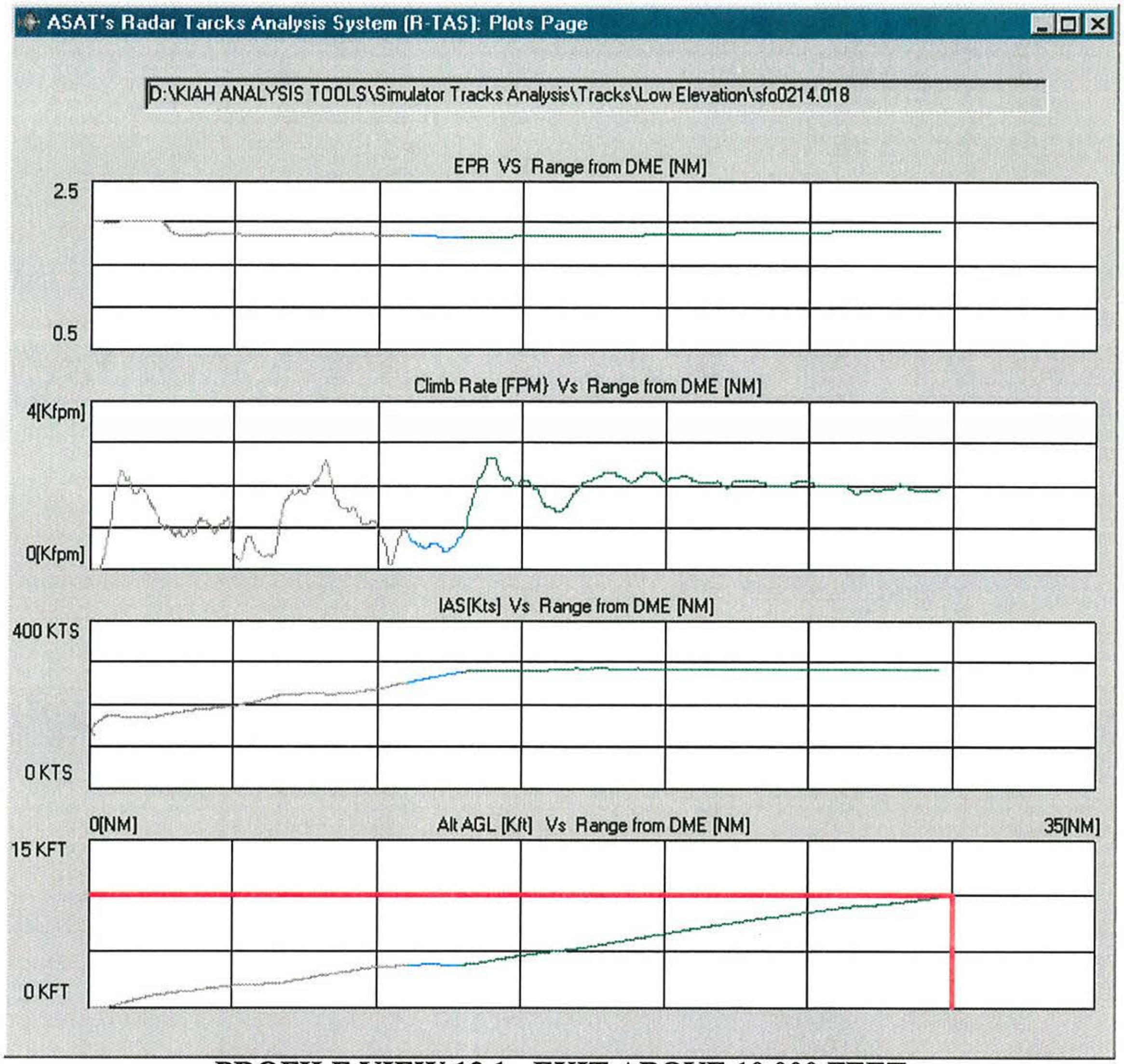
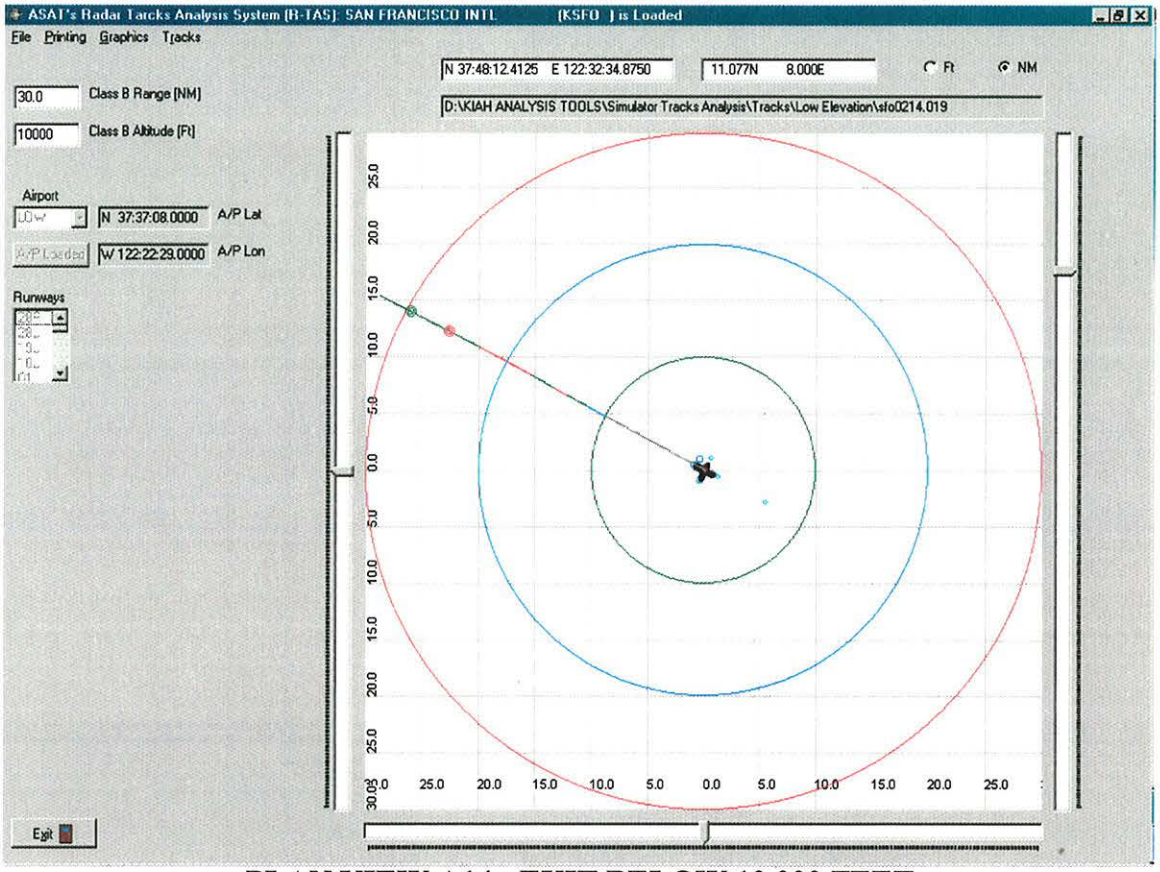
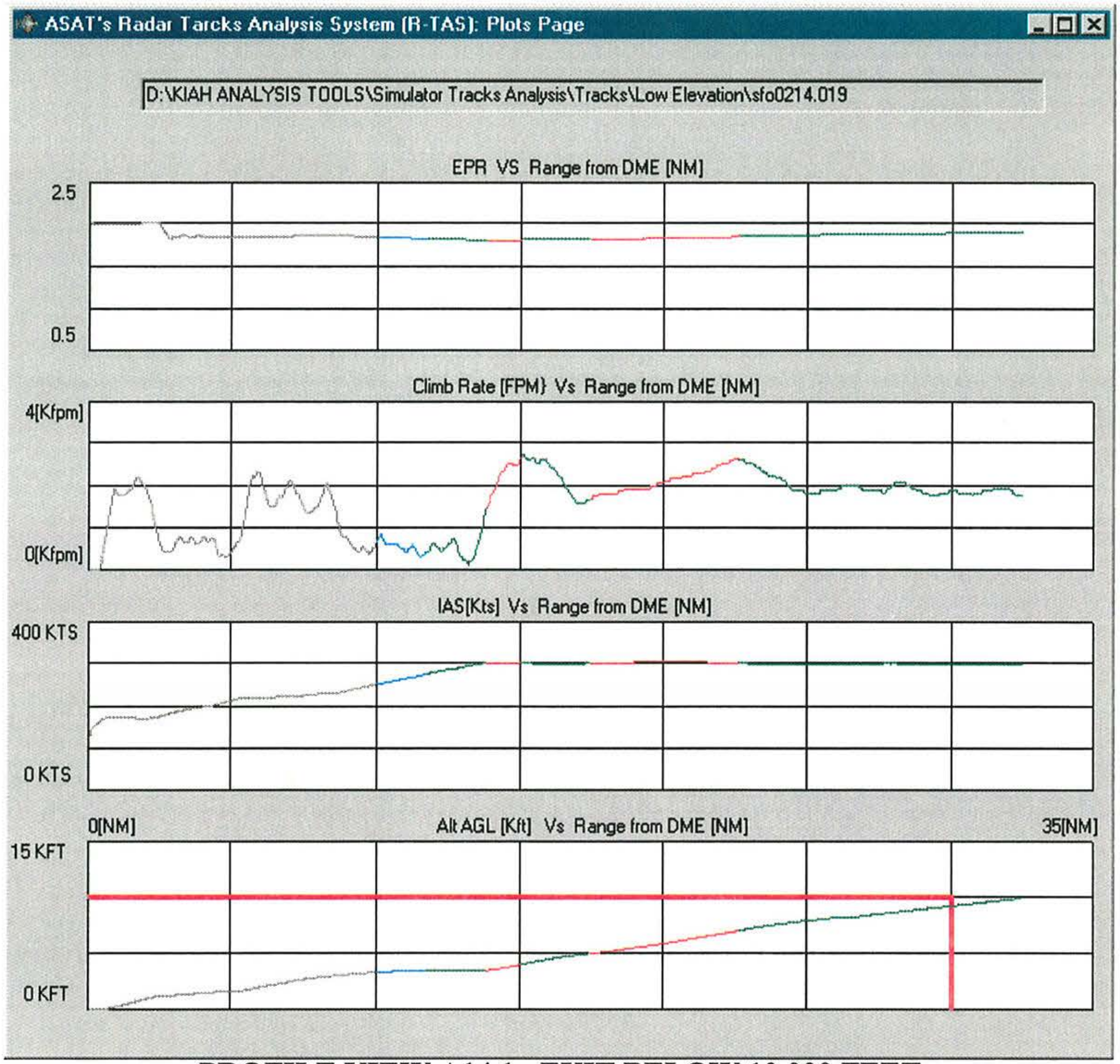


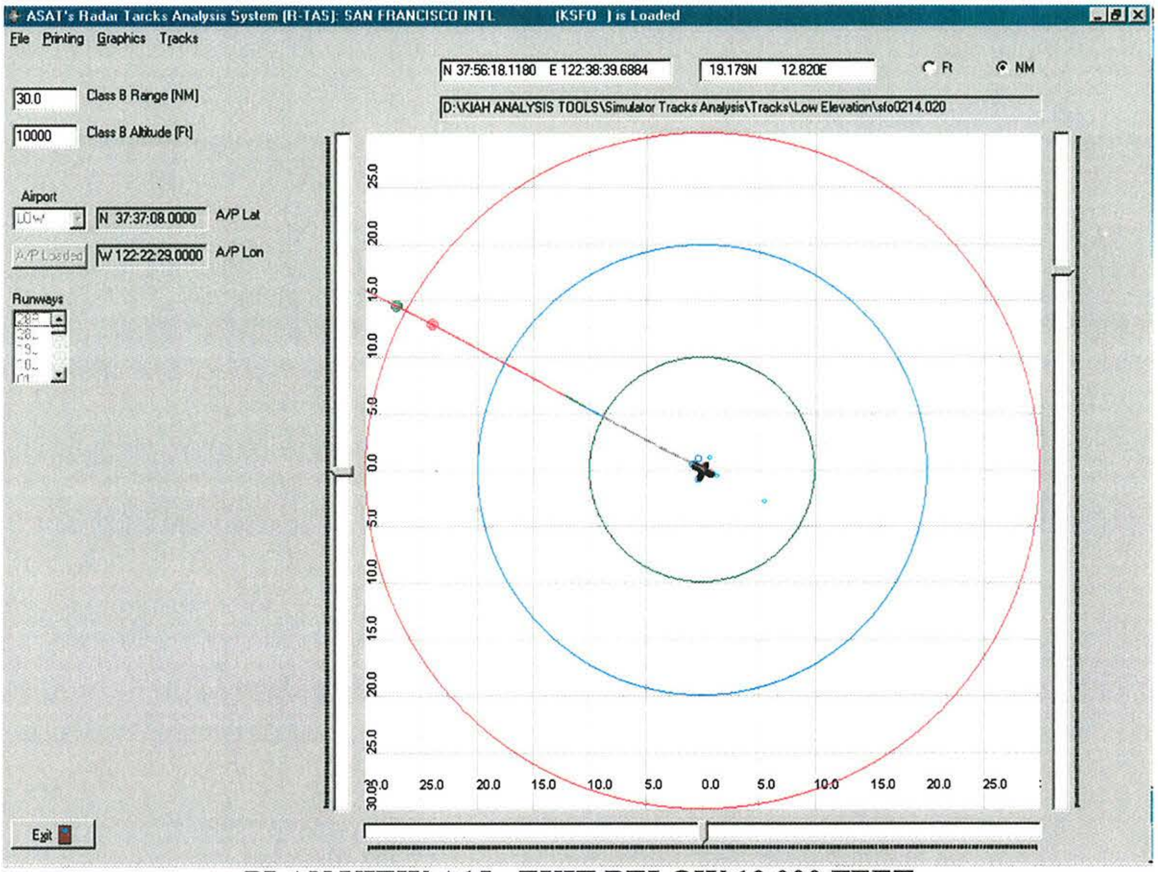
PROFILE VIEW 13.1: EXIT ABOVE 10,000 FEET



PLAN VIEW A14: EXIT BELOW 10,000 FEET



PROFILE VIEW A14.1: EXIT BELOW 10,000 FEET



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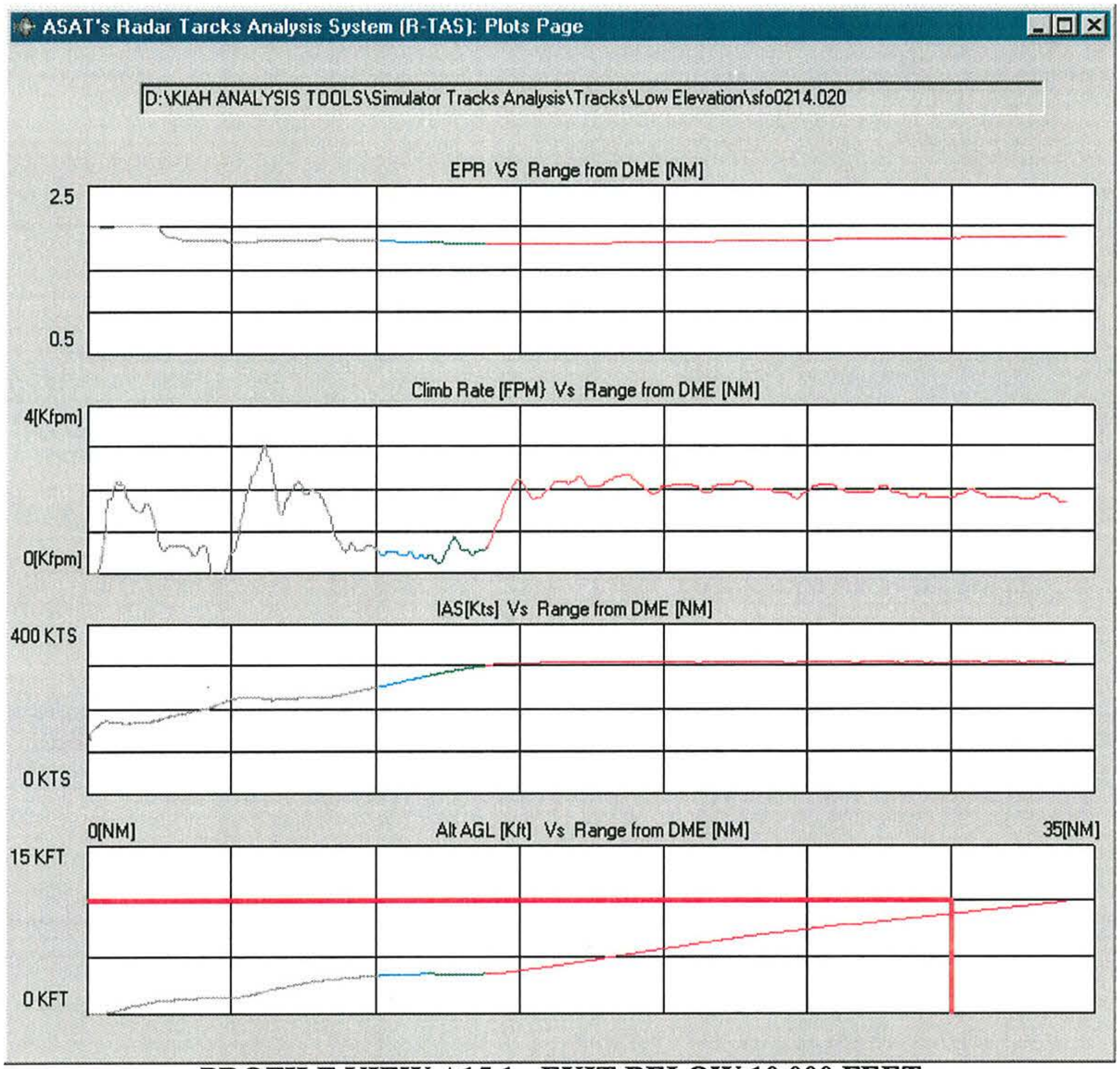

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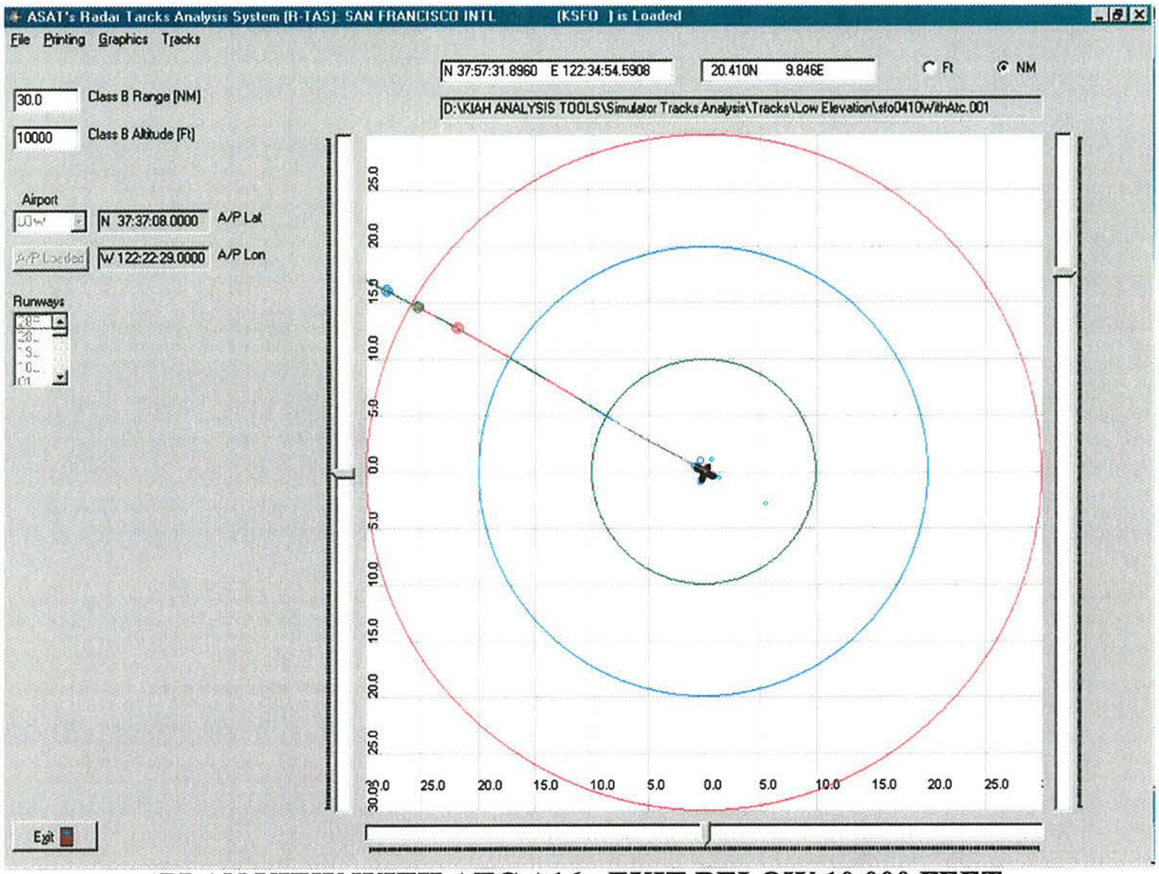
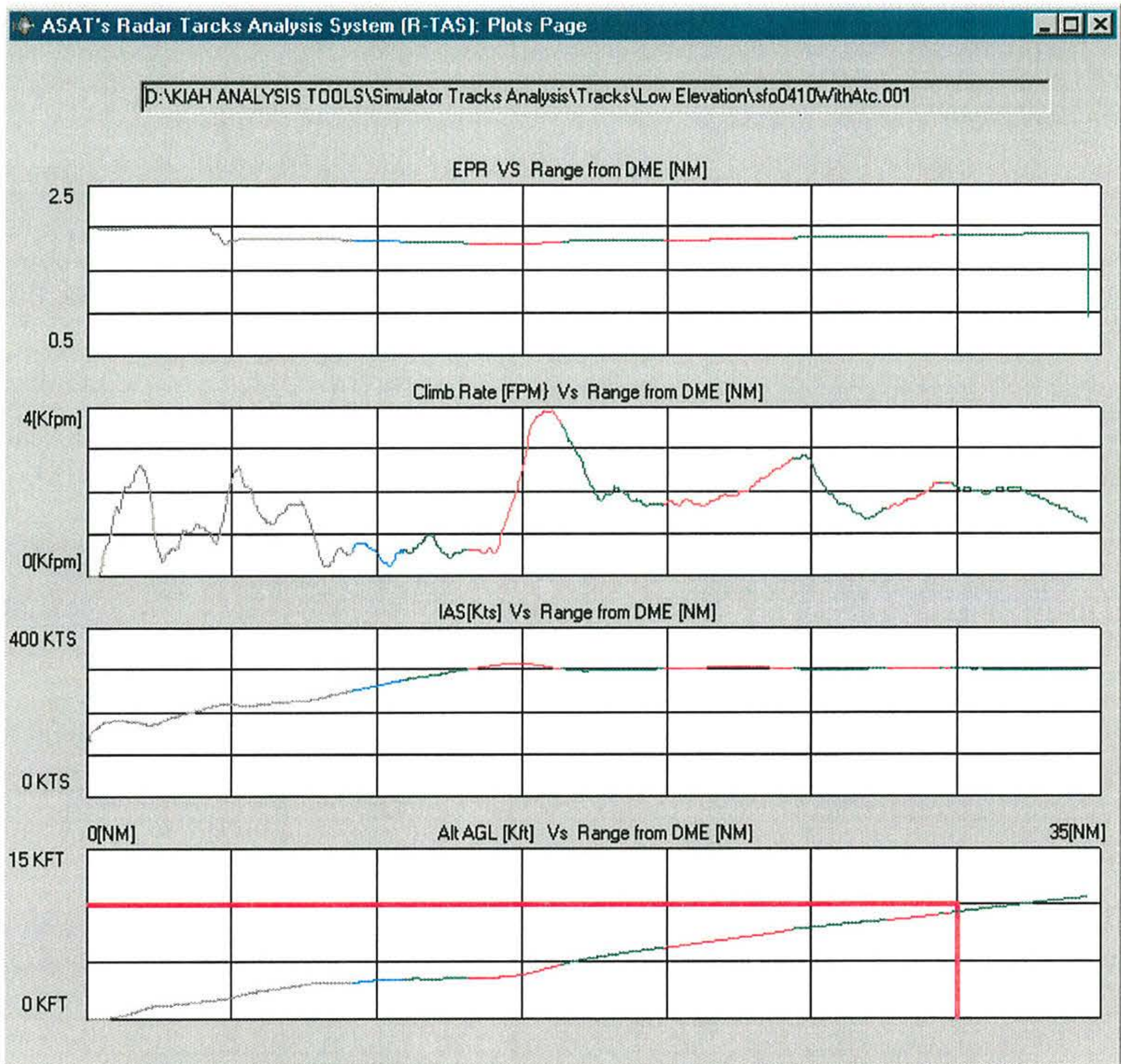


PLAN VIEW WITH ATC A16: EXIT BELOW 10,000 FEET



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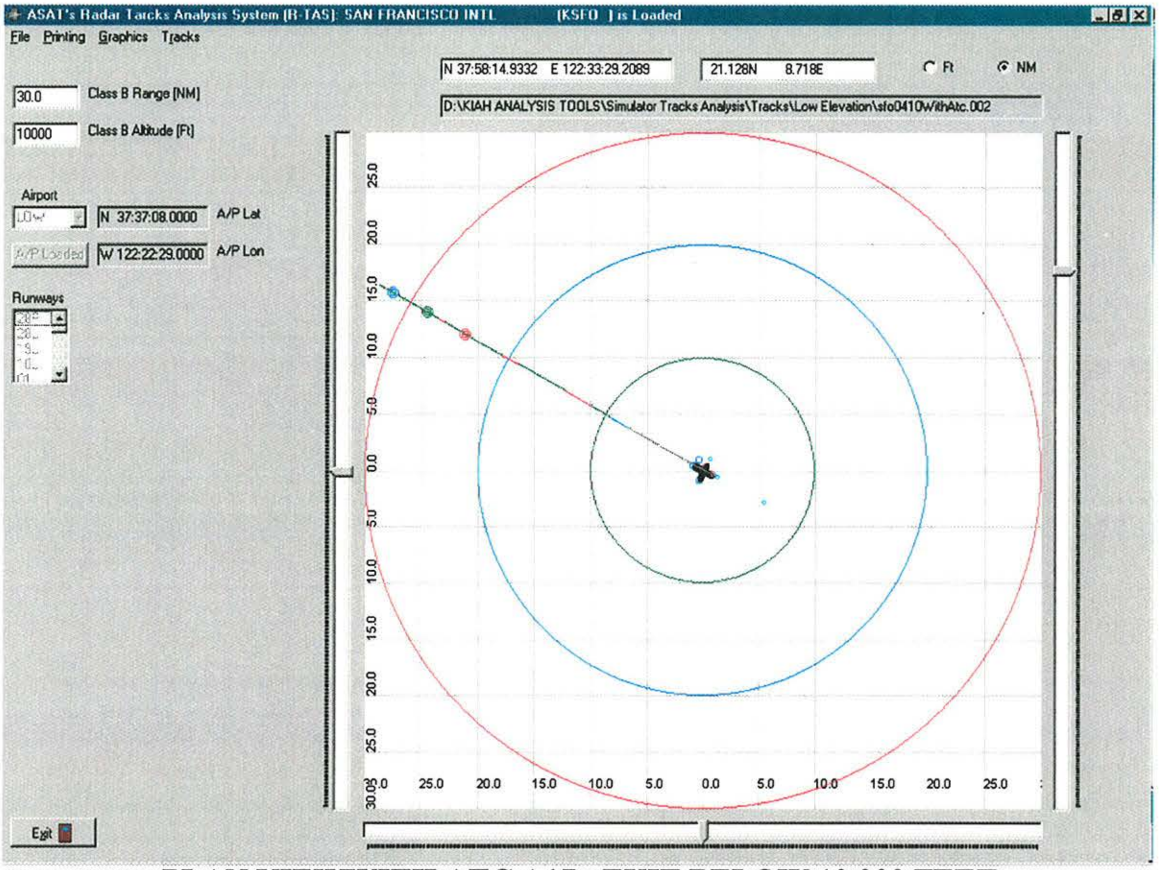

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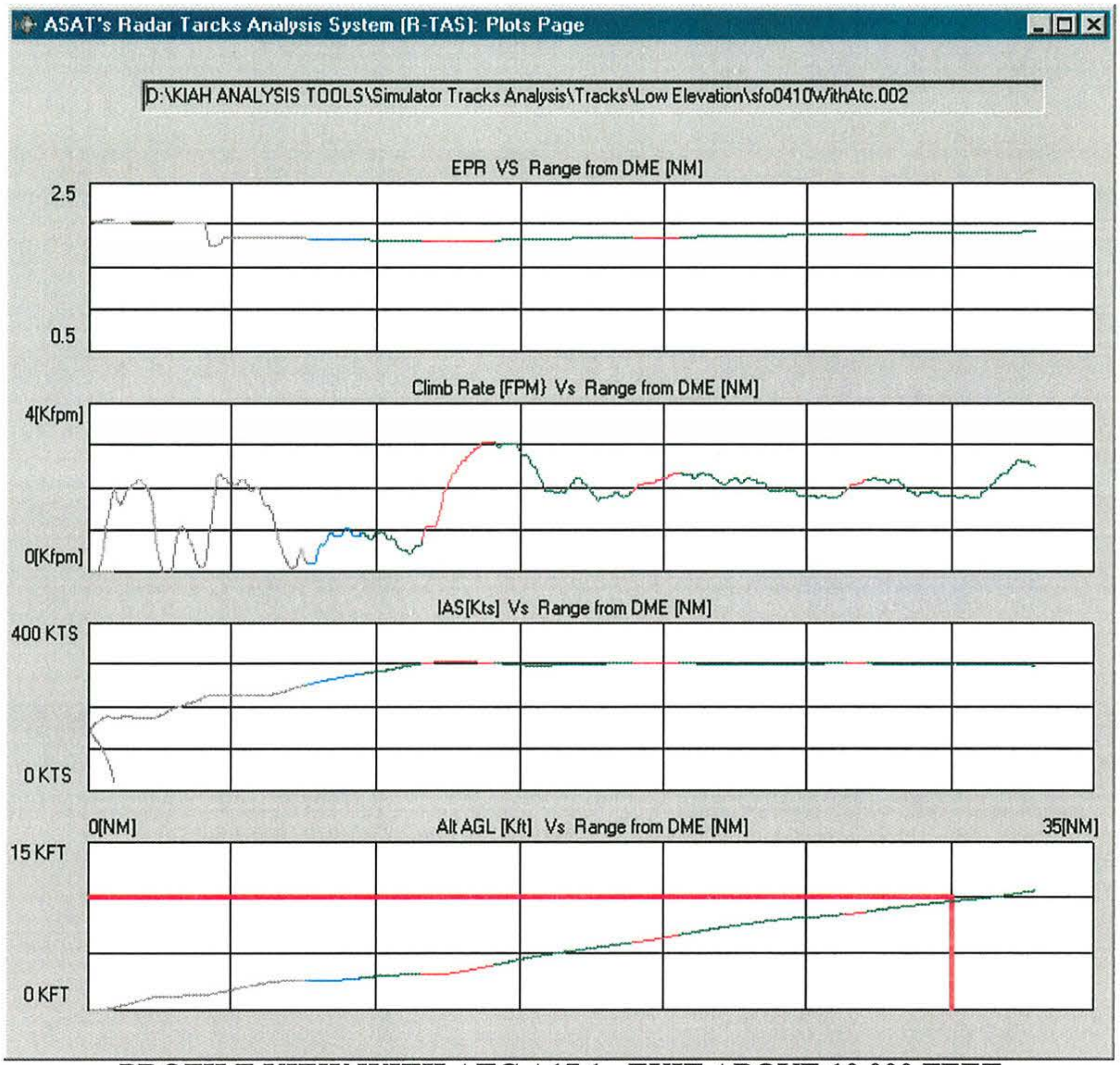

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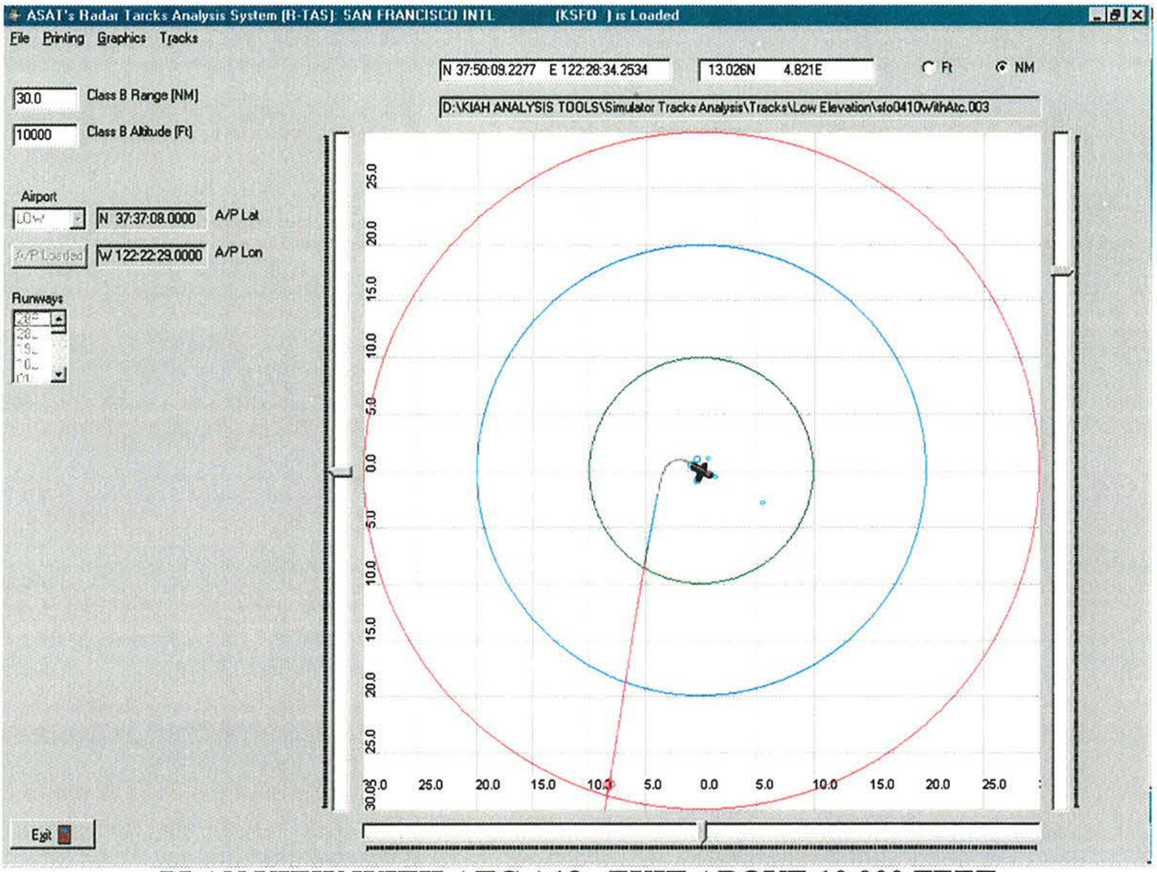

PLAN VIEW WITH ATC A18: EXIT ABOVE 10,000 FEET