SWAPA Submission to NTSB
Southwest Airlines Flight 1455
Burbank California, March 5, 2000

Introduction

As outlined in NTSB Rules of Practice CFR Title 49, Part 845.27 the Southwest Airline Pilots Association (SWAPA) submits the following analysis of the circumstances surrounding the overrun accident involving Southwest Airlines (SWA) flight 1455 on March 5, 2000, in Burbank, California. The intent of this submission is to highlight areas that we believe the NTSB should consider in its final report on this accident.

This overrun accident is the result of an unstable approach. Flight data analysis programs, such as Flight Operations Quality Assurance (FOQA), now being employed at most U.S. Airlines have documented that statistically; unstable approaches are not an uncommon event. All, but a small minority, result in uneventful safe landings. The benefits of the programs like FOQA and the associated safety investigations are to study where the approaches went unstable and implement procedures or training enhancements to reduce subsequent events. The ATC contributions to the unstable approach must also be analyzed and recommendations developed for prevention. There are two areas from this accident that SWAPA believes should be adequately analyzed:

- the ATC procedures used by the Southern California TRACON controller in positioning flight 1455 for the approach, and
- a detailed human factors analysis of the crew activities that resulted in the unstable approach.

Following this event, Southwest Airlines and SWAPA implemented substantial enhancements to the Southwest Airlines Safety Program through the development of the Voluntary Aviation Safety Information program (VASI). This program includes the Aviation Safety Action Partnership (ASAP) and the Flight Data Analysis Program (FDAP). Both will help enable SWA to be proactive in eliminating unstable approaches and other safety issues from its operation. Collectively, the industry will have to work together to reduce the factors originating from ATC regarding unstable approaches. SWAPA wishes to provide the NTSB an analysis of the contributing factors surrounding this event in order to ensure that appropriate safety recommendations are made and implemented from this investigation.

SWAPA appreciates the opportunity to submit these comments and the professional and cooperative environment the NTSB fostered during the investigation.

Air Traffic Control Issues

The facts identified during the investigation of this event indicate that the SOCAL TRACON controller did not follow correct procedures in vectoring SWA1455 to the final approach course for Runway 8 at Burbank. These errors resulted in an incorrect final approach intercept vector and high airspeed. This action set up the unstable approach and contributed to the overrun accident.

A thorough analysis of the ATC transcripts and radar data provides evidence that the controller, during light traffic workload, rushed approach clearances and heading and altitude assignments to several aircraft, including SWA1455. This resulted in missed or questioned clearances and caused two aircraft to overshoot their respective runway centerlines, including SWA1455. In addition, analysis shows that the speed restriction given to SWA1455 was not necessary to ensure adequate spacing. The issuance of this clearance by the controller shows a lack of attention to the sector and poor technique.

The following is a step-by-step analysis of the ATC procedures for SWA1455:

Starting from time 0159:41 of the ATC transcript, the controller has an over-flight aircraft (KING01) that is required to be monitored and then transferred to the next facility on its route of flight. This aircraft needs no turns (vectoring) or altitude changes, as it is following a route established by the facility for aircraft transiting to another facility, in this case, Point Magu.

There is also a Baron (a twin engine reciprocating engine aircraft with a speed of approximately 160 Kts.) making a non-precision approach to the Whiteman Airport.

Finally, at 0159:47, Execjet 327, a corporate jet aircraft with an approximate speed of 240 kts, is transferred to the controller for a precision approach (ILS) to Van Nuys Airport.

The controller now has one aircraft to monitor and two aircraft to vector to the final approach course and issue approach instructions. During his interview (on page 6 and 8 of the ATC Group Chairmen's Factual Report) the controller characterized his workload as moderate with Burbank traffic as light. Based on the traffic identified from the ATC transcript, it appears the workload should be considered closer to light. There certainly was no reason for the controller to be rushed in issuing clearances, turns, or altitude assignments.

Even with the traffic load described above, the controller rushed the clearance for the Execjet and did not repeat the clearance when Execjet asked for a re-clearance. Instead, he continued with the clearance for the slower-moving Baron.

From the SOCAL TRACON Woodland Radar Position transcript:

0200:33	WDLR	execjet three twenty seven five from umbra turn left heading one eight zero descend and maintain six thousand until established on the localizer cleared ils one six right approach
0200:41	EJA327	say again three twenty seven

At this point, due to the speed and angle of intercept, the controller should have reissued the clearance. The Execjet is doing approximately three and one half miles a minute. Instead the controller rushed to issue the Baron, going approximately 30% slower, his approach clearance. The Execjet, not certain of what instructions were issued, continued on his previous heading.

0200:42	WDLR	king air six sierra pa baron six sierra papa's four from van nuys turn right heading zero five zero maintain three thousand until established on the final approach course cleared v o r alpha approach circle to three zero
0200:51	N6SP	ok uh zero five zero three thousand until established cleared for the approach six sierra papa
0200:54	WDLR	execjet three twenty seven four from umber turn left heading one nine zero descend and maintain six thousand until the established on final approach course (unintelligible) on the localizer cleared ils one six right

Although only twenty-one seconds has elapsed since the first clearance issued, the execjet has traveled at least one mile. This would obviously necessitate a tighter turn to the final approach course (a heading more closely aligned to the final), but instead, the controller gave him a turn ten degrees wider. Without reading further, an experienced controller would see the error of such a turn.

Due to the speed and proximity of the Execjet to the final approach course, there is no doubt that he will overshoot through the course. This is the precursor to an unstabilized approach, a serious condition that has been a factor in more than one accident (i.e. Piedmont Airlines Flight 467, a Boeing 737-222, at Charlotte-Douglas International Airport on Oct. 26, 1986- NTSB/AAR-87/08). Airline FOQA data has shown that ATC procedures contribute directly to unstable approaches.

In this sequence, the controller issued clearances to Execjet in an attempt to recover his admittedly late turn to final.

0201:04	EJA327	ok left to one nine zero and down to four thousand until established cleared for ils one six approach execjet three twenty seven
0201:10	WDLR	execjet three twenty seven descend and maintain six

		thousand until established
0201:15	EJA327	left to one nine oh and down to six thousand six thousand until established execjet three twenty seven
0201:36	WDLR	execjet three twenty seven that was a late turn to the final turn left continue on the left turn now heading one four zero to join

It is typical, if not paramount for controllers to ensure that they have planned in advance far enough to allow for miscommunication or other errors affecting the outcome of each flight under their control (i.e., pilot errors, mistaken instructions, or misidentification). However, upon review of the transcripts, the controller appears to have waited until the minimum allowable time to issue his clearances to both the Baron and the Execjet. This is evidence of a lack of attention to the sector.

Also, the controller issued an approach clearance to the Baron, a slower aircraft, prior to the Execjet aircraft acknowledging his clearance. With the higher speed, the Execjet has a more demanding time constraint. It is our opinion, after analyzing the transcripts and relating the position and speed of both aircraft and reviewing the subsequent correction made by controller, that significant error in prioritizing occurred.

The error in prioritizing resulted in the rushed clearances. This is demonstrated by the fact that the first transmission of the clearance for Execjet began at 0200:33 seconds on the clock and the reply of Execjet began at 0200:41. That leaves eight seconds for the transmission of the clearance. If we include one second for the Execjet to key his mike and begin the reply, it implies that the transmission was given in seven seconds. In a fairly rapid delivery, we were able to repeat the transmission in ten seconds. This may sound trivial, but to rush a clearance in such a manner is only common in heavy traffic situations where time is compressed. It is our opinion that the compression of the transmission and the result of the rapid transmission lead to the misunderstanding and uncertainty of the Execjet crew (0200:41,"say again three twenty seven"). They misunderstood the altitude clearance given; this is also evidence of a rushed clearance. Also noteworthy is that Execjet abbreviated his call sign when the correcting clearance was given. This was the only time that occurred for the aircraft.

It should also be noted that the correcting turn was not given until one minute and four seconds had elapsed. Execjet traveled approximately three and one half miles during that time. If the controller had given himself more lead-time to turn both aircraft, we would not be using this as evidence of his lack of attention.

At 0201:52, the Baron was transferred to Whiteman Tower. Eleven seconds later, at 0202:03, the overflight (KING01) is transferred to Point Magu Approach. The only aircraft left on the frequency was the Execjet.

At 0202:34 the controller gave the Execjet a lower altitude. This is necessary only if the aircraft was not established on the approach. This is approximately one minute from the last turn, which indicates that the aircraft had significantly overshot the approach course, due primarily to the vectors of the controller.

At 0202:38, SWA1713, the aircraft in front of the accident aircraft, checked in with the controller. Then at 0202:45, SWA1455 also checked in. An approximate one- to three-second gap existed between the two flights' radio transmissions under a normal rate of speech, but the controller doesn't acknowledge them.

Without acknowledging SWA1455, the controller issues SWA1713 direct to the Silex intersection. This clearance shortens SWA1713 arrival approximately eight miles (distance between Toaks intersection and Silex), and thus gave the controller more than enough spacing for SWA1455 to follow.

At 0202:55, the controller transmits: "southwest fourteen fifty five socal approach atis papa current at burbank I missed if you had that altimeter two niner niner six expect i l s eight." The crews had checked in with the earlier airport information (ATIS Oscar) and were expecting a different runway. But, the important point is that they were expecting vectors to an ILS approach.

The FAA Air Traffic Control Handbook (FAAH 7110.65) states the maximum intercept angle for final approach courses is thirty degrees (Sec. 9, TBL 5-9-1) (*Attachment 1*). Therefore, a pilot will anticipate a twenty- to thirty-degree intercept vector to the final approach course with an interception of the course occurring about eight miles from the runway.

At 0203:33, the controller issued a heading of 190 for vectors to final. By using the "Overhead View Of Radar Data from the Recorded Radar Study Factual Report (*Attachment 2*) and ATC Communications, it is apparent that this was a good initial heading. Of course, once the aircraft was closer to the final approach course, an intercept heading would need to be given. Extrapolating the 190 heading further toward the final with no turns would have the aircraft intercept at approximately 18 miles. A good intercept heading of 110 degrees (inbound course 76 degrees magnetic plus the maximum allowable, 30 degrees, would give 106 degrees; rounding up would give 110 degrees) would ideally be given at fifteen miles from the field and 4 miles north of the final approach course. By reviewing Attachment 2, one can see that this is the norm for approaches into Burbank's Runway 8. Unfortunately, SWA1455 did not follow this approach path.

At 0203:42, Execjet 278 (EJA278 on transcript) checked in arriving from the northwest. After transferring EJA327 to Van Nuys Tower frequency, the controller issued a speed of 210 knots to EJA278 (0203:58) and a minimum speed of 230 knots or greater to SWA1455 (0204:05). This technique began a chain of events that resulted in the runway overrun. By utilizing speed adjustments, the distance between the aircraft will increase at a rate of approximately one half mile per minute (230-210=20knots, add 5 knots equivocally, for the "or greater" gives twenty-five knots. 30 knots would equal one half mile a minute). From the time the speed adjustment was issued (0204:05) until the clearance for a visual approach was given (0208:21), over four minutes elapsed. This corresponded to an extra two miles of spacing between the two aircraft during this time. Given the least conservative requirement of three miles separation planned between each aircraft, once they were established on final, the separation would still have increased until the SWA1455 slows down. Based on this evidence, it appeared that the speed adjustment to SWA1455 was unnecessary to ensure the proper separation.

Section 7 of Chapter 5 in the Air Traffic Controller's Handbook (*Attachment 3*) outlines the use of speed adjustments for controllers. There are several points to consider in this evaluation. The first paragraph states: "Keep speed adjustments to the minimum necessary to achieve or maintain the desired spacing." Two sentences later it also states: "Permit pilots to resume normal speed when previously specified adjustments are no longer needed." There is a note associated with the paragraph which states: "It is the pilot's responsibility and prerogative to refuse speed adjustment that he considers excessive or contrary to the aircraft's operating specifications." This is reminding both the controller and the pilot of the pilot's responsibility for the safe operation of the aircraft. We are not trying to argue that aspect. But it must be noted that, further in the same paragraph (c.) and in the note following paragraph e., the pilot is expected to maintain that speed until cleared for the approach. When cleared for the approach, the speed adjustment is canceled, unless restated by the controller.

The pilot of SWA1455 was not, nor should he have been concerned about the speed at this point. As previously stated, the crew was expecting a turn about four miles north of the final approach course. As noted earlier, the crew had been told that they were to expect an ILS approach to Runway 8, which implied a six- to eight-mile final. Unfortunately, the crew was not given the six- to eight-mile final once the 160-degree heading was given.

In his interview, the controller stated that the flight path taken by SWA1455 was the normal flight path for approaches from the west into the Burbank area (ATC Group Chairmen's Factual Report, page 6). The Overhead View of the Radar Data (*Attachment* 2) does not support the controller assertion. As indicated, most aircraft are given a 180-degree heading and then receive a further heading to intercept the Runway 8 centerline approximately 10 to 15 miles from the airport. The turns provided to SWA1455, coupled with the unnecessary speed adjustments to 230 knots, resulted in the overshoot and was the precipitating event culminating in the unstable approach.

At 0204:56, the controller issued SWA1713 a clearance for the approach. SWA1713 replied that they had the field in sight, and at 0205:04, the controller cleared them for the visual approach. Immediately after SWA1713 acknowledged, the controller issued a 160-degree heading to SWA1455 (0205:10).

As we can see from the radar data included in the investigation, this placed the aircraft on an intercept less than eight miles from the runway. The controller had placed them in a compressed situation. The turn took away approximately six miles of distance to maneuver, slow the aircraft down, and descend. The controller also added that same amount of miles to his separation between SWA1455 and EJA278. The speed adjustment was obviously no longer necessary.

Over the next minute, the controller issued instructions to another arrival to Van Nuys, as well as a departure. He then returned to SWA1455 and asked if he would like the visual (0205:56) and called out the position of the company aircraft. If SWA1455 had said unable at this time, the controller would have been forced to make some drastic adjustments to his traffic.

To achieve the intercept heading required by the FAA Handbook from SWA1455's heading would not have been possible since he was already heading straight for the final approach gate. The final approach gate, as defined in the Pilot Controller Glossary (*Attachment 4*), is: "...along the Final Approach Course 1 mile from the outer marker ... on the side away from the airport...." In this case, the outer marker was 6.1 miles from the runway; therefore, the Final Approach Gate was 7.1 miles from the runway. The turn to final was made with a maximum twenty-degree turn when the interception point was within two miles from the Final Approach Gate, or thirty degrees when more than two miles away.

During the interview (ATC3 Group Chairman's Factual Report, Page 6), the controller was asked what would he do if the visual approach did not work, and he stated that he was "setting 1455 up for the ILS." There seems to be some disparity between the controller's statement and the evidence presented by the radar presentation. It is also interesting to note that he stated earlier in his interview (ATC3 Group Chairman's Factual Report, Page 5) that he "then started to descend 1455 down to 3000 feet on an 11-12 mile base...." The radar data contained in the report shows this not to be true. This begs the question: "Did he really think SWA1455 was on a '11-12 mile base' or is it indicative of a lack of attention to detail?"

At 0209:38 the controller instructs SWA1455 to contact the tower. This is after the aircraft overshot the final approach course. In his interview, he did not recall seeing the aircraft overshoot (ATC3 Group Chairman's Factual Report, Page 5).

ATC Conclusions

An analysis of the ATC transcripts, radar data, and controller interviews reveals that SWA1455 was provided speed adjustments and vectors to the final approach course that precipitated the unstable approach. The analysis also shows that the controller had demonstrated previous instances of late and rushed clearances that resulted in improper vectors. The controller was dealing with a light traffic load at the time of the event. The controller did not follow prescribed procedures for runway intercept angles and erred in judgement by assuming SWA1455 would be able to make a visual approach, thus circumventing his responsibility to establish the flight on the approach path sufficiently outside the final approach gate, per ATC procedures.

It is apparent, given all the information, that the crew of SWA1455 was put into a compressed situation, *unnecessarily.* As stated before, unstable approaches are normally not caused by crew actions within the last 1000 feet of an approach. This is a classic case where actions that occurred 15 to 20 miles from the airport resulted in the aircraft being positioned to a point where a stabilized approach could not be properly executed.

The overhead radar data depiction of aircraft approach paths to Runway 8 at Burbank perfectly demonstrates this fact. The flight path and runway intercept angle of SWA1455 was significantly different than other aircraft making this approach.

As in any accident scenario, multiple factors contribute to the occurrence of an accident. Eliminating the precursors to the events will reduce the potential for accidents to occur. In light of this, the ATC contribution to this event should not be ignored.

Human Factors Issues

A review of pilot testimony, FDR, 72-hour history, and ATC information indicated that the accident flight crew experienced a routine flight until they accepted a visual approach clearance to BUR. Significant human performance events occurred during this final flight segment.

Human Performance Analysis – Captain

The captain was highly experienced with the B-737 and BUR operations. No health or personal factors contributed to the accident. He was well regarded and respected by his immediate supervisor. He was highly rated by his previously paired first officers. Company management knew of no history of performance or personality problems. The captain reported that he did not feel pressured by the company to rush or make up time for being behind on the schedule.

While a number of factors and events made this flight atypical of a normal LAS-BUR leg, no events of the early flight segments contributed directly to the accident. Also, there were no problems or events earlier in the flight that indicated CRM problems or contributed to decision errors made during the final flight segment.

A number of events, conditions, and factors contributed to an acceleration of flight events from the point where the captain accepted the visual clearance for runway 8 at BUR. During this final flight segment, the captain made a series of decisions that culminated in an unstabilized approach, over-speed landing, and ground collision with obstructions beyond the end of the runway. While none of these accelerating factors was individually enough to cause the accident, collectively, they contributed to task saturation and fixation. He missed, or misinterpreted, indications that an unacceptable flight condition was developing. As he became rushed, the captain failed to properly process or prioritize these critical aircraft parameters. As the approach progressed, the captain felt sufficiently "rewarded" since he was able to get the aircraft back on an acceptable glidepath. While he did not achieve a company-defined stabilized approach, he achieved a visual "picture" that was "familiar" and "comfortable" to him. Finally, the captain felt that he was close enough to "the slot" to warrant continuing the approach to landing.

Researchers studying decision-making in dynamic situations (Klein, G. (1993), *Naturalistic Decision-making: Implications for Design)* have suggested that experienced persons can quickly make decisions based on patterns that match with familiar past experience. The referenced text refers to this characteristic as recognition primed decision-making. According to this model, the decision-maker makes a rapid assessment of the situation and almost immediately selects a decision path and an outcome. Simply stated, when things are getting busy or confused, people tend to match the picture they see with pictures they have seen before. They take actions that will bring them from where they are to where they want to be. This decision-making technique is more common when the decision-maker is experienced, when time pressure is greater, and when conditions are less stable or nonstandard.

Recognition primed decision-making is normally a very successful way to quickly select accurate courses of action. It, however, presents risks to the decision-maker if the initial assessment of the situation is incorrect or if the situation changes sufficiently. In these cases, the decision-maker is reluctant to reconsider the initial decision. Instead, he or she continues to adapt their actions to make the original decision path work. In effect, they are reluctant to recognize their error. They try to force a square peg into a round hole.

Many features of this accident support the scenario of a recognition primed decision-making error by the captain. The three conditions introduced in the previous paragraph were profoundly present. First, the captain was very experienced and comfortable with the situation he perceived. He was not only extremely experienced in the B-737; he was extremely experienced with landing at BUR. In fact, he had been landing regularly at BUR for 20 years. Second, there was significant time pressure. Not only were there many factors accelerating his pacing in the final two minutes, his pacing accelerated faster and faster until the ground collision. Third, the conditions, starting from early that afternoon, were atypical. The crew experienced numerous nonstandard events from the beginning of the trip sequence. Some of these include a two-hour late departure, heavier than normal weight for the flight segment, departure off of runway 19L at LAS, windshear reports on departure, weather avoidance, turbulence, and a tighter-than-normal ATC arrival pattern at BUR. While none of these events was individually difficult or cumbersome, they all contributed to an underlying mood of nonstandardness of the flight.

Psychologically, the mood of nonstandardness can affect pilots in several ways. The increased stress level can initially improve performance by increasing task vigilance. Conversely, it can degrade performance by increasing the time and attention spent on distractions. Therefore, given the three influences, and resultant psychological impact, it is likely that the captain would tend to rely on past recognition paths.

The acceleration of events begins at the point where the crew acquired the BUR ATIS. ATIS OSCAR introduced a significant complicating factor to the flight. Significant west surface winds in BUR are very rare. Typically, BUR surface winds are southeasterly or light. This crew discussed the option of landing on runway 26, but selected runway 33 because it was more familiar.

The dusk lighting conditions may have further complicated the approach. The crew reported that they were not concerned with the lighting conditions at the time of landing. If they had gone around, the lighting level at their next landing opportunity would have been darker.

Next, ATC assigned them a shorter-than-normal vector pattern directly south toward VNY to facilitate their sequence between two other arriving aircraft. Typically, ATC vectors aircraft on a southeasterly dogleg to intercept final outside of VNY (See ATC discussion above). The profile was already busy when ATIS PAPA was released. PAPA significantly changed the surface wind report, cloud cover, and the landing runway. Now, instead of the nonstandard 26 or 33 arrival, they are given an arrival to runway 8 with a slight tailwind. In addition to the tight vector, ATC assigned a minimum speed of 230kts or greater. There is no evidence that ATC ever released them of this speed restriction, aside from clearing them for a visual approach.

It is apparent from the ATC Tracon Woodland Radar Position Transcript that the intention of the controller was to position SWA1455 for an ILS approach with the idea that a visual approach would be assigned. For this, the crew needed to acquire visual contact with the preceding company flight, SWA1713 (at a minimum). As they cleared a scattered to broken cloud layer, the captain acquired SWA1713 and the field. He accepted the visual approach. At this point, the captain's options had shifted from the "unfamiliar" visual circling approach to 33 to the very familiar straight-in approach to 8. This late change effectively rewarded the captain with a familiar recognition path option. What he saw at this point was something he had seen numerous times before - a visual approach to runway 8 from 3000' over VNY.

As the captain made his turn to final, his testimony supports that he made a visual assessment of his position. He determined that he "was faster than [he] wished to be." He deployed the speed brakes and called for flaps 5. He knew that he had excess altitude and speed energy. He determined that he needed to increase his drag and took the appropriate steps.

Throughout his approach, he relied on perceptual assessments of aircraft energy-state. He did not report using FMC profile computations, mathematical descent rules-of-thumb, or speed/glideslope comparisons. Instead, he relied on a visual assessment of his position and speed. Throughout the approach, he accurately assessed that he was high and fast. He did not accurately recall the magnitude of the excess speed.

ATC normally imposes an additional visual approach requirement for BUR aircraft by directing them to maintain 3000' until over VNY. Under normal conditions, this restriction forces BUR arrival aircraft to start their descent from a point about a dot or more high on glidepath. The captain expressed concern for general aviation traffic in the VNY pattern. Thus, it is reasonable to assume that the captain's recognition path of a typical visual arrival to BUR starts out higher than the normal glideslope, until passing VNY. At this point, things started to look wrong to him. He saw that he was losing his "picture." He recalled checking the FMC readout and seeing the 20kt tailwind component. This explained why his approach was getting "higher." He successfully detected the shift in his picture, but he discovered why and took corrective measures. He expected his actions to restore his original recognition path, so he continued.

He felt that his original recognition picture was still valid. It was the tailwind that was causing the rapidly steepening approach angle. He took additional steps to increase his drag calling for gear down and flaps 15. Seeing his approach angle steepening further, he pushed the nose over and dramatically increased his sink rate. He reported wanting to "get out of the tailwind." He was solving his glidepath problem by steepening his descent angle. He rapidly called for flaps 25, 30, and 40 – expecting that the increased drag would solve his airspeed problem. At this point, he felt that he had detected and responded to both of his airspeed and altitude problems.

Testimony of his mental prioritization further supports his recognition path. Departing 3000', he stated that his highest priority was his altitude (approach angle). He also expressed his desire to "get out of the tailwind" by increasing his descent angle and sink rate. He reported that his desire to solve his altitude problem remained his primary concern until he was on short final. At this point, he focused on the landing. His airspeed was never a top priority. This prioritization is consistent with recognition primed decision-making. The captain wanted to make the "picture" look right. To make the picture look right, he needed to solve his altitude/glidepath problem. He probably assumed that the airspeed problem would be solved through configuration drag and low power setting.

As events accelerated, the captain missed or devalued significant approach variables. Through his testimony, it was clear that he was very aware of his altitude and the tailwind. He was also aware that his airspeed was high, but did not recall particular values. Again, his priority was to match the desired approach visual picture, not the desired approach energy-state. While his aircraft weight was significantly greater than normal, there was no evidence that he considered the weight effects on his overall energy state (heavy aircraft decelerate more slowly due to effects of momentum). Additionally, he failed to consider that "getting out of the tailwind" would result in an increase in indicated airspeed. This airspeed increase would prevent flap deployment to 40. This is due to an automatic blow-up feature that limits actual flap position to 30 until speed decreases. This condition further worsened his energy-state.

There was also a significant factor of distraction. As they continued their approach, they were gaining rapidly on SWA1713. The captain reported that SWA1713 was a strong priority to them while they were on final approach. It remained a strong priority until the aircraft cleared the runway. At this point, the captain recalled that they were probably inside 500'. Since this distraction was outside of the cockpit, he was more likely to miss specific parameters that were displayed on gauges. This is consistent with his inability to recall specific speeds on final.

Aside from a momentary consideration to break-off his approach and circle to runway 33, the captain never reconsidered his initial decision to land on 8. There is little doubt that had he been unable to regain an acceptable glidepath, the captain would have executed a go-around.

This scenario is further supported by his testimony that he never felt the approach was unmanageable. This process continued through touchdown and until the aircraft entered a skid before impacting the blast wall. From his testimony, the captain felt that he could stop the aircraft up to this point. This is also consistent with his recognition path. Once committed to his recognition path, he was reluctant to discard it as long as he "thought he could make it."

The captain's airspeed awareness was low. While he recalled that his speed was excessive, he was visibly shocked to learn that his actual touchdown speed was 181kts.

The captain felt that he was allowed some latitude in dealing with out-of-parameter conditions. He recalled the Ground Proximity System warnings for excessive sink rate, but viewed them as informative in VMC conditions. Thus, he did not immediately act to correct the sink rate. He recalled the parameters for being "in the slot." He stated that he met all slot requirements, except airspeed. He felt that the airspeed deviation did not necessitate a go-around.

The captain lost situational awareness during the descent to land. Moreover, he did not realize that he had lost situational awareness. He did not recall whether he ever achieved flaps 40. He underestimated his touchdown speed by at least 25 knots.

Human Performance Analysis – First Officer

Like the captain, the first officer was very experienced and comfortable with the B-737 and the BUR arrival. All of his previous three captains rated him as an above average first officer. They considered him well skilled and professional. There were no significant events in his 72-hour history that affected this accident.

The first officer stated that he was very comfortable flying with this captain. Additionally, he felt no intimidation by the captain. He felt free to make CRM inputs and believed that the captain would respond to his inputs.

Many of the same recognition path errors occurred with the first officer. It was apparent from his testimony that he also relied heavily on visual cues and references while flying in VMC conditions. As the pilot-not-flying (PNF), there were several additional factors that contributed to his part in this accident.

A significant factor in this flight was the first officer's comfort level. In testimony, he stated that he was never uncomfortable with the approach or landing until abeam the company gates. At this point, he thought that they might not stop and he joined the captain on the brakes. This high comfort level helps explain why he did not voice any objections to this approach.

Another significant factor was the first officer's viewpoint. There is evidence to support that the first officer strongly empathized with the captain's decision choices. Two of his three previous captains reported that they had had conversations with the first officer concerning captain upgrade. Each had made comments that the first officer was learning to think like a captain. Aspects of his testimony seem to support that he was well aware of the approach problems, but agreed with the captain's actions to correct the problems. From his testimony, he projected a willingness to "think like his captain." His actions supported his willingness to help the captain make the approach work.

The first officer's interpretation of his PNF role was pivotal to this accident. From his testimony, it is clear that he felt his PNF role was to detect information that the captain missed and to alert him to it. He was questioned extensively about his failure to make required deviation call-outs. He stated that the call-outs were unnecessary because the captain was well aware of the deviations and was taking corrective measures. He could tell that the captain was task-saturated with flying the approach, so he focused his attention on additional considerations that he thought the captain might miss. While he was concerned about the steep approach, he felt that the captain was taking adequate corrective measures.

During the descent on final, his highest priorities were the landing clearance and ensuring that the previous company flight cleared the runway. He queried the captain about the landing clearance and then confirmed it with BUR Tower. He continued to watch SWA1713 to ensure that they cleared the runway. As SWA1713 cleared the runway, he recalls that the captain was about to land.

The first officer seemed situationally aware of the captain's level of task saturation. He knew that events were moving quickly. He appeared to mentally divide the necessary landing tasks between himself and the captain. He seemed to consciously omit or streamline items that he considered less important. He realized that the calls were required, but apparently omitted them as either a task prioritization choice or through his own task saturation. He knew that he did not read the Final Descent checklist, but he visually confirmed "5 green lights". It was not clear whether he omitted the checklist because he was task saturated, or because he did not wish to add further burden to the captain's task load.

Like the captain, the first officer relied heavily on a visual perception of approach parameters. After setting the flaps to 40 and alerting the captain to the flap limit speed, his attention was highly focused on the runway environment. His testimony made many references to how the approach "looked." His recall of the airspeed was limited. His priority was on seeing the previous company flight clear the runway and seeing that the final approach segment "looked right."

He did not consider directing a go-around. In his opinion, the approach never reached a point where it "looked unmanageable." He did not personally use numerical go-around parameters. Instead, he relied on a positional or visual assessment of the need to make a go-around. From his testimony, it is clear that this decision centered on a visual assessment of his relative relationship to the glideslope. Airspeed considerations were secondary.

CRM Issues

The first officer recalled that the captain gave a flight crew briefing prior to the flight. The company does not script items to be covered in this briefing. He did not recall the captain's exact briefing items, but he did recall that it covered all of the typical items he was accustomed to hearing. He was not reluctant to speak up in the cockpit. He felt that the captain would have been receptive to his input.

A paradox of lost situational awareness is that it is difficult for a pilot who has lost situational awareness to realize that he has lost situational awareness. To counteract this, we rely on CRM calls and company call-outs by the PNF to alert the PF of critical parameter deviations. In this case, the first officer decided that the captain knew what was happening and did not need to be alerted. As the captain became fixated on his visual recognition path, he stopped monitoring his airspeed. Deviation calls from the first officer probably would have benefited the captain.

The interpretation of slot requirements varied somewhat across the airline. Company management officers generally viewed slot requirements as directive, while allowing for some reasonable judgment. Pilot interviews seemed to agree with this, but there was some variation in what was considered an acceptable airspeed and power setting. Everyone seemed to agree on configuration and glideslope requirements. The accident crew knew the slot requirements, but treated the parameters as informative. They felt the ultimate landing/go-around decision was at the captain's discretion.

Pilot testimony and lack of cockpit communication during this final approach segment support the conclusion that little verbal communication occurred between the pilots.

Human Performance Factual Findings

The captain and the first officer underestimated the aircraft's energy state. The combination of speed, altitude, tailwind, and weight gave them more energy than they could reasonably dissipate to make a stabilized approach and safe landing.

The recognition path that the captain selected was complicated by the tight approach vector by ATC, the 20-knot tailwind on final, and the high aircraft weight. All of these factors intensified their condition.

Both the captain and the first officer failed to recognize that the excessive airspeed invalidated the underlying assumptions of their recognition path. They continued to force the original solution they chose as they departed 3000'. Neither pilot reconsidered the decision to land.

Neither had a personal go-around threshold based on airspeed. Both pilots based their go-around threshold primarily on a visual assessment of altitude and glideslope.

Human Factor Conclusions

This accident was a decision-making and performance failure of two very experienced, respected, capable, and comfortable line pilots. They had enjoyed so many years of flying success that they failed to consider a situation where they could fail. They saw that they were high and fast, but they had been high and fast before. The picture they saw was one they had both seen before and solved before. The descent angle was visually "something they could handle," but not at their speed, weight, and configuration. They underestimated the effects of speed and failed to factor the effects of the aircraft weight, a 20-knot tailwind, and a short runway with no overrun.

In many ways, this was the perfect scenario to produce failure. Initially, it is understandable that they decided to continue the approach. At every critical decision-point, something happened to reward the crew and encourage them to continue the approach. The rewards start when the landing runway was changed from a non-standard 26/33 to the familiar 8/15. Following this, the crew broke through the weather and visually acquired the runway and the preceding aircraft. Events seemed to be falling into place – another reward. When the captain detected the steepening approach, he discovered the tailwind, and increased his drag to compensate. He detected the trend, discovered the source of the problem, and took corrective action. Next, he was concerned by the steep glidepath, so he increased the descent angle. He was rewarded with an improving visual picture. Next, he was concerned with his tight spacing on the preceding flight. As the flight cleared the runway, he was rewarded by the resolution of that problem. These rewards continued to draw the crew toward a landing decision. At no point, did the captain seriously reconsider his decision to land.

The more critical question is why did they not go around? One explanation is that they had unshakable faith in the aircraft and confidence in their abilities to fly it. In this case, due to short-term task saturation, fixation, narrowed attention focus, surprise, startle-reflex, and wishful thinking, they failed.

The critical decision point in this approach was the point when SWA1713 cleared the runway. If SWA1713 had not cleared, they would certainly have gone around. With SWA1713 clear, there is the first clear opportunity to reconsider the landing decision. At this point, they both reported that the approach was still "manageable." Testimony supports that this decision was based on a visual assessment of approach parameters. Neither pilot recalled instrument parameters from this point on.

There are two historically common features of landing accidents. First, accident crews are distracted by a particular problem that is eventually resolved. As this distracting problem is resolved, it creates a perception that all problems are resolved. If this occurs while the crew is task saturated or situationally disoriented, they will more likely fail to detect critical errors. SWA1713 clearing the runway is exactly this sort of "false problem resolution." Second, pilots perceive that a successful landing effectively negates approach errors. With their goal immediately achievable, the crew is more likely to minimize their assessment of other out-of-tolerance parameters. The common availability of long runways rewards this thinking. If this had been an 8000' runway, the crew could have landed long, slowed normally, and cleared at the end. The short runway and lack of overruns at BUR eliminates this option. The crew was not specifically asked this question, but this mindset is reflected in their assessments that the approach was manageable.

Lastly, the overall goal of CRM was lost. Instead of two pilots backing each other up, these two pilots were operating in perfect unison. They were "on the same sheet of music" and in perfect agreement. Consequently, they each made exactly the same mistakes and errors. Had the pilot-not-flying made required call-outs, despite his agreement with the pilot-flying's actions, the pilot-flying would have been cued to reassess his decision to land.

Probable Cause

The probable cause was a failure of the flight crew to detect a steep and fast approach created by substandard TRACON approach vectors and tailwinds at altitude. The flight crew became task-saturated, failed to achieve prescribed "in the Slot" criteria, and elected to continue the approach resulting in an overspeed touchdown, overrun of the available runway, and ground collision with airport obstructions.

Recommendations

1. This event should provide an appropriate example for controllers regarding how not following proper procedures could contribute to an unstable approach. Just as it is important for pilots to understand how not to get setup for an unstable approach, controllers should also receive training on how not to place aircraft in improper flight paths and profiles.

2. Crew Resource Management (CRM) training should teach crewmembers the "red flags" that pilots may exhibit when their distraction is such that all situational awareness disappears. Both the captain and the first officer relied primarily on a visual perception of the aircraft energy state. Both crew members' recognition paths led them to believe that the speed would bleed-off sufficiently for a safe landing if only they could get to a proper glidepath. The captain and the first officer minimized the effects of speed on energy state. Both pilots, but especially the captain, lost situational awareness.

3. Parameters for an unstable approach should be adequately defined. Criteria for making a missed approach should be specified in the Flight Manuals.

4. The FAA should implement and continue to support protective regulatory initiatives to ensure that voluntary safety reporting programs like ASAP and FOQA are implemented at all U.S. Airlines. This includes regulatory guidance regarding enforcement prohibition for participation and support of industry safety data sharing efforts.

Attachment 1

Section 9. Radar Arrivals

5-9-1. VECTORS TO FINAL APPROACH COURSE

Except as provided in para 7-4-2, Vectors for Visual Approach, vector arriving aircraft to intercept the final approach course:

a. At least 2 miles outside the approach gate unless one of the following exists:

1. When the reported ceiling is at least 500 feet above the MVA/MIA and the visibility is at least 3 miles (report may be a PIREP if no weather is reported for the airport), aircraft may be vectored to intercept the final approach course closer than 2 miles outside the approach gate but no closer than the approach gate.

2. If specifically requested by the pilot, aircraft may be vectored to intercept the final approach course inside the approach gate but no closer than the final approach fix.

b. For a precision approach, at an altitude not above the glideslope/glidepath or below the minimum glideslope intercept altitude specified on the approach procedure chart.

c. For a nonprecision approach, at an altitude which will allow descent in accordance with the published procedure.

NOTE-
A pilot request for an "evaluation approach," or a "coupled approach," or use of a similar term, indicates the pilot desires the application of subparas a and b.

d. *EN ROUTE.* The following provisions are required before an aircraft may be vectored to the final approach course:

1. The approach gate and a line (solid or broken), depicting the final approach course starting at or passing through the approach gate and extending away from the airport, be displayed on the radar scope; for a precision approach, the line length shall extend at least the maximum range of the localizer; for a nonprecision approach, the line length shall extend at least 10NM outside the approach gate; and

2. The maximum range selected on the radar display is 150 NM; or

3. An adjacent radar display is set at 125 NM or less, configured for the approach in use, and is utilized for the vector to the final approach course.

4. If unable to comply with subparas 1, 2, or 3 above, issue the clearance in accordance with para 4-8-1, Approach Clearance.

REFERENCE-
FAAO 7110.65, Approach Clearance, Para 4-8-1.
FAAO 7110.65, Final Approach Course Interception, Para 5-9-2.

5-9-2. FINAL APPROACH COURSE INTERCEPTION

a. Assign headings that will permit final approach course interception on a track that does not exceed the interception angles specified in the TBL 5-9-1.

TBL 5-9-1

Approach Course Interception Angle

Distance from interception point to approach gate	*Maximum interception angle*
Less than 2 miles or triple simultaneous ILS/MLS approaches in use	20 degrees
2 miles or more	30 degrees (45 degrees for helicopters)

b. If deviations from the final approach course are observed after initial course interception, apply the following:

1. Outside the approach gate: apply procedures in accordance with subpara a, if necessary, vector the aircraft for another approach.

2. Inside the approach gate: inform the pilot of the aircraft's position and ask intentions.

PHRASEOLOGY-
(Ident) (distance) MILE(S) FROM THE AIRPORT, (distance) MILE(S) RIGHT/LEFT OF COURSE, SAY INTENTIONS.

NOTE-
The intent is to provide for a track course intercept angle judged by the controller to be no greater than specified by this procedure.

REFERENCE-
FAAO 7110.65, Chapter 5, Section 9, Radar Arrivals, and Section 10, Radar Approaches- Terminal.

c. *EN ROUTE.* When using a radar scope range above 125 NM, the controller shall solicit and receive a pilot report that the aircraft is established on the final approach course. If the pilot has not reported established by the final approach gate, inform the pilot of his/her observed position and ask intentions.

NOTE-
It may be difficult to accurately determine small distances when using very large range settings.

Attachment 2

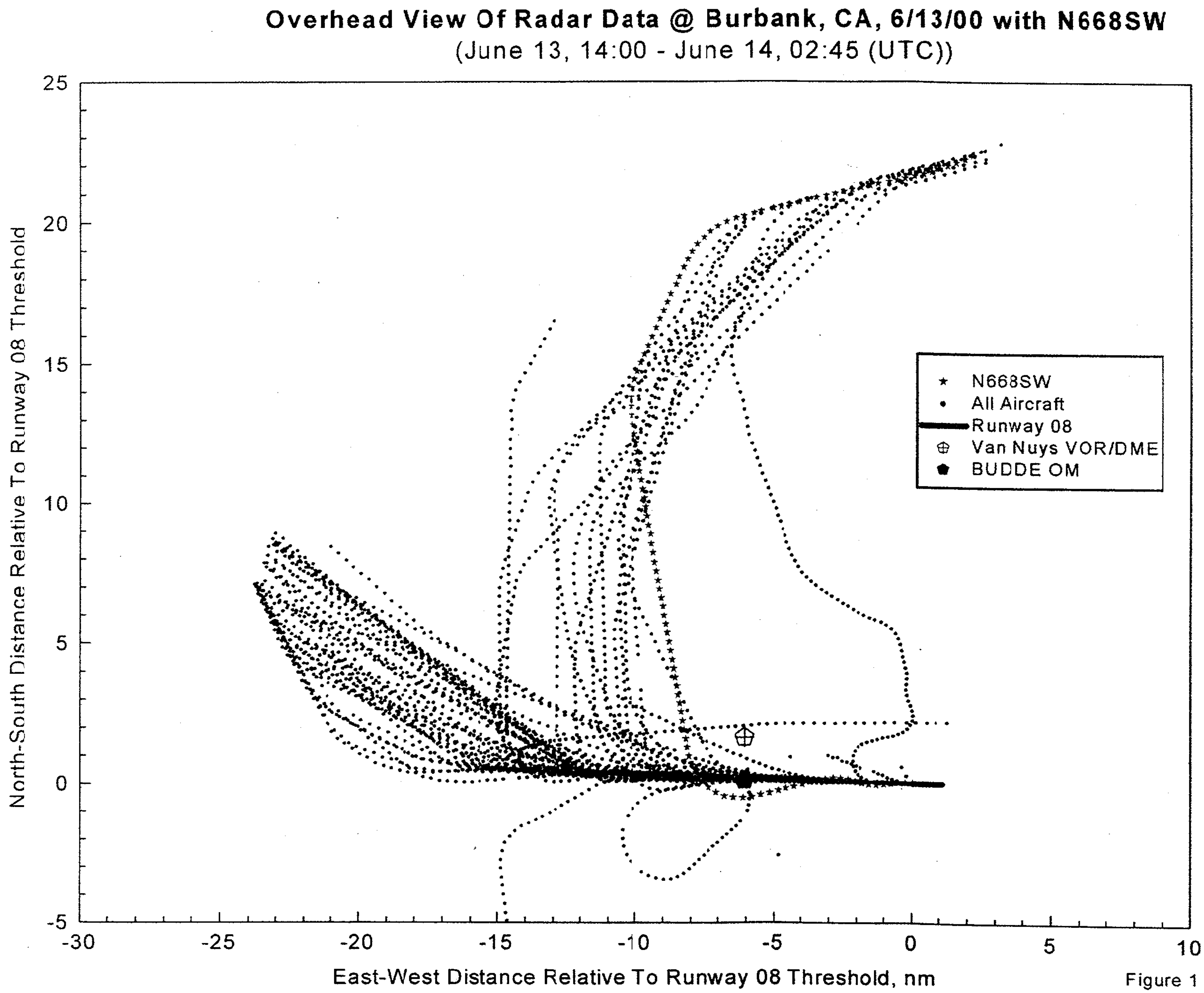

Figure 1

Attachment 3

Section 7. Speed Adjustment

5-7-1. APPLICATION

Keep speed adjustments to the minimum necessary to achieve or maintain required or desired spacing. Avoid adjustments requiring alternate decreases and increases. Permit pilots to resume normal speed when previously specified adjustments are no longer needed.

NOTE-

It is the pilot's responsibility and prerogative to refuse speed adjustment that he/she considers excessive or contrary to the aircraft's operating specifications.

a. Consider the following when applying speed control:

1. Determine the interval required and the point at which the interval is to be accomplished.

2. Implement speed adjustment based on the following principles.

(a) Priority of speed adjustment instructions is determined by the relative speed and position of the aircraft involved and the spacing requirement.

(b) Speed adjustments are not achieved instantaneously. Aircraft configuration, altitudes, and speed determine the time and distance required to accomplish the adjustment.

3. Use the following techniques in speed control situations:

(a) Compensate for compression when assigning air speed adjustment in an in-trail situation by using one of the following techniques:

(1) Reduce the trailing aircraft first.

(2) Increase the leading aircraft first.

(b) Assign a specific airspeed if required to maintain spacing.

(c) Allow increased time and distance to achieve speed adjustments in the following situations:

(1) Higher altitudes.

(2) Greater speed.

(3) Clean configurations.

(d) Ensure that aircraft are allowed to operate in a clean configuration as long as circumstances permit.

(e) Keep the number of speed adjustments per aircraft to the minimum required to achieve and maintain spacing.

b. Do not assign speed adjustment to aircraft:

1. At or above FL 390 without pilot consent.

2. Executing a published high altitude instrument approach procedure.

3. In a holding pattern.

REFERENCE-
FAAO 7110.65, Holding Instructions, Para 4-6-4.

4. Inside the final approach fix on final or a point 5 miles from the runway, whichever is closer to the runway.

c. At the time approach clearance is issued, previously issued speed adjustments shall be restated if required.

d. Approach clearances cancel any previously assigned speed adjustment. Pilots are expected to make their own speed adjustments to complete the approach unless the adjustments are restated.

e. Express speed adjustments in terms of knots based on indicated airspeed (IAS) in 10-knot increments. At or above FL 240, speeds may be expressed in terms of Mach numbers in 0.01 increments for turbojet aircraft with Mach meters (i.e., Mach 0.69, 0.70, 0.71, etc.).

NOTE-
1. *Pilots complying with speed adjustment instructions should maintain a speed within plus or minus 10 knots or 0.02 Mach number of the specified speed.*

2. *When assigning speeds to achieve spacing between aircraft at different altitudes, consider that ground speed may vary with altitude. Further speed adjustment may be necessary to attain the desired spacing.*

REFERENCE-
FAAO 7110.65, Methods, Para 5-7-2.

5-7-2. METHODS

a. Instruct aircraft to:

1. Maintain present/specific speed.

2. Maintain specified speed or greater/less.

3. Maintain the highest/lowest practical speed.

4. Increase or reduce to a specified speed or by a specified number of knots.

PHRASEOLOGY-
SAY AIRSPEED.

SAY MACH NUMBER.

ALTERNATE AIRPORT- An airport at which an aircraft may land if a landing at the intended airport becomes inadvisable.

(See ICAO term ALTERNATE AERODROME.)

ALTIMETER SETTING- The barometric pressure reading used to adjust a pressure altimeter for variations in existing atmospheric pressure or to the standard altimeter setting (29.92.)

(Refer to FAR Part 91.)

(Refer to AIM.)

ALTITUDE- The height of a level, point, or object measured in feet Above Ground Level (AGL) or from Mean Sea Level (MSL.)

(See FLIGHT LEVEL.)

a. MSL Altitude- Altitude expressed in feet measured from mean sea level.

b. AGL Altitude- Altitude expressed in feet measured above ground level.

c. Indicated Altitude- The altitude as shown by an altimeter. On a pressure or barometric altimeter it is altitude as shown uncorrected for instrument error and uncompensated for variation from standard atmospheric conditions.

(See ICAO term ALTITUDE.)

ALTITUDE [ICAO]- The vertical distance of a level, a point or an object considered as a point, measured from mean sea level (MSL.)

ALTITUDE READOUT- An aircraft's altitude, transmitted via the Mode C transponder feature, that is visually displayed in 100-foot increments on a radar scope having readout capability.

(See AUTOMATED RADAR TERMINAL SYSTEMS.)

(See NAS STAGE A.)

(See ALPHANUMERIC DISPLAY.)

(Refer to AIM.)

ALTITUDE RESERVATION- Airspace utilization under prescribed conditions normally employed for the mass movement of aircraft or other special user requirements which cannot otherwise be accomplished. ALTRV's are approved by the appropriate FAA facility.

(See AIR TRAFFIC CONTROL SYSTEM COMMAND CENTER.)

ALTITUDE RESTRICTION- An altitude or altitudes, stated in the order flown, which are to be maintained until reaching a specific point or time. Altitude restrictions may be issued by ATC due to traffic, terrain, or other airspace considerations.

ALTITUDE RESTRICTIONS ARE CANCELED- Adherence to previously imposed altitude restrictions is no longer required during a climb or descent.

ALTRV-

(See ALTITUDE RESERVATION.)

AMVER-

(See AUTOMATED MUTUAL-ASSISTANCE VESSEL RESCUE SYSTEM.)

APPROACH CLEARANCE- Authorization by ATC for a pilot to conduct an instrument approach. The type of instrument approach for which a clearance and other pertinent information is provided in the approach clearance when required.

(See INSTRUMENT APPROACH PROCEDURE.)

(See CLEARED APPROACH.)

(Refer to AIM and FAR Part 91.)

APPROACH CONTROL FACILITY- A terminal ATC facility that provides approach control service in a terminal area.

(See APPROACH CONTROL SERVICE.)

(See RADAR APPROACH CONTROL FACILITY.)

APPROACH CONTROL SERVICE- Air traffic control service provided by an approach control facility for arriving and departing VFR/IFR aircraft and, on occasion, en route aircraft. At some airports not served by an approach control facility, the ARTCC provides limited approach control service.

(Refer to AIM.)

(See ICAO term APPROACH CONTROL SERVICE.)

APPROACH CONTROL SERVICE [ICAO]- Air traffic control service for arriving or departing controlled flights.

APPROACH GATE- An imaginary point used within ATC as a basis for vectoring aircraft to the final approach course. The gate will be established along the final approach course 1 mile from the outer marker (or the fix used in lieu of the outer marker) on the side away from the airport for precision approaches and 1 mile from the final approach fix on the side away from the airport for nonprecision approaches. In either case when measured along the final approach course, the gate will be no closer than 5 miles from the landing threshold.

APPROACH LIGHT SYSTEM-

(See AIRPORT LIGHTING.)

Per your request, I have examined the circumstances of flight 1455 and offer the following analysis and opinions. My opinions are based on (1) interviews with both the captain and first officer, (2) SWA Flight Operations Manual, (3) various materials from the SWA investigation, (4) SWA's 2000 CRM program, (5) discussions with several SWA pilots, and (6) review of other information.

To surface the root causes of any accident, it is necessary go well beyond a superficial analysis of what happened. Determining what happened is relatively easy. To get at the root causes it is necessary to determine why the various events and actions occurred.

In the following analysis, I have separated the "what happened" items from the "why did it happen" items. You will find the significant "what happened" items listed in Part I by Roman numerals I through V. The "why did it happen " items are listed under the Roman numerals as letter and numbered items.

In Part II, I have identified some of the common elements of the accident, and reexamined the training deficiencies in more depth than Part I.

In part III, I have offered my opinion regarding the probable cause of the accident.

In Part IV, I have listed a number of reasons why the crew should not be sanctioned.

PART I – ACCIDENT ANALYSIS

I The aircraft was in too high an energy state when it passed Van Nuys at 3000 feet.

A The dispatch selected alternate of LAS unnecessarily increased the gross weight by at least 3000 pounds.

B SWA's CRM program did not adequately train the crew when to conduct a briefing or how to make an effective briefing.

C SWA's CRM program does not contain adequate information about effective thought patterns (attitudes).

D The crew was not trained how to make an energy efficient approach or what the outside limitations of such an approach should be.

E. The aircraft maintained too high a speed prior to localizer intercept.

1) ATC directed the flight to maintain 230 knots or greater but never cancelled the restriction.
2) Crew was distracted from airspeed control during the period they were attempting to find the aircraft they were following (SW1713).
3) Crew was also distracted by several weather conditions including: sun to the West, lower clouds between them and the field, and dusk conditions.

F. The ATC directed heading of 160 degrees required an 80 degree turn to intercept the localizer course.

G. The flight encountered an unanticipated and unreported tailwind in excess of 20 knots.

H ATC noticed the aircraft's ground speed was 270 knots but did not advise the crew. This information would have alerted the crew to the true energy state of the aircraft and provided the basis for calculating the increase in indicated airspeed that would occur when the tailwind decreased.

I The crew's use of the autopilot and the resulting overshoot of the localizer further distracted the crew and delayed the normal reduction of airspeed and configuration change.

J The crew complied with the 3000 feet restriction at Van Nuys in accordance with Burbank page 10-7.

II As the flight continued inside Van Nuys, the crew was placed in a rushed situation.

A. The FOM guidance on page 3.6.56 encouraged the crew to continue the approach while in the "Adjustment Area" of the approach.

B. The crew had not been adequately trained during CRM to understand human error, slips, lapses, mistakes, biases or the strategies to counteract errors.

C. The crew had not been trained during CRM to be aware of and to avoid the 3 hazardous states of attention – distraction, preoccupation and absorption (or fixation).

D. The crew had not been adequately trained during CRM to develop a cautious/wary thought and action pattern and to avoid aggressive – "can do" - attitudes.

E. The culture of SWA was to make aggressive, slam-dunk (energy, time, and cost efficient) VFR approaches to minimize time and fuel burned.

F. The captain had made this type of approach before and believed the approach would become normal as soon as he got out of the tailwind. This belief set him up for the confirmation bias.

   1) The captain was not trained to recognize that the indicated airspeed would increase as the tailwind decreased.

G. The first officer had also seen this type of approach before at SWA. Each time he mentally identified an item that needed to be accomplished, the captain made the appropriate correction or callout without any prompting from the first officer.

III <u>Several attention-focusing callouts below 1000' were not made by the F/O</u>. These callouts should have included escalating levels of concern and assertiveness regarding the speed and rate of sink.

A. The first officer was distracted by the landing aircraft (SW1713) in front of them, the transmissions to the tower and the GPWS alerts. At one time the overtake rate between SWA 1455 and SWA 1713 appeared to be more than 80 knots.

B. Because of the steep approach, the first officer was compelled to look out the window to determine if the flight path would result in a landing within the touchdown zone or if he would have to intervene in some way.

C. The first officer thought further comments about high airspeed would be redundant since he had already informed the captain of the high airspeed by pointing to the airspeed indicator when the captain requested 30 degrees of flaps. Having alerted the Captain to the airspeed problem, he focused his attention on other tasks to back up the Captain. He confirmed the landing clearance, aircraft configuration setting, and the clearing of runway by SW1713 which occurred when SWA 1455 was on short final (I understand that FAA security video cameras showed SWA 1455 touching down on runway 8 less than 20 seconds after SWA 1713 cleared runway 8). Further, the first officer knew the captain was busy and the first officer didn't want to bother the captain again as he had apparently done when he asked about the clearance to land.

   1) The first officer had not been trained to recognize the possibility that the captain could become distracted or fixated and therefore might miss or misinterpret important information.

   2) The first officer had not been adequately trained about the hazards of a resigned attitude. Experiences with other SWA captains had caused him to become accustomed to non-standard practices such as continuing the takeoff roll with the warning horn blowing, landing in windshear

conditions, and using speed brakes with the flaps extended more than 5 degrees.

3) The first officer had not been adequately trained to avoid the "let the captain do it" attitude (bystander apathy) and to communicate his independent perspective to the captain.
4) The first officer had not been adequately trained how to be assertive.
5) The first officer had not been trained to repeatedly remind the captain of critical information – such as the airspeed - that the captain might have overlooked.
6) The first officer had not been trained to recognize that the captain's abruptness was an indication of fixation.
7) The first officer had not been trained how to effectively monitor another pilot. Effective monitoring requires, among other things, that the monitoring pilot determines when and how to intervene.

IV <u>The crew did not initiate a go-around due to the high airspeed when the flight was below 500 feet AGL.</u>

A. The captain was fixated on the aircraft's flight path and the touchdown zone. The first officer was focused on the previous aircraft, as well as their own flight path and the anticipated touchdown point. Neither of them was aware of the airspeed or the vertical speed during the last 500 feet.
B. Both the captain and the first officer visually projected the aircraft to land within the touchdown zone. This visual information confirmed their previous belief that the approach would become normal as soon as they got out of the tailwind. The confirmation bias precluded any consideration of a go around.
C. The FOM (page 3.6.56) does not specify the point at which the go-around should begin. The go around language on page 3.6.56 is very loose. The "slot" itself is imprecise and subject to several interpretations. High idle thrust is considered "spooled up." (page 3.6.47)
D. The First officer has no stated authority under SWA procedures to initiate a go around in VFR conditions.
E. The large proportion of VFR approaches at SWA caused both crew members to adopt a sensory orientation instead of an analytical orientation. This orientation contributed to the fixation with the visual aspects of the approach.
F. ATC noticed the aircraft's ground speed was 210 knots when the aircraft was on a 1 1/2 mile final but did not advise the crew of this fact.

V <u>The crew was unable to stop the aircraft on the runway.</u>

A. The aircraft landed on runway 8 at an airspeed of 181 knots.
B. Neither the captain nor the first officer immediately applied maximum brake pressure.
   1) Neither crew member had been trained to exert the continuous, very heavy pressures that are necessary to achieve a minimum distance stop.

C. At approximately 900 feet from the departure end of runway 08, the aircraft began to skid – causing a reduction in the braking efficiency. The reason for the skid has not been determined.

D. At approximately 200-300 feet from the departure end of the runway, the captain attempted to extend the stopping area by turning onto a portion of the ramp. The turn also contributed to the previously mentioned skid.

   1) The captain had not been informed about the hazard of braking and turning simultaneously.

PART II - TRAINING DEFICIENCIES

The common element that emerges from the above analysis is clearly inadequate training. There are, in fact, more than 20 indications of inadequate training. These training deficiencies can be grouped into four basic areas:

1. Inadequate human factors (CRM) training at Southwest Airlines

A. Inadequate training about human error, error types, human error principles, and the underlying causes of human error.
B. Inadequate effective thought pattern (attitude) training that should have included how to avoid the well known hazardous attitudes of macho, invulnerable and resigned.
C. Inadequate briefing training that should have included the need to: (1) make an approach briefing before every approach (page 3.6.1); (2) make a thorough mental review of the situation to determine the briefing needs (i.e. – what are the risks for the particular flight); (3) tailor make the briefing to fit the unique circumstances of the situation, and (4) explicitly request feedback from the other crewmember.
D. Inadequate attention management training that should have included knowledge of the 3 known hazardous states of attention (distraction, preoccupation and fixation) as well as the counteracting skills that could have been used to avoid these hazardous states.
E. Inadequate monitoring training that should have included the requirement to determine when and how to intervene.
F. Inadequate communication training that should have included the use of clear directive communications.
G. Inadequate assertiveness training that should have included the following steps: (1) Take the initiative in expressing your professional opinion to the appropriate person in an appropriate way. (2) If appropriate, continue to follow up until the situation has been corrected. (3) If necessary, re-state the facts about the situation; disclose how it makes you feel and specify how the situation needs to be changed. (4) In extreme circumstances when the refusal of the other person places the safety of the operation in jeopardy, state the consequences in terms of action you plan to take.
H. Inadequate leadership & followership training that should have included the following points: (1) Each crewmember should strive to maintain an independent perspective and resist "groupthink". (2) Subordinate crewmembers should avoid the "let the captain do it" attitude (bystander apathy). (3) Each crewmember should be vigilant for opportunities to back up" another's attention and memory lapses. (4) Each crewmember should take the initiative to express his/her opinion. (5) Each crewmember should practice assertive communications.

2. Inadequate guidance in Southwest Airlines' Flight Operations Manual

A. The Flight Operations Manual (FOM) should have required an approach briefing before every approach. Additionally it should have required an evaluation of the current situation to determine the specific items that need to be briefed (i.e. – what are the risks for the particular flight). Examples should have been provided. The FOM should also have required the pilot making the briefing to explicitly ask for feedback from the other pilot.

B. The FOM should have contained language that instructed pilots to avoid "rushed approaches". The guidance should also have stated that during the planning phase of an approach, crews should give primary consideration to keeping each crewmember's attention within normal boundaries. That is, situations should be avoided that could lead to distraction, preoccupation, fixation or task overload.

C. The FOM should have provided specific airspeed, altitude, distance and tailwind recommendations to help crewmembers avoid situations that are too high, too fast, and too close to the landing runway.

D. Specific guidance should have been provided in the FOM to instruct crews to make an early decision to abandon marginal approaches rather than wait until the last minute.

E. The FOM should have stated that deviation callouts must be continued until the condition has been corrected.

F. The FOM should have included a section on directive communications. (i.e. – go around)

G. The FOM should specify a takeover procedure that would be used if the PF does not correct an unsafe condition after two warnings. This concept is usually called the "two challenge rule."

H. If the approach is not stabilized, the FOM should specify the precise point at which a go-around is mandatory.

I. The FOM should have specified the conditions under which a go-around should be initiated after the aircraft has landed.

J. The techniques section of the FOM should have explained the technique to accomplish a minimum distance stop. The explanation should include a caution not to attempt a turn while making a maximum effort stop.

3. Inadequate operational safety training at Southwest Airlines (special event training)

A. Because of the predominance of VFR approaches at SWA, pilots should have been trained how to make energy and time efficient approaches in a safe manner.

B. Because of the predominance of VFR approaches at SWA, pilots should have been trained, in the simulator, how to recognize and avoid too high, too fast, and too close to the runway situations.

C. Flight crews should have been trained how to make a minimum distance stop. The training should have included exposure to the very heavy foot pressure required as well as the undesirable effect of turning during heavy braking.
D. SWA pilots should have been exposed to situations in the simulator that would emphasize the benefits of discontinuing marginal approaches at an early time when multiple options are still available.
E. SWA should have verified in the simulator that all of their crews will make a go around at precisely 500 AGL if the aircraft is not stabilized.
F. SWA pilots should have received training about how to be assertive when the other pilot is flying and is fixated. This training would be similar to subtle incapacitation training but the clues would be more subtle.
G. First Officers at SWA should have been trained how to be assertive when flying with either autocratic or democratic captains.

4. **A Southwest Airlines' culture that has permitted, and even encouraged, aggressive, expedited, VFR approaches.**

A. The emphasis at SWA appears to be whether the approach can be made instead of whether it should be attempted.
B. The culture at SWA appears to emphasize cooperation with ATC under any circumstance.
C. The culture at SWA appears to overemphasize quick - 15 minute - turnarounds when the flight is delayed.
D. Many pilots at SWA have been observed taxiing at excessive speeds.
E. There appears to be a mindset at SWA to continually "press the envelope" and "remain on the edge" in order to save time and fuel.
F. Many pilots at SWA appear to have a "can do" (macho) attitude.
G. Many pilots at SWA consider a perfect approach to be one where the power is reduced to idle at 35,000 feet and remains at idle until just before 500 feet AGL.
H. Many pilots at SWA apparently believe that good pilots should continually demonstrate their ability by making aggressive VFR approaches under very challenging circumstances.

PART III - PROBABLE CAUSE

The reason for determining probable cause is to identify areas that need correction. I believe the probable cause of this accident is the following:

The probable cause of this accident is: (1) inadequate human factors (CRM) training at Southwest Airlines, (2) inadequate guidance in Southwest Flight Operations Manual, (3) inadequate operational safety training at Southwest Airlines, and (4) a Southwest Airlines' culture that has permitted, and even encouraged, aggressive, expedited, VFR approaches.

PART IV – FAA Enforcement Sanctions

I find it difficult to understand why the FAA has proposed a 365 day suspension of the crew's licenses. There are a number of reasons why this extreme punishment should be reduced.

A. The crew's errors were unintentional. Clearly, errors caused by distraction or fixation are unintentional – not reckless - and therefore do not warrant severe sanctions. While pilots occasionally violate FAA rules or company procedures, the violations are almost always unintentional. For example, it is well known that altitude deviations are not caused by either a willful intent to violate the rules or careless disregard of the rules. Altitude deviations are almost always caused by the absence of critical information – usually due to overload, distraction, or fixation. This same situation existed with flight 1455. Because of the crew's fixation on the previous aircraft and 1455's flight path relative to the touchdown zone, neither crew member was aware of the airspeed during the last portion of the approach and landing. To believe that the crew was aware of the excessive airspeed and still landed the aircraft is ludicrous. Every pilot intuitively knows that this was not the case.

B. The sanctions are not fair. Since almost all of the crew errors were caused by inadequate training at Southwest, it is not fair to place all of the blame on the crew. Fixation (or absorption, channeled attention, or tunnel vision as it is sometimes called) is well known in the aviation industry. It should never be thought of as an indication of poor piloting but rather as one of the evolutionary characteristics of all human beings. Enlightened organizations such as the Navy, USAF and many airlines recognize that fixation and distraction are to be expected and therefore have developed various procedures to ensure a safe operation even though pilots will occasionally become fixated or distracted. Southwest failed to develop the necessary procedures and guidance to ensure a safe operation during periods when their crews might become distracted or fixated. The crew should not be punished for Southwest's errors.

C. The reason for the severe sanctions is most likely improper. Some people tend to advocate increased punishment for more serious incidents or accidents. If the extensive damage to the B-737 was the reason for the extreme sanctions, it was improper. A fundamental human factors principle is to separate the error from its consequences. Any sanction should be based on the error and intent – not on the consequences of the error. While an individual may have some control over a particular error, he/she usually has little control over the consequences of the error. The converse is also true. That is, all errors, however minor in consequence, are informative. For example, in six previous such incidents at Southwest – Amarillo twice, Burbank, Dallas, Nashville and Ontario - the aircraft were not damaged. The lack of damage apparently prevented a meaningful investigation and the kind of corrective action that could have prevented this accident.

D. Unequal treatment. Runway excursions and overshoots are well-known types of incidents and accidents. I cannot think of a situation where a pilot has been had his license suspended for 365 days because of an unintentional overshoot. Again, intent is the central concept to any consideration of sanctions. In 1455, the crew was not aware of the excessive airspeed and therefore the intent to land did not constitute an action that any pilot would consider to be unsafe. Additionally, the crew of 1455 obviously did not intend for the consequences of the unknowingly fast landing to occur.

E. Progressive discipline. The concept of progressive discipline is well established in the aviation industry. The crew of 1455 did not have a single blemish on their record and therefore severe sanctions are not appropriate.

F. Safety will not be improved. While the FAA undoubtedly thinks that safety will be improved by imposing severe sanctions on the crew, it will, almost certainly, have the opposite effect. Severe sanctions send the clear message that the only problem is with the crew. The concept of "defensive attribution" allows others at Southwest to avoid accepting responsibility for this accident. The only way to improve safety and to remove the future risk of unstabilized approaches is to change the culture, procedures, human factors training and FOM guidance at southwest Airlines.

A focused effort to correct the enumerated human factor deficiencies at Southwest will not only ensure that this type of accident does not occur again but will also provide effective defenses to counter most accident situations.

Sincerely,

Captain David A. Simmon (Ret)
[redacted]
Denver, CO 80206
[redacted]