SA-428 FILE NO. 1-0007

AIRCRAFT ACCIDENT REPORT

PAN AMERICAN WORLD AIRWAYS INC
BOEING 747, N747PA
FLIGHT 845
SAN FRANCISCO, CALIFORNIA
JULY 30, 1971

ADOPTED: MAY 24, 1972

NATIONAL TRANSPORTATION SAFETY BOARD
Washington, D. C. 20591
REPORT NUMBER: NTSB-AAR-72-17

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No. NTSB-AAR-72-17	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Aircraft Accident Report pan American World Airways, Inc., Boeing 747, N747PA, Flight 845, San Francisco, California, July 30, 1971		5. Report Date May 24, 1972
		6. Performing Organization Code
7. Author(s)		8. Performing Organization Report No.
9. Performing Organization Name and Address Bureau of Aviation Safety National Transportation Safety Board Washington, D. C. 20591		10. Work Unit No. 11. Contract or Grant No.
12. Sponsoring Agency Name and Address NATIONAL TRANSPORTATION SAFETY BOARD Washington, D. C. 20591		13. Type of Report and Period Covered Aircraft Accident Report July 30, 1971 14. Sponsoring Agency Code
15. Supplementary Notes		

16. Abstract

A Pan American Boeing 747 Struck the Approach Light Structure (ALS) for Runway 19L while taking off from Runway 01R at the San Francisco International Airport. The crew continued the takeoff and, after an inflight inspection for damage, dumped fuel and returned for a landing at San Francisco. Two passengers were injured during the impact with the ALS and eight others sustained serious back injuries during the evacuation after the landing.

The aircraft had been dispatched for a departure from a closed runway and, upon changing to an open runway, the crew did not recompute the proper reference speeds for takeoff under the existing conditions.

The National Transportation Safety Board determines that the probable cause of this accident was the pilot's use of incorrect takeoff reference speeds. This resulted from a seriesofirregularities involving: (1) the collection and dissemination of airport Information; (2) aircraft dispatching; and (3) crew management and discipline; which collectively rendered ineffective the air carrier's operational control system.

17. Key Words	18. Distribution Statement
Takeoff, ALS structure, takeoff reference speeds, flap configuration, runway length, preferential runway criteria, NOTAM data, AIRAD data, ATIS information, airport restrictions, communications breakdown, aircraft evacuation	Release to Public Unlimited Distribution

19. Security Classification (of this report)	20. Security Classification (of this page)	21. No. of Pages	22. Price
UNCLASSIFIED	UNCLASSIFIED	57	

NTSB Form 1765.2 (11/70)

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SYNOPSIS

A Pan American World Airways, Boeing 747-121, N747PA, operating as Flight 845, struck the Approach Light System structure at the departure end of Runway O1R while taking off from the San Francisco International Airport on July 30, 1971, at 1529 Pacific daylight time. Flight 845 was a scheduled international passenger/cargo operation from the Los Angeles International Airport, Los Angeles, California, to Tokyo, Japan, with an intermediate stop at San Francisco. The flight departed from the gate at San Francisco at 1501 P.d.t., with 199 passengers.

Two passengers, in seats 47G and 48G, were seriously injured by parts of the Approach Light System structure which penetrated the passenger compartment and 27 other passengers were injured during the evacuation after the aircraft had landed. Eight of these passengers suffered serious back injuries. The aircraft sustained major structural damage to the fuselage and empennage and three of the four hydraulic systems were disabled.

The flightcrew continued the takeoff and then flew the aircraft for 1 hour and 42 minutes while assessing the structural damage and dumping fuel before landing on Runway 28L at the San Francisco International Airport.

After landing, the aircraft veered off the right side of Runway 28L and came to a stop in the unpaved area approximately 5,300 feet from the approach end of the runway.

The passengers and crew evacuated the aircraft using the emergency evacuation slides. Upon activation of the slides for evacuation, four of the 10 passenger slides failed to function properly and were not useable. During the evacuation the aircraft tilted slowly back onto the rear section of the fuselage. This occurred approximately 1 minute and 10 seconds after the aircraft had come to a stop, and it remained tilted until after the evacuation was completed.

The National Transportation Safety Board determines that the probable cause of this accident was the pilot's use of incorrect takeoff reference speeds. This resulted from a series of irregularities involving: (1) the collection and dissemination of airport information; (2) aircraft dispatching; and (3) crew management and discipline; which collectively rendered ineffective the air carrier's operational control system.

As a result of this investigation, the Board, on January 3, 1972, recommended that the FAA take the following actions:

"1. Review the procedures for the issuance of NOTAM and AIRAD for standardized implementation within the appropriate FAA facilities and modify the procedures to assure that information

pertinent to "Safety of Flight" is disseminated without delay.

"2. Require that V reference speed checks be included on the last checklist used immediately prior to takeoff

"3. Require the installation of runway distance markers at all civil airports where air carrier aircraft are authorized to operate.

"4. Require the use of takeoff procedures which will provide the flightcrew with time and distance reference to associate with acceleration to V_1 speed.

"5. Require manufacturers to include information in the Aircraft Flight Manual concerning the aircraft controllability and performance characteristics with the loss of any system that involves flight controls. Consideration should be given to incorporating training in such in-flight emergencies in all approved simulator programs at the earliest possible date."

On February 24, 1972, the FAA replied that:

1. They had initiated a study to reevaluate the NOTAM system. Following receipt of comments from the FAA regions and evaluation by a headquarters .team, a manual which will consolidate and standardize all information concerning NOTAM's will be developed.
2. They plan to issue an operations bulletin to all their field inspectors to ensure that airline training programs emphasize the necessity for flightcrews to assure that takeoff reference speeds include accurate resolution of all pertinent factors prior to initiating a takeoff. They also noted that PAA plans to include takeoff reference speeds on the hefore-takeoff checklist for all their aircraft.
3. Runway distance markers have been evaluated in the past and found lacking for takeoff purposes.
4. They agreed in principle with the recommendanion that flightcrews be provided with :time and distance reference to associate with acceleration to V_1 speeds. They also noted that "various segments of the industry" were ,investigating systems to monitor aircrafit takeoff performance. The FAA is following the development of these systems and their possible application to everyday operations.
5. They believe that present flight manuals and training procedures are satisfactory at this time.

In view of the difficulties experienced in transmitting the order to evacuate the aircraft to the cabin attendants and passengers, the Board further recommends that:

1. The FAA require all air carrier aircraft to be equipped with an audio and visual evacuation alarm system. This system should be capable of being activated in the cockpit and at each flight attendant's station. The alarm system should be self-powered so that interruption of the aircraft electrical systems will not [interfere with use of the evacuation alarm.

The Board found that there were several problems associated with the 'escape system installed in this aircraft. These prohlems included passenger escape slides that did not function correctly or, when they did function they were not useable. One slide failed to deploy because the trigger mechanism in the wheelwell area was damaged by impact. Another slide was dislodged from its installed position at impact. A third slide failed to deploy because the gas generator bottle was dislodged, probably due to its proximity to the impact area in the fuselage. One slide inflated properly but was blown out of position by the wind and could not be used. Considering these problems, the Board additionally recommends that:

2. The FAA review the slide pack mounting design, gas generator retention design, and

the protection of the wheelwell mounted gas generator installation. This review should be made to determine what actions can be taken to improve these components and make them more reliable.

The Board has been informed that the manufacturer **is** reviewing the design of the escape slides to determine what can be done to prevent or reduce the effect of wind on inflated slides. The Board encourages this work and wishes to reiterate its interest in the resolution of this problem.

The Board also noted that there was a difference between the life jackets supplied for passenger use and the life jackets used by the cabin attendants during the passenger briefing. Only one cabin attendant was aware of this difference. Therefore, the Board further recommends that:

3. The FAA take additional steps to ensure that all cabin crewmembers are properly informed regarding the safety equipment installed in the cabin and that the emergency equipment used for passenger demonstrations is the same **as** that provided for the passengers' use.

The Board is also concerned about the hazard offered by the displacement of ceiling panels in this aircraft. Some of these panels fell into the cabin in such a way that they could have restricted or blocked passenger attempts to escape from the cabin. The Board therefore recommends that:

4. The FAA review the criteria for the installation of these panels and effect whatever action is appropriate to improve the installation *so* that the panels will stay in position during survivable impact loads imposed on the cabin structure.

1. INVESTIGATION

1.1 History of the Flight

1.1.1 Operations

A Pan American World Airways, Boeing 747-121, N747PA, operating as Flight 845 (PA 845), struck the Runway 19L Approach Light System (ALS) structure located at the departure end of Runway O1R, while taking off from the San Francisco International Airport on July **30,** 1971, at 1529 P.d.t.[1] PA 845 was a regularly scheduled international passenger/cargo flight from Los Angeles, California, to Tokyo, Japan, with an intermediate stop and crew change at San Francisco, California. The aircraft departed from the **Los** Angeles International Airport at 1311 and arrived at the San Francisco International Airport at 1358.

The flightcrew did not check the field conditions prior *to* accepting the dispatch release or while performing their calculations for a departure from Runway 28L. They extracted the takeoff reference speeds (V speeds[2]) for a takeoff at 708,002 pounds with a 10° flap setting, from the aircraft operating manual and their interpolation indicated that those speeds were:

V_1 speed – – – – – 156 knots
V_R speed – – – – – 164 knots
V_2 speed – – – – – 171 knots

These calculations were made while the crew was in the dispatch office, and were based on a wind from 300° at 15 knots, a temperature of 66° F. (19° C.), and a barometric altimeter setting of 29.99 QNH[3].

[1] **All times are Pacific daylight time based on the 24-hour clock.**

[2] **V_1 - criticalengine-failure speed**
V_R - rotation speed
V_2 -takeoff safety speed

[3] **QNH - That value of pressure for a particular airport and time, which when set on the sub-scale of a standard altimeter, will cause the altimeter to read the height of the airport when the aircraft is at rest on the airport.**

The crew boarded the aircraft about 1430 and began their preparations for flight. The checklists were completed and the aircraft was pushed back from the gate at 1501. The first officer monitored his radios for the latest ATIS[4] information while the "Prestart" checklist was being completed. He became aware that Runway 28L was closed and that the first 1,000 feet of Runway OIR was closed also. This information was a part of ATIS "XRAY" which was valid from 1402 through 1525.

At 1511, the first officer radioed the tower for taxi clearance and the flight was cleared to taxi to Runway OIR, the preferential runway (see Appendix G) being utilized by the San Francisco Tower for all departures. The first officer, on his own volition, requested and received a clearance to Runway 28R. The captain directed the first officer to request Runway 28L and was then informed by the first officer that this runway was closed. The first officer then called the tower to verify the closure of Runway 28L.

At 1512:44, upon confirmation of the closure, the crew contacted Pan American Operations/Dispatch (PANOP), informed the flight controller that 28L was closed, and requested that he check, along with them the limitations for the use of 28R. The flight controller informed the crew that Runway 01R with clearway (see Appendix G), could be used for takeoff with a zero wind component. The flight controller had considered the possibility of using Runway OIR during the initial flight planning but opted to use 28L, the longer runway. He also stated that there was a zero wind component on Runway 01R. The crew then asked the flight controller about the status of the first 1,000 feet of Runway 01R. The flight controller replied that OIR was not restricted as far as he could tell but he would check with the tower.

The tower controller received a call from Pan American Operations concerning the closing of a portion of Runway 01R and voluntarily informed the caller that the closure would not affect the runway distance available for a B-747 takeoff. The tower controller stated that he had reference to a runway restriction[5] last issued by the San Francisco Airport Authority on February 11, 1971.

The Pan American flight controllers testified that on July 30, 1971, they were not aware of any restriction on the B-747 when using Runway 01R. Further, they were not aware that the 9,500 feet shown in the Pan American Route Manual was not available from the displaced threshold.

At 1517:09, the flight controller advised PA 845, "Talked to tower, the thousand feet they were talking about that's closed is actually overrun, you couldn't start from that point in any event because of thrust damage. Start at the painted threshold and you still have 9,500 feet plus clearway ahead of you and under those circumstances the page using 3-A power shows no takeoff limitation at your gross, over." The crew replied, "We don't have those charts in our particular manual, here, we only have the dash 3."

Additional conversation between the flightcrew and the flight controller established that to take off from Runway 01R at the planned gross weight of the aircraft would require a 20° flap setting, a 3A-Wet[6] power setting and "Clearway" computations. "Clearway" computations are maintained only in the Dispatch Office copies of the Pan American Route Manual, so the flight controller relayed the information to the flightcrew. The flaps

[4] **ATIS - Automatic Terminal Information Service a continuous broadcast of the current airport information, including weather, runways in use runways closed. and other advisory material.**

[5] ***Notice* to Airmen (NOTAM) 6537 for San Francisco International Airport advising "Boeing 147 type aircraft departing Runway OLR, not to use takeoff power until reaching displaced threshold marker, due to jet blast on freeway."**

[6] **3A-Takeoff (Wet) -- This is the maximum thrust available *for* takeoff. This rating is obtained by actuating the water injection system and "setting" the throttle to obtain the wmputed wet takeoff thrust for existing ambient temperature and pressure conditions. The wet rating is restricted to 2-1/2 minutes at takeoff.**

were reset to 20° prior to departing the run-up area according to the crew.

The takeoff reference speeds for the above configuration as taken from the Pan American B-747 Aircraft Operating Manual were: V_1-149 knots, V_R-157 knots, and V_2-162 knots. The crew did not recheck the 20° flap computations though, so the reference speed bugs were left at the settings for a takeoff using the speeds applicable for a 10° flap configuration.

At 1519, PA 845 requested and received clearance from the tower to taxi to 01R. Following this clearance, PA 845 stated they would be "holding momentarily." Following the brief hold, the flight was cleared into position on Runway 01R "to hold," and the captain aligned the aircraft on the runway with the nosegear on the displaced threshold. At 1526, the flight was informed the wind was from 270° at 22 knots and, at 1528, the takeoff clearance was issued.

The crew stated that the engines were operating properly and the aircraft seemed to be accelerating normally during the takeoff roll. The first officer called V_1 at the "bug"[7] setting of 156 knots. This "bug" value had been set during the accomplishment of the Prestart Checklist prior to the aircraft's being pushed back from the gate. The first officer then called V_R at 160 or 161 knots because the end of the runway was, ". . . coming up at a very rapid speed" and not because the aircraft had reached the calculated 164 knots rotation speed.

At 1529, as the aircraft rotated, the first officer saw the airspeed passing through 165 knots and felt a bump or jolt.

Two passengers, in seats 47G and 48G, were seriously injured by parts of the-ALS structure which penetrated the passenger compartment.

The flightcrew continued the takeoff and after determining the condition of the injured passengers, flew the aircraft for 1 hour and 42 minutes. This was the amount of time the flightcrew stated that they needed to assess the structural damage and dump fuel before landing on Runway 28L at the San Francisco International Airport.

Aftei landing, the aircraft veered off the right side of Runway 28L and came to a stop in the dirt approximately 5,300 feet from the approach end of the runway.

The passengers and crew evacuated the aircraft using the emergency evacuation slides. Upon activation of the slides for evacuation, four of the 10 passenger slides failed to deploy properly and were not useable. The aircraft tilted slowly back onto the rear section of the fuselage during the evacuation, approximately 1 minute and 10 seconds after the aircraft had come to a stop, and it remained tilted until after the evacuation was terminated.

Twenty-seven passengers were injured during the evacuation. Eight of them suffered serious back injuries.

1.1.2 Post-Impact Activities and Landing

Immediately following aircraft rotation and the ensuing jolts, the flight engineer saw that they had lost the hydraulic fluid from systems 1, 3, and 4. He executed the hydraulic shutdown procedures from the emergency checklists for those systems and informed the captain of his actions. The in-flight director of the cabin crew came to the flight deck and informed the captain that the aircraft had structural damage in the passenger cabin and that two passengers had been injured. The second officer and the second flight engineer were sent to the passenger cabin to evaluate the condition of injured passengers and to assess the damage, while the captain, first officer, and first flight engineer ascertained what controls were still functioning The landing gear and flaps were left extended. The captain checked the effectiveness of the flight controls and climbed the aircraft first to 1,500 feet and subsequently to between 2,500 and 3,000 feet.

The aircraft was maneuvered out over the ocean in preparation for fuel dumping and Pan

[7] Movable indices on instruments utilized to designate desired speed or setting.

American personnel on board a U. S. Coast Guard aircraft visually checked the damage of PA **845** prior to fuel dumping. The crew of PA **845** was informed that the right body gear was missing and the left body gear was hanging down with **two** wheels missing

The crew of PA **845** decided to dump fuel to a landing weight of about **430,000** pounds and calculated that this would require **30** minutes to accompliih. It took about **45** minutes to dump approximately 180,000 pounds of fuel to achieve the desired landing weight.

The captain decided to return to and land at San Francisco and the flight was vectored to a position from which an approach to Runway **28** could be initiated. A visual approach was made utilizing the ILS as a backup reference. Runway **28L** was opened for the landing while the aircraft was proceeding inbound from the outer marker.

The flaps were extended by the electrically operated, alternate system to a 30° position on the inboard segments and a 28° position on the outboard sections. Normal approach speeds for the **430,000** pound weight of the aircraft with 30° flaps were used. **A** threshold reference speed of **123** knots was selected by the crew but no compensation **was** made for the limited amount of flight controls that were functional.

The captain noted a loss of elevator control effectiveness as the aircraft slowed to about **133** knots (threshold speed plus 10 knots) at an altitude of about 200 feet.

The aircraft couched down hard on Runway **28L,** bounced back into the **air,** touched down again, and turned gradually to the right as it rolled down the runway The aircraft ran off the right side of the runway onto the unpaved surface about **3,900** feet from the approach end of the runway and came to a stop at the intersection of the four runways, approximately **5,300** feet from the approach end of Runway **28L.**

The first officer believed that he gave the order to evacuate the aircraft over the passenger address system, but the order was not heard in the passerger cabin. The announcement was heard, however, in the tower and was recorded on the tower radio frequency cape. The evacuation began about **30** seconds after the aircraft came to a stop.

1.1.3 Dispatch

Pan American flights into the Tokyo area were processed by the company's Western Area Headquarters Dispatch Office located at the San Francisco International Airport. The office was staffed by certificated and currently qualified dispatchers (flight controllers). The day shift on July **30,** 1971, consisted of **a** senior flight controller, two flight controllers, an assistant flight controller, and several administrative clerks.

The flight controller responsible for PA **845** took a company physical examination during the period from **0830** to **1115,** ate lunch, and returned to his duty post at **1145. His** duties, during this absence, were performed by the second flight controller on duty who stated that at no time during the period from approximately 1100 to 1200 were runway closures or runway limitations included in the ATIS broadcasts. ATIS information "VICTOR." effective from **1059** to **1230,** 'contained in part, "Advisory, runway two eight left is closed. . . departing runways one"

The flight controller responsible for PA **845** was briefed, upon returning to his normal duty post, by the second flight ,controller. Shortly thereafter, the responsible controller ,initiated the preparation of the flight release papers for PA **845.**

The San Francisco based Pan American flight controller' 'responsible for the preparation of the dispatch release documents for PA **845** planned a takeoff on Runway **28L** which was 10,600 feet in length. The selection of this runway was based on aircraft weight and

[8] Pan American designation for flight dispatcher.

forcast weather conditions. The alternate runway for planning purposes was 01R, the preferential takeoff runway for noise abatement purposes. This preplanning was accomplished about 1230 on the date of the flight. The scheduled departure time from San Francisco, was 1500. The flight controller did not check the San Francisco airport conditions on July 30, 1971, prior to the release of the flight. Thus, he was not aware that Runway 28L had been closed at 0830 and would remain closed. at bhe scheduled departure time of the flight.

The information concerning the closing of Runway 28L on July 30 1971, was on four consecutive ATIS broadcasts beginning at 0836 until it was omitted, on the 1230 "WHISKEY"[9] broadcast. The information was reinstated on ATIS "XRAY" at 1402. The "XRAY" broadcast was the first to contain the information about the closure of the first 1,000 feet of Runway 01R.

To plan a departure from San Francisco, the flight controllers had available the ATIS broadcasts, a telephone to the tower, a complete set of Jeppesen Manuals (which included a chart of the airport), the required Pan American Flight and Planning Manuals, and a telephonic briefing service of up-to-date airport conditions. This last service was available by dialing a published, four-digit number on the airport telephone system. The flight controllers stated that they "very seldom" used chis telephone service and, depended upon NOTAM's and ATIS broadcasts for their airport information.

The assistant flight controller actually prepared the paperwork for the f l i t release of PA 845 using information1 supplied by the flight controller responsible for the flight. This action was completed about 1315. The flight controller stated that he had used ATIS information "WHISKEY" in his planning and that there was no limitation on any runway at that time. Further, the wind direction and velocity then existing made Runway 28 the desirable one to use. ATIS information, "WHISKEY" reported ". . . departing Runways one. . . ." The flight controller did not discuss this information with the crew.

The initial radio call from PA 845 was received by the assistant flight controller who then informed the responsible controller chat PA 845 was calling to request a change in departure runways. The flight controller immediately assumed radio control. However, he was not aware that PA 845 had specifically requested assistance in determining the feasibility of departing from Runway 28R. Since he had considered using 01R as well as 28L in his initial planning, he knew that with the circumstances then in effect, the flight could use Runway 01R and he so informed the crew. Following this transmission, the crew informed the flight controller that the first 1,000 feet of Runway 01R was closed. Upon hearing this, the flight controller listened to ATIS broadcast "XRAY"[10] for the first time. He then called the tower to check the currency of the information. This call was monitored by his supervisor. They stated that the tower controller informed them that the first 1,000 feet was closed; however, this portion of the runway would not have been available for use by PA 845 under any circumstances since it

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[9] "WHISKEY" 19302 (1230 P.d.t.) - "This is San Francisco and Paint Reyes information, for San Francisco Airport. Weather - sky clear, visibility one five, temperature six six, wind: two eight zero degrees at one five, altimeter two niner niner niner, stratus northwest. ILS runway two eight approach in use, landing two eight right, departing runways one. Advisory for ground control all aircraft use one to one point eight. Inform Bay Approach Control or San Francisco Ground Control on initial contact that you have received information "WHISKEY"."

[10] "XRAY" 21022 (1402 P.d.t.) - "This is San Francisco and Point Reyes VOR information XRAY for San Francisco Airport. Weather - clear, visibility one five, temperature six six, wind three zero zero degrees at one five, altimeter two niner niner niner, ILS Runway two eight approach in use landing Runway two eight right, departing Runway one.

Notice to Airmen -Runway two eight left is closed, the first one thousand feet of Runway one right is closed. Ground. . ."

was "blast overrun." In addition, they stated that the tower controller said the aircraft would have **9,500** feet from the painted displaced threshold.

The tower controller confirmed that he had received a telephone call from Pan American and that he had voluntarily given the information that the 1,000 feet of closed runway would not have been available to PA **845** under any circumstances because of the standing runway restriction. The controller denied that any specific runway lengths or distances were mentioned during this conversation.

1.2 Injuries to Persons

1.2.1 Injuries During Takeoff Impact:

Injuries	Crew	Passengers	Others
Fatal	0	0	0
Nonfatal	**0**	**2**	0
None	**19**	**197**	

1.2.2 Injuries During Evacuation After **Landing:**

Injuries	Crew	Passengers	Others
Fatal	0	0	0
Nonfatal	0	27	0
None	**19**	172*	

(* - The two passengers injured during the takeoff are included in this total.)

1.3 Damage to Aircraft

1.3.1 General Damage

The aircraft damage resulting from contact with the Runway **19L** approach light structure was confined to the airframe aft of approximately fuselage Body Station **(BS) 1380.**

The damaged areas included the left and right main body gear including their respective wheel wells and doors, the aft cargo compartment and cargo containers, the inboard flap assemblies and flap wells, the inboard flap track canoe fairing Nos. **4,** 5, and **6,** the passenger compartment from **BS-1489** to **BS-2412,** the aft pressure bulkhead, the left and right horizontal stabilizers, the right inboard and outboard elevator assemblies, the internal structure of the vertical stabilizer, and the right APU access door. All fractures observed were typical of those caused by overload.

1.3.2 Passenger Compartment - Section **46 (BS-1480** to **BS-2360)**

The right main landing body gear was forced back and up through the fuselage. The main passenger cabin floor had been raised **6** to **12** inches in a large area immediately aft of **BS-1480.** Cabin occupants reported that the floor was displaced approximately 2 feet while the aircraft was in flight. This damage was confined to the area of the left seats 36C and **B,** the center four seats of Rows **34, 35,** 36, **37,** and the right aisle between seat Rows **35** and **38.**

Three pieces of **2"** x **2"** x .25" angle iron from the ALS structure entered the cabin. One piece of angle iron, **17** feet long. pierced the floor panel under seat **45F** and lodged within the cabin. A second piece of angle iron pierced the floor under seat **46G** and passed through seats **47G** and 48G, the overhead hat rack, the ceiling panel above seat 52, and exited through the fuselage skin at **BS-2285** near the upper body centerline. The third piece of angle iron pierced the cabin floor under seat 54F, passed through the aft cabin partition, the three aft right-hand lavatories, penetrated the aft pressure bulkhead approximately **24** inches above the bulkhead centerline at left buttline **4.5,** and then punctured the external fuselage skin approximately **5** inches outboard of the vertical stabilizer at **BS-2505.**

1.3.3 Systems

The brakes and brake valves, the engine instruments, the engine reverse mechanisms,

the flap position indicators, the horizontal stabilizer position indicator, the airspeed indicators, the control input to boost packages, and the leading edge devices were examined. These systems which, singularly or in combination, could adversely affect the takeoff performance of the aircraft were found to be operational and without malfunction or defect.

Six wing landing gear tires were blown out during the landing and were abraded in an "X" type of pattern. Some of the wheels had a flat milled spot on them. None of these tires showed any evidence of rotation after they had blown out. The crew stated that the antiskid system was armed and that all antiskid fault lights were on during the takeoff, the flight, and the landing. They also stated that only the No. **4** engine reverse light came on when reversing was selected during the landing roll.

The primary and alternate landing gear position display circuits were found shorted by damaged wiring in the main body gear wells. An interruption of these circuits would prevent engine thrust reversal and landing gear antiskid operation.

The Boeing **747** aircraft has four separate hydraulic systems which provide redundancy for the operation of the various subsystems. The redundancy allows aircraft control to be maintained with three of the four systems inoperative.

The body landing gears of PA **845** struck the pilings and railings of the approach light pier at the end of the runway during takeoff. Hydraulic systems Nos. **1, 3,** and 4 failed immediately thereafter. The right body gear was forced aft and upward into the aft cargo compartment and passenger cabin floor. The left body gear was broken loose and was dangling beneath the aircraft. The bulkhead, to which the body gear was mounted, had failed on both sides of the fuselage. The No. 1 hydraulic system lines for both body gear extend and retract mechanisms were mounted on this bulkhead and were severed during the impact with the ALS structure.

The right-hand horizontal stabilizer received severe structural damage in the area of the power control actuators for the right-hand elevators. Bbth the pressure and return lines from Nos. **3** and **4** hydraulic systems to the elevator outboard power control actuators were severed.

1.4 Other Damage

The Approach Light System for Runway 19L sustained major damage. **Four** terminating bar light stanchions were broken off at their frangible fittings.

Faint tire tracks were found starting at a point approximately **200** feet south of the threshold bar lights of Runway 19L. These tire marks continued past the threshold bar lights to a point **61** feet onto the blast pad of Runway 19L. Two sets of tire marks approximately 1/2 to 1 inch deep were visible for about the last **15** feet of the blast pad which was **86** feet in length.

Approximately **120** feet past the end of the asphalt blast pad, four terminating bar lights were broken off at the frangible base fittings and one light housing exhibited black scuff marks **6-1/2** inches below the top.

The approach light support bars and lights located on the edge of the airport perimeter road and down the service walkway to the 1,000-foot marker bar were destroyed.

The handrail on the service walkway was torn loose and was missing from the third approach light support piling to approximately **20** feet beyond the sixth light.

The 1,000 foot-marker, left inner light bar was destroyed and two lights were knocked off the right inner. (See Appendix D for details.)

1.5 Crew Information

The crew was trained and certificated in accordance with existing regulations for the operation in which they were involved.

The captain was required to wear and was wearing glasses for near and distant vision while

exercising the priveleges of his airman's certificate (See Appendix **B** for details.)

1.6 Aircraft Information

The aircraft was certificated and. maintained in accordance with the current FAA and company regulations. The weight and balance of the aircraft was within the prescribed limits and the aircraft was equipped properly for the intended flight. The aircraft had been fueled with aviation kerosene (Jet A) at the San Francisco International Airport. (See Appendix C for details.)

A performance study was conducted to ascertain the Boeing 747 takeoff capability and limitations relative to the circumstances of the accident. This included consideration of maximum, allowable takeoff gross weights for Runways 01R and 28R, actual distances to V_R V_{LOF}, and V_2, for a variety of flap, rotation speed, and wind' conditions and an evaluation of the accelerative performance of the aircraft. No deviations from the certificated limits for the aircraft were noted. (See Appendix E.)

1.7 Meterological Information

The weather sequence for San Francisco that was available to the crew of PA 845 at briefing time was: "1326 - sky clear, visibility 15 miles, temperature 66 degrees, dewpoint 54 degrees, wind from 300 degrees at 16 knots, altimeter setting 29.98."

About 1526, upon instructions from the tower cab coordinator, the local controller issued the following wind information to PA 845: "CLIPPER EIGHT FORTY FIVE THE WINDS TWO SEVEN ZERO DEGREES AT TWO TWO."

At 1528, as PA 845 was beginning the takeoff roll, the local controller gave the following winds to another aircraft: "WIND TWO SIX ZERO DEGREES AT TWO ZERO." At 1529, the following wind information was given to another aircraft: "THE WINDS TWO SEVEN ZERO DEGREES TWO ZERO."

The accident occurred during daylight hours.

1.8 Aids to Navigation

Not pertinent to this inquiry.

1.9 Communications

Communication was maintained with the aircraft at all times by either tower/center facilities or other aircraft.

1.10 Airport and Ground Facilities

1.10.1 Runway Information

San Francisco International Airport is located south of the city of San Francisco, California, and east of the cities of San Bruno and Millbrae, California. The coordinates are 37°37'07" N. latitude and 122°22'35" W. longitude.

There. are four runways at the airport which are 200 feet wide. The information contained in the FAA Airport Master Record was dated August 15, 1970, showed the runway lengths to be 28L-10R 10,600 feet; 28R-10L 9,700 feet with 600 feet between the displaced threshold, lights at the end of the runway; 01R-19L 9,500 feet with 1,100 feet between the displaced threshold and the end of the runway; 01R-19R 7,000 feet. A new master record was dated on April 24, 1971, and contained the same runway information except that Runway 28R-10L was now shown as 9,496 feet long with 800 feet between the end of the runway and the displaced threshold lights.

The Remarks column gave the following corrected lengths for the runways: 28L-10R 9,886'; 28R-10L 9,052'; 01R-19L 8,896; and 01L-19R 6,536'. Also in the Remarks were the following comments: ". . . there are clearways for takeoff from 1R and 10L. Instrument marking Runway 1L-19R. All weather markings Runways 1R-19L; 10R-28L. TDZ and Centerline 1ts on Rwy 28L. . . ."

Section 137 of the April 24, 1971, Master Record stated in part: "RWY 28R 1st 800 FT

CLOSD TIL APRX 11/1/71. RWY 01L 15 MPH X-WIND ALL RWYS . . . ."

The elevation of the departure end of Runway 01R (19L threshold) was 11.07 feet m.s.l. The elevation of the ground at the terminating bar lights 200 feet beyond the runway end was 10.38 feet m.s.l.

The service walkway for the ALS sloped up from a ground elevation of 9.86 feet m.s.l. at the No. 1 platform to 12.55 feet m.s.l. at the No. 2 platform of the ALS. The guardrail at the No. 2 platform was 16.45 feet m.s.l. This platform was 400 feet from the departure end of the runway.

Pan American had changed its takeoff charts to conform to the 9,700 feet length of Runway 28R as depicted in the master record of August 5, 1970, but Jeppesen and Co., had not changed their charts. The Chief, Photogrammetry Division, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, had received different runway lengths as indicated by the following paragraph from his letter to the Chief, Airport Planning Branch of the FAA in Los Angeles on November 6, 1970: ',We are satisfied that the 9,496' length is correct as charted; however, we will have survey parties operating in California this winter and a measurement can be made if you so desire. I suggest that any remeasurement be made in the presence of Mr. Nessen (sic) and those who claim 9,696 feet to insure that all parties are in agreement."

On August 20, 1971, the Safety Board Operations Group Chairman, and one other group member, accompanied airport personnel while they measured Runway 28R. They found that there was 8,898 feet of lighted runway available, for 24-hour all weather operations. There was an additional 500 to 600 feet of surface prior to (east of) the displaced threshold that could be used for daylight takeoffs and another 200 feet of surface that had been covered with 1 to 12 inches of soil. The airport engineer said that the 600 feet of surface mentioned above was load bearing. There are no runway lights east of the the displaced threshold.

At San Francisco, Runways 01 Left and Right are the preferential takeoff and 28 Left and-Right are the preferential landing runways., These runways were selected based on noise abatement considerations. Runway 01 should not be used for takeoff when the winds exceed 15 knots from 80° either side of the runway heading (see Appendix G).

At the time of the accident, a trailer with flags had been placed in the middle of Runway 01R about 500 feet from the blast fence in order to show the closing of a portion of that runway. Barricades also had been placed across the taxiway leading to the threshold end of Runway 01R. The first open access to that runway was the taxiway 216 feet north of the painted, displaced threshold.

Runway 28L was closed for repair due to a surface failure near the intersection of Taxiway G and the runway. This surface damage had been found about 0715 by the airport safety officer during a routine inspection. The runway was closed at 0830 but was reopened for the emergency landing of PA 845.

There were no distance indication markers on or around any runway, nor were there any physical indications of lengths or distances remaining for any runway at San Francisco International Airport. There are no requirements for such markings.

1.10.2 NOTAMS and AIRAD Service

San Francisco Airport personnel believed that when they submitted a NOTAM concerning the airport it would be ,published as a NOTAM by the FAA. They found some years ago, however, that some of this information was not being .published as NOTAMS. Consequently on April 25, 1969, they provided a four-digit telephone number that could be called at any time to obtain current information regarding the status of the airport facilities. Information concerning this telephone

number was delivered to the chief pilots of all air carriers as well as other units based at the San Francisco International Airport. Pan American flight controllers, as previously noted, seldon used this number, but relied primarily upon the NOTAM system and ATIS for the airport condition information.

On February 10, 1970, the airport operations personnel issued the following NOTAM information: "All high thrust-line type aircraft using Runway 1R for takeoffs to the north are prohibited from applying takeoff thrust in the area from the blast fence to the landing threshold 1,100 feet north of the blast fence. Prohibition applies to Boeing 747, 727, VC-10, and all other aircraft with high rear-mounted turbojet engines." This NOTAM was signed for by the following recipients: the Flight Service Station operator where the information was processed as a NOTAM or as an AIRAD'[1]; the Control Tower operator who was responsible for the incorporation of the information in the ATIS broadcast; the Fixed Base Operator; and the Fire Department. The information was also placed on the tape for the telephone service that provided the current field conditions.

The Oakland FAA Flight Service Station (FSS) did not send the information out as a NOTAM. The supervisor said that it did not meet NOTAM criteria as it did not concern landings and, therefore, fell into the AIRAD category. Tower personnel stated that the information was placed on the ATIS broadcast originally, but that it had not been carried for some time. All Pan American personnel questioned, however, said that they had never heard of the restriction.

On April 16, 1970, the following NOTAM information was issued by the airport operations personnel: "Takeoff restrictions of 747 aircraft on Runway 1R rescinded." On February 11, 1971, the restriction was reinstated with publication of the following airport operations NOTAM information: "Boeing 747 type aircraft departing Runway 1R, not to use takeoff power until reaching displaced threshold marker, due to jet blast on Freeway." This information received the normal FAA distribution, and again it was transmitted by the FAA as an AIRAD not a NOTAM. The airport had no specific followup procedure to ascertain what action was taken concerning safety information they originated and they were of the opinion that a NOTAM had been published in this case.

On July 30, 1971, the airport operations personnel originated the following NOTAM information (No. 6736): "28L-10R CLOSED 0830 for approx 10 hours. 1R-19L between crossover 1R and south end CLOSED 1000 hours- 1630 hours. B between crossover 1L-A and 1R CLOSED 1000 hours-1630 hours. G between F and 1R runup mat CLOSED 0830 hours-1630." San Francisco Flight Service Station coded the information as "NOTAM" and forwarded it to the Oakland Flight Service Station, who publishes all NOTAMS for the San Francisco area. The Chief of the San Francisco IATSC[12] stated: "Number 6736 was received and time stamped in on July 30, 1971, 1656 GMT. (0856 P.s.t.) The portion concerning 1R-19L does not meet NOTAM criteria. The closure of 28L-10R was inadvertently included with the AIRAD material concerning 1R-19L and given AIRAD distribution via Service B to Oakland FSS."

The "criteria" referred to above by the Chief of IATSC was found in Change 2 to Regulation 7110.10A, Section 4. Paragraph 533, LANDING AREA NOTAMS, is quoted in part as follows: "Report the following as a NOTAM when the airport is annotated with the symbol && in the AIM[13]: a. Airport closed; b. ...; c. ...; d. Report conditions which restrict/preclude the use of a hard surface runway when the runway falls into any or all of the following categories: (1) It is the longest available runway on the

[11] AIRAD - Airmen Advisory - A Notice to Airmen normally only given local dissemination, during preflight or inflight briefing, or otherwise during contact with pilots.

[12] IATSC - International Aeronautical Telecommunications Switching Center.

[13] AIM - Airman's Information Manual.

airport. (1) It is served by an instrument approach procedure with straight-in minimums. (3)It is 4,000 feet or more in length." The entry regarding the San Francisco International Airport was annoted as prescribed and indicated that Runway O1R-19L was served by an instrument approach procedure and was 9,500 feet long.

The Airman's Information Manual, Part 3, contains Operational Data and Notices to Airmen that are continuing in nature and are known sufficiently in advance to permit its publication.'[4] Information of a time-critical nature that is required for flight planning and not known sufficiently in advance to permit publication on a chart or in the AIM, receives immediate handling through the National Notice to Airmen Systems.

The following information was contained in Part 3 of the AIM dated July 22, 1971: "SAN FRANCISCO INTL ARFT: Rnwy 28R threshold displaced 800' W. Fuel barges operg in sealane with mast aprxly 25' to 55' high within 1100'-1500' from the N end rnwys 1L-19R and 1R-19L UFN. ..."

1.11 Flight Recorders

1.11.1 Flight Data Recorder

The aircraft was equipped with a Lockheed Air Service Model 109-D flight data recorder, serial No. 455.

The recorder and foil recording medium were undamaged and all parameter traces were active and clearly legible. The readout was made beginning at a point where the aircraft was turning onto the runway for takeoff and continued until the trace indicated an altitude of approximately 1,900 feet m.s.l., a total of 4 minutes 40 seconds. A second readout was made of the landing, beginning 4 minutes prior to touchdown. (Appendix F.)

There was a gap in all traces for the takeoff segment between 3 minutes 5 seconds and 3 minutes 16.5 seconds which cover a period wherein all parameter traces were so disturbed as to make them undecipherable. The altitude information was based on the San Francisco altimeter setting of 29.97 inches Hg for the takeoff readout and 29.95 inches HG for the landing readout. No other corrections were made to any parameters.

The following are the recording accuracy tolerances for each parameter:

Pressure Altitude	± 100 feet at Sea Level to ± 700 feet at 50,000 feet
Indicated Airspeed	± 10 knots
Magnetic Heading	± 2°
Vertical Acceleration	± 0.2 "g" units
Timing	± 1% in 8 hours

Based on the current recorder calibration for altitude, with the two aforementioned altimeter settings, the evaluations measured on the airport prior to takeoff and following the landing were both 25 feet m.s.l. while the published airport evaluation was 10 feet m.s.l. The difference of 15 feet was well within the tolerance of ± 100 feet at sea level.

1.11.2 Cockpit Voice Recorder

The aircraft was equipped with a Fairchild Model A-100 Cockpit Voice Recorder (CVR), serial No. 872.

The tape was removed from the undamaged CVR and replayed. The recording covered a time period of about 35 minutes prior to engine shutdown and recordings of the earlier portions of the flight had been erased by normal operation of the recorder.

1.12 Wreckage

Not applicable.

1.13 Fire

There was no fire as a result of the aircraft striking the ALS structures during takeoff.

Fire was observed on and around the left wing main landing gear as the aircraft was veering off

[4] Part 3 of the AIM is issued every 28 days and Part 3A every 14 days.

the right side of Runway 28L, during the landing roll. This fire was extinguished as the aircraft proceeded into the dirt area off the side of the runway. No mechanical agent or fire-fighting method was used to extinguish the fire.

1.14 Survival Aspect

1.14.1 Takeoff Phase

Several passenger seats in the middle coach section were displaced by the floor disruption during impact; however, they were unoccupied at the time and no injuries resulted.

One section of angle iron penetrated the passenger cabin floor below seat 46G, nearly severed the left leg, below the knee, of the passenger in seat 47F, severely lacerated and crushed the left upper arm of the passenger in seat 48G, and then exited through the fuselage.

A second piece of angle iron penetrated the floor of the cabin and impaled seats 45F, 46F, 47F, and 48F but no injuries resulted as the seats were unoccupied.

A third section of angle iron penetrated the passenger cabin, and passed through other unoccupied seats and lavatories.

Other takeoff impact damage or occurrences, that could have affected the passenger cabin safety, included:

1. The complete passenger escape slide pack fell from the left No. 4 door.
2. Three sections of ceiling paneling fell to seat top level, causing no injury but effectively blocking access to and egress from this area of the forward economy section.
3. The movie screen near the right No. 1 exit fell to the "down" position, blocking the view and movement from the aisle to the exit.
4. Several overhead baggage compartment doors came open.

1.14.2 In-flight Phase

The injured passengers were cared for by two doctors, who were passengers, and a stewardess who was a nurse. Medical aid was limited to control of the bleeding and immobilization of the injured extremities. The medical aid was limited by the supplies available on the aircraft.

Passengers were. relocated from the damaged areas of the passenger cabin to seats in the forward area with the exception of about 30 passengers who remained in the undamaged portion of the rear cabin. The passengers were briefed and prepared for either a ditching or a crash landing. Lifejackets were donned, shoes and sharp objects were ,removed,and pillows and blankets were issued. Instructions were given on how to assume the "BRACE" position, and exit assignments were made. Nine dead-heading male crewmembers were assigned to aid children or assist stewardesses at certain exits.

Three stewardesses and two dead-heading crewmembers were .assigned to the left No. 4 exit where the complete slide pack had fallen to the floor. They did not know that when the pack was separated from the door there was no way to inflate that slide.

The stewardess-nurse was normally assigned to the right No. 2 exit however, she was attending the injured passengers. None of the other stewardesses or dead-heading crewmembers were assigned to take her place and the right No. 2 exit was not attended by a crewmember during the landing.

The cabin crew and passengers were instructed that the aircraft would be evacuated via the slides. The order to commence the evacuation was to be given from the flight deck or, would be initiated by the cabin crew if the command from the flight deck did not come within a reasonable time.

1.14.3 Landing and Evacuation

There was no announcement over the public address system to evacuate the aircraft. The second officer and second flight engineer came down from the flight deck shouted to the cabin crew to start the evacuation, and opened the No. 1 right and left exits and the right No. 2 exit.

Cabin attendants further back in the cabin opened their assigned exits when they saw the evacuation activities in the front of the cabin. They did not hear the verbal, command to start the evacuation.

A study of the motion pictures taken of the landing provided the following time sequence after the aircraft came to a stop:

ACTION	TIME (Minutes and Seconds)
Aircraft stopped	00:00
Exits Right and Left No. 1 open	00:30
Exit Right No. 2 open	00:38
First evacuee down R-1 slide	00:43
Exit Right No. 3 open	00:48
First evacuee down L-1 slide	00:56
Exit Right No. 5 open	01:10
Exit Left No. 5 open (approx.)	01:10

As the right No. 5 door was being opened at 01 plus 10, the aircraft tilted from a level attitude to a tail-on-the-ground position.

Slide L-1 was initially canted aft and was not used until someone on the ground pulled the slide forward to a more normal position.

Slide L-2 was blown back across the wing and parallel to the fuselage. This slide was not used.

Slide R-2 extended in a horizontal position until a passenger entered the slide. The passenger's weight tilted the slide down to the ground.

The left-over-the wing slide (L-3) was not used because the slide portion over the wing flap to the ground did not inflate. The gas generator for this slide was in the left body gear wheelwell and the trigger mechanism had sustained impact damage.

The L-4 slide had fallen from the door during the takeoff and was not useable.

The R-4 slide did not inflate. The gas generator bottle, mounted in the upper portion of the door structure, had shifted toward the center of the aircraft and misaligned the trigger mechanism and the bottle. One of two retainer straps for the bottle was found undamaged and unhooked.

Slide L-5 was jammed under the fuselage as the aircraft tilted to the tail down position. The exit floor was then about 5 feet above the ground and some passengers utilized the exit by jumping to the ground.

The forward exit slides became almost vertical as the aircraft settled back on its tail. At least four persons were observed using slide L-1 and others were known to have used R-1 after the aircraft tilted.

Eight passengers were hospitalized with serious back injuries after they used the No. 1 slides. Nineteen other passengers were examined for minor cuts, abrasions, contusions, and sprain type injuries that occurred, during the evacuation.

There was no record of the elapsed time required to complete the evacuation.

1.15 Tests and Research

1.15.1 Powerplants

All four of the engines were inspected, removed, placed in the United Air Lines engine test cell, and operated to determine their functional capability. The engine pressure ratio (EPR), fan and compressor rotor speeds, exhaust gas temperature (EGT), fuel flow, and net thrust output were recorded. These parameters, with the exception of the EPR, were corrected to a standard day condition and then compared to previous test cell and in-flight data. The comparison indicated the engines were operating within Pan American and Pratt & Whitney specifications.

1.15.2 Brake Components

All of the available brake assemblies were examined and tested to the extent possible. The only assemblies that could not be fully tested were those on the damaged left and right body-gears. There was no evidence of abnormal wear or excessive heating on any of the brake assemblies. All measured clearances were within

normal operating limits. All brake metering valves were tested and found to be in normal operating condition.

1.16 Other Information

1.16.1 Control Surfaces Available Following Accident

With the loss of hydraulic systems 1, 3, and 4, the aircraft had the following flight controls available from the No. 2 hydraulic system:

Lower rudder
Right hand inboard elevator
Elevator feel
Stabilizer trim **"B"**
Left hand central control actuator
Left hand outboard aileron
Right hand inboard aileron
Left hand spoilers 2 and **3**
Right hand spoilers 10 and **11**

Also available, if selected, was the reserve brake system.

There had been no data made available to the crew in any of their manuals or in their training, regarding the effectiveness of each segment of the flight controls if it were isolated from the other segments.

There were no warnings found in any of the flight manuals relating to a minimum safe control airspeed following the loss of a segment or segments of flight controls and there was no way they could assess rapidly the degradation of the aircraft controllability and performance with only the No. *2* hydraulic system operable.

1.16.2 Fuel Jettison System

The fuel jettison system basically consisted of four jettison pumps (two pumps in each wing inboard main tank) and two override/jettison pumps (in the center tanks), the jettison manifold, appropriate valves, and the jettison nozzles mounted near the tip of the trailing edge of each wing. The fuel output of the six pumps operating in concert had been demonstrated at a rate of 317,000 pounds per hour or 880 pounds, per pump, per minute.

The center tank was fueled to 65,000 pounds even though it had. a capacity of approximately 84,430 pounds. There was no provision for in-flight transfer of fuel from the wing tanks to the center tank and, when the center tank was empty, the system lost the output flow of the two override/jettison pumps and the fuel flow was reduced by 1,760 pounds per minute.

2. ANALYSIS AND CONCLUSIONS

2.1 Analysis

2.1.1 Accident

It became apparent, as this investigation progressed, that the causal factors in this accident were in the operational area. The crew was properly certificated and was qualified to perform its duties in accordance with the existing company and federal regulations applicable to this operation. The flight controllers were certificated and currently qualified to perform the duties required in this operation. The aircraft performance capability and the physical dimensions of the runway utilized (O1R) were adequate for the takeoff, if the aircraft had been operated in conformance with the recommended procedures. The actual wind conditions were in excess of the crosswind limits recommended for the utilization of Runway O1R as the preferential runway for takeoff, but these conditions are not considered significant with respect to this accident.

The investigation revealed that the "clearway" for Runway O1R did not meet the FAA criteria for a clearway. The regulatory requirements for a clearway were predicated on no obstruction penetrating a 1.25 percent upward slope beginning at the departure end of the runway. This slope was penetrated by the handrail installed on the access walkway to light platforms of the ALS to Runway 19L. The clearway would also have been violated if the channel used by fuel barge had been in use.

Failure to meet the clearway criteria was not significant in the first instance where the handrail penetrated the clearway, and academic in the second instance, since there was no barge traffic in the sea lane at the time of the accident. Although these deviations from criteria and procedure were not found to be causal factors in this accident, they do illustrate the need for responsible operating officials to assure by verification rather than by assumption, that operational conditions are in fact as intended.

The elevation of the departure end of Runway O1R was 11.07 feet m.s.l. and the handrail at the second light platform 400 feet from the end of this runway, was 16.45 feet m.s.l. However, the floor of the clearway (the maximum allowable elevation at this point) was 16.07 feet m.s.l. Finally, the Board found no evidence that a procedure or method had been established to provide positive control over the fuel barge traffic cited in the Extended Duration Notices to Airmen, section of Part 3 of the Airman's Information Manual of July 22, 1971. The Board has been advised that Pan American no longer uses clearways for takeoff.

The pattern of occurrences preceding this accident was initiated when the flight controller planned and prepared for a heavy jet departure from the longest runway (28L) on the airport without ascertaining the status of that runway. This runway was routinely available and a closure of the runway was the exception to the rule rather than the normal circumstance. The flight controller assumed that all conditions were routine, and did not check the available information sources. He was subjected to one of the most insidious hazards facing any routine operation, that of being lulled into a sense of complacency. This condition would exist because previous checks he had made for unusual conditions were routinely unfruitful and he had no reason to suspect that this day would be different.

The flight controllers availed themselves of the telephone briefing system only when something unusual occurred. If they relied on this procedure as a safeguard, then the chief flight controller, who listened to the ATIS broadcasts on an hourly routine schedule should have used the telephone service as soon as the information about Runway 28L being closed was omitted from the "Whiskey" ATIS issued at 1230. It was incumbent upon the supervisor of the shift to assure himself that the change in runway status was accurate and that all flight controllers working for him had that information.

The procedures for communicating required information were lax within the dispatch office at San Francisco. There was no formal procedure for briefing the flight controller on the conditions and circumstances existing, or expected to exist, over the part of the airline's system for which this office was responsible. Since the flight controller responsible for PA 845 was not at his duty post until about 1145, he had no opportunity to learn from any ATIS broadcast of the closure of Runway 28L prior to the actual flight release planning. The contradictory statements made by the relief controller, concerning the information contained in the ATIS broadcast from 1100 to 1200, would indicate that an accurate briefing could not have been given by him and the senior flight controller (supervisor) stated that he did not brief the subject controller upon his return from taking the company physical examination. The Board believes that the requirement for a proper briefing is a supervisory responsibility that cannot be delegated or omitted.

Before the crew taxied the aircraft out for takeoff, they learned that Runway 28L was closed. They called Pan American Dispatch via an ARINC radio frequency and requested them to check the feasibility and legality of using Runway **28R** for departure. The flight controller responsible for the flight did not receive the call but he was notified that the crew of PA 845 was having a problem and was requesting a change of runways due to the closure of Runway 28L. The flight controller was aware, from the information he had utilized to prepare the original dispatch, that PA 845 could use Runway O1R

with a clearway departure and a flap setting of 20° without a weight restriction and he so informed the crew. He had specific recall of this information from the Pan American Route Manual. This manual was, in part, a collection of charts specifically tabulated with takeoff gross weight for each type of aircraft (e.g. B-747). These charts also listed the useable runway length for each type of aircraft B-707, B-747, etc. In this particular case, the runway length for O1R was listed as 9,500 feet rather than the 8,400 feet available for the B-747. There was no particular reason for the flight controller to question the accuracy of this figure. It was reasonable for him to assume that any runway operating restrictions for a particular type aircraft had been considered when the aircraft's route manual was compiled.

When the tower controller stated that the 1,000 feet of Runway O1R which was closed would not have been available to a B-747 under any circumstance, the flight controller then assumed that the 9,500 feet listed in the Route Manual was correct and available for use by PA 845. The actual distance to liftoff, based on the observed disappearance of tire marks on the blast pad of Runway O1R, was 8,461 feet. This distance is consistent with the airspeed at which rotation is believed to have actually occurred, 163 knots. The two controllers were talking about two different subjects; however, the tower controller's reply was made in a way which served to reinforce the flight controller's presumption regarding the useable length of Runway O1R. Consequently, the flight controller found no discrepancy with the 9,500 feet listed in his manual.

The tower operator assumed that the Pan American flight controller knew of, and was conversant with, the airport restriction to Runway O1R utilization by B-747 and other high-thrust-line aircraft. This assumption made his volunteered information to the flight controller clear and precise insofar as he, the tower controller, was concerned. The flight controller, on the other hand, assumed that if the length of the useable runway were different from that listed on the charts, the tower. operator would give the specific length.

Whether the distance from the displaced threshold was 9,500 feet or 8,400 feet, the aircraft should have required only, 7,430 feet to accelerate to liftoff if it had been rotated at 154 knots according to the performance data supplied by The Boeing Company. Even using a rotation speed of 161 knots, (10° flap) from The Boeing Company performance data, with 20° of flaps extended, the aircraft should have reached the lift-off point in 8,130 feet. These distances were subject to a ± 200 feet deviation due to variations in engine performance, pilot technique, etc. The use of the 10° flap reference speeds made the runway length critical.

Despite the fact that the aircraft could have theoretically taken off in the existing runway, the Board has determined, that such a takeoff would not have provided the protection to the flight that is contemplated by the Federal Air Regulations relating to takeoff runway requirements.

Calculations made using the data from the PAA aircraft operating manual indicate, that, given the conditions that existed at takeoff, the maximum takeoff gross weight for 8,400 feet of runway with clearway, should have been limited to approximately 697,400 pounds. Under the same condition with the existing takeoff gross weight of 708,000 pounds, the runway length required for takeoff would, have been approximately 8,675 feet with clearway. Therefore, the Board believes that, had the actual runway length been known to the flight controller, he would not have dispatched the flight to Runway O1R.

The Board has calculated that to achieve liftoff at the point where the wheel tracks stop in the blast pad, and assuming that rotation was initiated at 160 to 161 knots, the aircraft took 200 to 300 feet more runway than predicted by the Boeing performance data, to reach the rotation point. The Board cannot determine the reason for this difference in performance.

It is to be expected that a prudent pilot would check his charts pertaining to a particular runway and compare the aircraft gross weight to the maximum gross weight listed for takeoff under the existing conditions. If the aircraft weight was below the maximum gross weight limitation, the company has calculated that there would be sufficient runway length for 'takeoff. However, if a crew were informed that the length of a runway was less than that published, the prudent crew then would have checked the performance charts carried on board the aircraft to determine whether there would be sufficient runway available for takeoff. A crew, operating under this last condition, would be expected to be more meticulous in the preparation for, and execution of, the takeoff. In this connection, the Board notes that both pilots stated that, had they known the runway **was** only 8,400 feet long they would not have attempted the takeoff.

The Board bas recommended to the FAA on several occasions that runway distance markers be installed on runways utilized by turbine powered aircraft. The Board's recommendations have been directed toward making aircraft acceleration performance checks possible for the operating crew. This accident highlights an added benefit that would be gained from such markings, i.e., a positive indication to the crew of the amount of runway available for takeoff.

The confusion that existed regarding the length of Runway 28R, and the runway distance available from the displaced threshold, would have been eliminated if runway distance markers had been placed every 1,000 feet down the runway. These markers are designed to show the distance remaining from the marker to the departure end of the runway. In this case, the fist marker visible to the crew would have been **an** "8" indicating 8,000 feet available rather than a "9" indicating 9,000 feet available. The Board believes that such a marker would have alerted the pilots to the difference in runway data provided to them and they would not have attempted the takeoff.

The operating restriction pertaining to the use of full takeoff thrust, placed on selected types of aircraft by the airport authority. seems reasonable to the Board. In 1969, the need was established to restrict those aircraft whose jet blast passed above the top of the blast fence, and at full takeoff thrust, endangered motorists on the freeway. It also was reasonable for the airport authority to use the painted, displaced threshold as a ready reference point for the takeoff of those aircraft. However, at the time of the accident, there had been no tests performed to determine whether or not this point was the minimal required distance from the freeway for the jet blast to be diminished or deflected. The general attitude of the airport personnel seemed to be that since no one had complained of the shortening of the runway there was no need to examine the adequacy or inadequacy of the change.

The airport operations personnel had, in accordance with their procedures, published and disseminated to the appropriate distribution points an Airport NOTAM about an operational restriction to Runway 01R. The distribution points, such as the FSS representative of the FAA, were then expected by the airport personnel, to disseminate the message in accordance with the FAA procedures. The airport personnel's procedures for initiating action and disseminating information **were** adequate. However, they had no method to insure that the information they initiated was actually transmitted, or, if it was transmitted, in what form. They did have a second system of communicating information to local users, the telephonic updating of field conditions, but, as has been demonstrated, Pan American flight controllers did not use this system.

There was no way of ascertaining who received the information placed on the telephonic briefing tape and no way to determine when any information could safely be deleted from the tape. The airport authority is commended for having such a tool available for use. However, the briefing tape cannot be relied

upon or accepted as a panacea to the communication of important or necessary information.

The FAA did not disseminate the airport information delivered to them in accordance with their own rules. Several conditions (e.g. Runway 01 restriction, Runway 28L closure and 01R partial closure), all of which qualified as information to be disseminated under the NOTAM criteria, were omitted from the system. Also, information submitted as NOTAM information by appropriate organizations was reclassified by FSS personnel, sometimes erroneously, without informing the originator.

NOTAM's are transmitted on the "Service A" and AIRAD's on the "Service B" teletype circuits. However, all users do not have both of these circuits. Therefore, information improperly classified and put out as AIRAD information would not reach users who do not have "Service B." Since the information about the operating restriction on Runway 01R for the B-747 was reclassified as an AIRAD, and since Pan American did not have "Service B" at San Francisco, this may explain why the Pan American flight control personnel were unaware of the 1,100-foot restriction for B-747's. It also would explain why the Pan American personnel who were responsible for the preparation of the B-747 Route Manual, did not reflect the 8,400-foot takeoff length for this runway, and why all of the tabulated data for the maximum gross weight limits for that runway were in error.

The FAA tower coordinator on duty at the time of this accident was also an assistant tower chief. As an assistant tower chief, he was aware of the noise complaint situation that occurred almost every time 28R was used as the departure runway. He was conversant with the recommended crosswind limits of 80° and 15 knots which applied to the preferential use of Runway 01R for noise abatement purposes, but he favored the use of Runway 01 for departure any time the conditions allowed. He was aware that the crosswind at the time of the accident was exceeding the recommended limits in both direction and velocity. He specifically directed that PA 845 be given the wind conditions just prior to the takeoff clearance. It is now apparent that he was assuring that the pilots of departing aircraft were informed of the wind conditions. He did not change the runway or recommend the use of Runway 28R.

The Board believes that, where recommended limits on runway use have been established by the Federal Aviation Administration, the representatives of the Administrator should adhere to those limits as closely as possible. While the crosswind was not a critical factor in this case, no operation should be condoned that, as a matter of expediency, jeopardizes or degrades the established margins of safety. If the only reason for exceeding established operating limits (recommended or mandatory) is expediency, then the operation should be discontinued rather than jeopardize the crew, passengers, or persons on the ground.

The flight controller responsible for the flight did not receive the initial radio call from PA 845 and was unaware of the request for information about 28R. He simply reverted to his original alternate planning consideration of 01R with clearway for departure. Since Runway 28R was favored by the wind. the desirability of its use for the takeoff was examined by the Board. The actual length of Runway 28R was not known to those required to know and to publish it. Two different lengths were given by representatives of the airport authority and a third length was listed in the airport diagram attached to the FAA Airport Master Record (FAA FORM 5010-1) dated April 1, 1971. The letter from the Chief, Photogrammetry Division, National Oceanic and Atmospheric Administration, dated November 6, 1970, and another airport diagram attached to the FAA Form 5010-1, dated April 30, 1970, contained additional differing lengths for the same runway.

The airport authority had issued a NOTAM in October 1969. stating that there was 9,700 feet available for takeoff on Runway 28R. In accordance with this NOTAM, Pan American had modified the data in their Route Manual and the

charts reflected 9,700 feet available for that runway. The NOTAM did not include the information that runway lights extended only to the displaced threshold and that only **8,896** feet were available for use at night. Additionally, no information had been published indicating that the first 200 feet of the load bearing surface of the runway was covered with fill material to stabilize additional area for a future lengthening of this runway. This made that particular portion of Runway 28R unuseable. There was so much confusion as to the actual length available for Runway 28R that the airport engineering personnel, accompanied by the Board's representative, measured it. They found that there was 8,898 feet of lighted runway available. This is the amount of runway that could be used for a 24-hour, all weather operation. There was an additional 500 to 600 feet of surface prior to the displaced threshold that could be used for daylight takeoff **as** well **as** 200 feet of fill-covered surface. The appearance of this 700 to 800 feet of surface was such that it would make the load bearing capabilities suspect to the pilot of a heavily loaded jet aircraft.

Again, the tabulated charts from the Pan American Route Manuals were in error. The error was caused by utilization of the information that had been provided by the airport authority. There was nothing about the appearance of the approach end of Runway 28R that would cause a pilot to believe its length was other than that. published on the charts. This was a potentially dangerous situation.

This accident record revealed several examples of assumptions made by involved personnel that "someone else" verified the accuracy and/or the currency of information being used. Assumptions were also made that the "other" person was using the same data when communicating about this operation. In this case, as in most accidents, there was a chain of events which culminated with the accident. If that chain had been broken at any point the accident could have been prevented. The events in this chain are usually designated **as** contributing factors and normally they can be eliminated, thus breaking the chain, by adhering without exception or deviation to established rules and procedures. The Board believes that any phase of an operation, e.g **,** providing the facilities, preparing of charts, planning and preparing the paper work, or the briefing of crewmembers, is just **as** important and vital, and must receive the same meticulous attention to detail, **as** the operation of the aircraft itself.

The captain accepted the planning for a departure from 28L and he assumed the flight controller had checked the availability of the runway before he prepared the paperwork for the flight. The captain did not check the airport conditions although he could have done so. His past experiences relating to the validity of the information provided by a flight controller probably negated any need to check this data. The Board believes it would be appropriate for flight crews to verify the airport conditions before they leave the dispatch office in the same manner that they verify weight and balance flight planning, etc.

After the crew had boarded the aircraft and had gone through the routine of the pre-start checks, wherein the "Bugs" (V reference speeds) predicated on **a** 10° flaps setting for takeoff were set on the captain's and first officer's respective airspeed indicators, the aircraft was pushed back from the gate, the engines were started and taxi clearance was requested. It was during the above sequence that the first officer, while listening to the ATIS broadcast, became aware of the closing of 'Runway 28L, the prevailing northwest wind, and that Runway 01 was being used for departures. A combination of the wind information and the aircraft weight caused the first officer to request Runway 28R when the tower cleared the flight to taxi to Runway 01R. The captain heard the clearance and the request for 28R and. at that time, told his first officer he wanted 28L. It was obvious from this interchange that, at that time, the captain was unaware of the closure of 28L. The radio request to PANOP, ". . . like to use 28R -

would you check that along with us?", was a prudent step. Unfortunately, the flight controller responsible for the flight and, presumably the one who had the most information about the conditions surrounding this departure, did not receive the first radio communication with the request regarding the feasibility of using 28R. In retrospect, if he had received the request, he probably would have concurred in the use of 28R which still would have required a change in the flap setting from 10° to 20° for takeoff.

After the flight controller had given the crew the information concerning the length of Runway 01R; read them the numbers from the charts normally used for selecting a takeoff runway; and indicated that the clearway departure was feasible with the use of 20° flaps; the acceptance of this recommendation by the captain was routine. The crew had been in the process of taxiing or holding on the taxiway for about 15 minutes while trying to decide what action to take. They were aware that they were consuming fuel and were impeding the aircraft behind them. These conditions tended to place a sense of urgency on the crew to make the necessary changes and proceeded with the takeoff. None of these factors, however, were sufficient to explain why five qualified airmen would allow more flaps to be extended than had originally been planned, and not call for or recalculate the required takeoff reference speeds. While it is the captain's responsibility to order this new calculation of reference speeds, every airman on the flight deck should know the criticality of these speeds and should have brought to the captain's attention the need for changing these speeds.

The Board believes there is a value in placing a review of aircraft configuration and reference speeds in the "Takeoff" checklist as a reminder to the crew just prior to commencing the takeoff roll.

A primary causal factor in this accident was that the crew did not calculate and utilize the reference speeds (V_1 and V_R) appropriate for a 20° flap configuration. The V_R for a 10° flap setting was 164 knots and the V_R for 20° flap setting was 157 knots. For the 20° flap configuration it would take appmximately 4 seconds and about 1,000 feet of runway for the aircraft to accelerate the additional 7 knots to the estimated rotation speed of about 164 knots. It is impossible to say exactly where, in relation to the painted, displaced threshold (i.e., nose wheel on, behind, or ahead) the aircraft stopped prior to starting the takeoff roll. The normal procedures for takeoff were: advance the engines to a stabilized 1.1 EPR with the brakes set; release brakes; then, advance the power to the rated takeoff EPR. Based on a rotation speed of 154 knots from the FAA Flight Manual, a distance of 7,430 feet (± 200 feet) would have been required to attain normal lift-off speed using 20° of flap. With 8,400 feet of runway available, pilot technique and prompt, precise application of power was not critical. However, since the crew used reference speeds from the FAA B747 Operating Manual for a 10° flap setting, a distance to lift-off of 8,430 feet (± 200 feet) would be required.

Variables, such as the aircraft position prior to brake release, the rate at which power was advanced, the technique used to rotate the aircraft, and the aircraft's instrument accuracy became extremely critical.

The evidence indicates the aircraft crossed the departure end of the runway with the main gear in firm contact with the ground. The evidence also indicates that the aircraft was being rotated at this point. The nose gear marks were not in evidence nor did the nose gear strike the terminating bar lights, as did the main gear. This evidence is in concert with the witnesses who described a late, near the end of the runway, two step rotation of the aircraft.

The aircraft's main body gear struck the lights on the first platform of the ALS. The damage to the aircraft and the ALS indicates the aircraft was rotating to a climb attitude as it was passing over the first 300 feet of the ALS. The left body gear struck each of the first 3 light platforms which are mounted to the left side of the

,walkway facing north, but the fuselage cleared the handrail and service walkway. These strikes by the body gear went progressively deeper into the light platforms and, just past the third platform, the underside of the fuselage came in aontact with the handrail and walkway and dragged thnough .approximately 300 feet of the structure. The damage was the result of the aircraft rotation, which effectively lowered the body gear .and the aft portion of the fuselage, rather than from a sinking or loss of altitude. The .fuselage damage resulted from direct contact with the ALS structure and penetration by pieces of the structure, mainly the steel handrail sections, up through the lower fuselage, cabin and on into the vertical fin. Wood debris and metal pieces also struck the inboard sections of the wing flaps, the horizontal stabilizer, and the elevators. The impact damage .failed the Nos. 1,3, and 4 hydraulic systems. Metal debris that struck the 'right horiaontal stabilizer passed through the stabilizer structure and into the right elevator. This particular missile passed within 4 inches of the No. 2 hydraulic system lines and boost package for the right inboard elevator and was within 4 inches of completely disabling the aircraft flight controls.

2.1.2 Landing

As the aircraft approached for landing, the checklists were completed. It was anticipated that the aircraft would weigh 430,000 pounds at the time of landing and, if the flaps could be successfully lowered to 30°, a threshold crossing speed of 123 knots would be required. This threshold speed was the normal speed for an .undamaged aircraft at this weight with a 25" flap configuration. The crew did not discuss the desirability or possible necessity of using additional speed in order to maintain aircraft control. The crew did know that the aircraft was responding adequately at speeds of 140 knots or more. Degradation of longitudinal control did not manifest itself until the captain attempted to slow the aircraft's rate of descent as it was passing through approximately 200 feet. Even though the captain immediately applied power in order to .increase the aircraft's speed and control response, the aircraft was in a stabilized descent at this time and there was insufficient time to alter the direction or amount of this momentum before the aircraft contacted the runway. There was no information in any of the manuals or in the training curriculum pertaining to degradation of longitudinal control effectiveness when only one of the four elevator sections was operable. The Board has recommended that this type of information be developed and the crews made aware of the ramification of reduced control capabilities. Conditions, such as those experienced in this accident and other accidents where aontrol difficulties were experienced, could be programmed into today's simulator computers and flightcrews trained to handle the situation. (See Recommendation, Section 3.)

After the aircraft touched down and was rolling on the runway, the captain tried to configure his engines for reverse thrust. The No. 4 engine was the only one that indicated it had gone into the reverse thrust condition. The captain did not apply power. If he had done so, the aircraft would have swerved violently instead of slowly veering to the right.

The fire that was seen developing around the left wing landing gear was extinguished by the dirt and dust envelopment as the aircraft ran off the runway.

As the aircraft came to a stop, the first officer started making the announcement to commence the evacuation. This announcement was not completed because the captain and flight engineer were shutting down the aircraft system: and the battery power was turned off shutting off all systems, except those with self contained power. The lack of coordination at this point had no real bearing on the delay because the first officer's announcement was transmitted over the radio rather than the passenger address system. Apparently, following his last announcement to the passengers to "brace," the first officer routinely, or through force of habit

selected the previously tuned radio. He may have done this in case he had to answer the tower or radio some other message during the landing. The fact that he did not complete the message because another crewmember turned off the battery indicated breakdown of an emergency procedure.

During an emergency, it is vital to be able to communicate to all sections of the aircraft and a system should be required for this purpose that does not require an operational aircraft electrical system. Until a self-powered system is installed in all aircraft, crews must be trained and drilled so that the procedural action of one crewmember does not make it impossible for a second crewmember to accomplish his tasks. (See Recommendations.)

2.1.3 Evacuation

After the aircraft came to a full stop, the second officer and the second engineer went from the flight deck to the passenger cabin, expecting to see the evacuation procedures being executed. Instead, they found the passengers and cabin attendants still in their seats. The flight crewmembers shouted for the evacuation to commence and they themselves opened the No. 1 right and left exits and the No. 2 right exit. The available, self-powered "bullhorns" were not used to start the evacuation.

Those cabin crewmembers who did not hear the shouted order to evacuate, commenced the evacuation procedures at their stations when they observed the forward exits being opened or observed the activities of the passengers that they (the cabin attendants) associated with an emergency evacuation. This resulted in the sequential opening of the exits from the front to the rear.

The evacuation of approximately eight passengers from the forward section of the aircraft, plus the movement of passengers to the rear of the passenger cabin because of the full or partial failure of slides L-2, L-3, L-4, and R-4, resulted in a shift of a sufficient amount of weight to cause the aircraft to tilt back onto the rear fuselage. This situation could result at any time both body gear cannot be extended or do not have the capability of bearing weight. The aircraft cannot rotate to the taildown attitude under the most adverse condition of passenger and/or cargo distribution, if at least one body gear is in place.

As a result of this accident, the manufacturer has changed its recommended fuel dumping procedures if there is a likelihood of body gear being unuseable. Prior to this accident, there was no requirement to retain fuel in excess of the fuel dump standpipe levels for balance considerations. The manufacturer now recommends retaining at least 40,000 pounds of fuel over the standpipe level, in order to offset the most adverse passenger movement or location. If this additional fuel cannot be retained, the forward exits should not be used unless the existing conditions dictate otherwise. This decision will have to be made by the crewmembers at the time of the occurrence; however, training and guidelines to assist them in making this decision should be established.

2.2 Conclusions

2.2.1 Findings

1. The crewmembers were certificated and qualified for the intended flight.
2. The aircraft was certificated, maintained, and equipped for the scheduled operation.
3. The aircraft's weight, center of gravity, and load distribution was within the established limits.
4. There was sufficient runway length available for a successful takeoff from Runway 01R, however, the runway length did not meet the FAA criteria for a takeoff under the existing conditions.
5. The FAA tower controller utilized a preferential takeoff runway with existing wind conditions in excess of the recommended crosswind limitations.

6. The Pan American flight controllers were certificated and qualified for their assigned duties.
7. The takeoff gross weight computation by the flight controller was based on the use of Runway 28L for the departure of PA 845.
8. The Pan American flight controller did not check the existing and forecast airport conditions prior to planning for the departure of PA 845.
9. Runway 28L was closed for repair during the planning for PA 845's departure and was forecast to be closed until after PA 845's scheduled departure time.
10. The closure of Runway 28L and the first 1,000 feet of 01R was not included in the appropriate NOTAM.
11. There was a restriction against B-747 and other specific types of aircraft utilizing full takeoff thrust prior to reaching the displaced threshold on Runway 01R.
12. There was 8,400 feet of runway plus a clearway authorized for B-747 takeoffs from Runway 01R on the date of this accident.
13. The ALS structure for Runway 19L penetration of the clearway and the entry of barges across the takeoff zone for Runway 01R negated the availability of a clearway for a 01R departure.
14. The tower controller assumed that the flight controller was familiar with the B-747 restriction on the use of 01R when the flight controller called the tower concerning the closure information carried on ATIS information "XRAY" and responded to the flight controller accordingly.
15. The Pan American B-747 Route Manual computations were based upon the assumption that Runway 01R had 9,500 feet available for takeoff.
16. PA 845 was configured to 10° of flaps and reference speeds (V_1-156 knots, V_R-164 knots, V_2-171 knots) were set on the airspeed indicator bugs for takeoff on Runway 28L before the crew learned it was closed.
17. PA 845 was configured to a 20° flap setting for takeoff from Runway 01R while in the runup area.
18. The takeoff reference speeds shown in the Pan American B-747 Aircraft Operating Manual for PA 845's gross weight and a 20° flap setting were: V_1-149 knots, V_R-157 knots, V_2-162 knots.
19. The flight crew did not recompute the required takeoff reference speeds (V speeds) for a 20° flap condition.
20. Confusion and lack of uniform procedures existed at all levels related to the processing of information to be transmitted to flightcrews through NOTAM, AIRAD, and other means.
21. Confusion and lack of agreement existed relative to the actual length of the runways at the San Francisco International Airport.

2.2.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the pilot's use of incorrect takeoff reference speeds. This resulted from a series of irregularities involving: (1) the collection and dissemination of airport information; (2) aircraft dispatching; and (3) crew management and discipline; which collectively rendered ineffective the air carrier's operational control system.

3. RECOMMENDATIONS

As a result of this investigation, the Board recommended on January 3, 1972, that the FAA take the following actions:

"1. Review the procedures for the issuance of NOTAM and AIRAD for standardized implementation within the appropriate

FAA facilities and modify the procedures to assure that information pertinent to "Safety of Flight" is disseminated without delay.

"2. Require that V reference speed checks be included on the last checklist used immediately pdor to takeoff.

"3. Require the installation of runway distance markers at all civil airports where air carrier aircraft are authorized to operate.

"4. Require the use of takeoff procedures which will provide the flightcrew with time and distance reference to associate with acceleration to V_1 speed.

"5. Require manufacturers to include information in the Aircraft Flight Manual concerning the aircraft controllability and performance characteristics with the loss of any system that involves flight controls. Consideration should be given to incorporating training in such in-flight emergencies in all approved simulator programs at the earliest possible date."

On February 24, 1972, the FAA replied that:

1. They had initiated a study to reevaluate the NOTAM system. Following receipt of comments from the FAA regions and evaluation by a headquarters team, a manual which will consolidate and standardize all information concerning NOTAM's will be developed.

2. They plan to issue an operations bulletin to all their field inspectors to ensure that airline training programs emphasize the necessity for flightcrews to assure that takeoff reference speeds include accurate resolution of all pertinent factors prior to initiating a takeoff. They also noted that PAA plans to include takeoff reference speeds on the before-takeoff checklist for all their aircraft.

3. Runway distance markers have been evaluated in the past and found lacking for takeoff purposes.

4. They agreed in principle with the recommendation that flightcrews be provided with time and distance reference to associate with acceleration to V_1 speeds. They also noted that "various segments of the industry" were investigating systems to monitor aircraft takeoff performance. The FAA is following the development of these systems and their possible application to everyday operations.

5. They believe that present flight manuals and training procedures are satisfactory at this time.

In view of the difficulties experienced in transmitting the order to evacuate the aircraft to the cabin attendants and passengers, the Board also recommends that:

1. The FAA require all air carrier aircraft to be equipped with an audio and visual evacuation alarm system. This system should be capable of being activated in the cockpit and at each flight attendant's station. The alarm system should be self-powered so that interruption of the aircraft electrical systems will not interfere with use of the evacuation alarm.

The Board found that there were several problems associated with the escape systems installed in this aircraft. These problems included passenger escape slides that did not function correctly or, when they did function, they were not useable. One slide failed to function because the trigger mechanism in the wheelwell area was damaged by impact. Another slide was dislodged from its installed position at impact. A third slide failed to function because the gas generator bottle was dislodged, probably due to its proximity to the impact area in the fuselage. One slide inflated properly but was blown out of position by the wind and could not be used. Considering these problems, the Board recommends that:

2. The FAA review the slide pack mounting design, gas generator retention design, and

the protection of the wheelwell mounted gas generator installation. This review should be 'made to determine what actions can be taken to improve these components and make them more reliable.

The Board has been informed that the manufacturer is reviewing the design of the escape slides to determine what can be done to prevent or reduce the effect of wind on inflated slides. The Board encourages this work and wishes to reiterate its interest in the resolution of this problem.

The Board also noted that there was a difference between the life jackets supplied for passenger use and the lifejackets used by the cabin attendants during the passenger briefing. Only one cabin attendant was aware of this difference. Therefore, the Board recommends that:

3. The FAA take additional steps to ensure that all cabin crewmembers are properly informed regarding the safety equipment installed in the cabin and that the emergency equipment used for passenger demonstrations is the same as that provided for the passengers' use.

The Board is also concerned about the hazard offered by the displacement of ceiling panels in this aircraft. Some of these panels fell into the cabin in such a way that they could have restricted or blocked passenger attempts to escape from the cabin. The Board recommends that:

4. The FAA review the criteria applied to the installation of these panels and effect whatever action is appropriate to improve the installation so that the panels will stay in position during survivable impact load imposed on the cabin structure.

BY THE NATIONAL TRANSPORTATION SAFETY BOARD:

/s/ JOHN H. REED
Chairman

/s/ OSCAR M. LAUREL
Member

/s/ FRANCIS H. McADAMS
Member

/s/ LOUIS M. THAYER
Member

/s/ ISABEL A. BURGESS
Member

May **24, 1972.**

INVESTIGATION AND HEARING

1. Investigation

The Board received notification of the accident about 1910 e.d.t., on July 30, 1971, from the Federal Aviation Administration Communication Center in Washington, D. C. Investigators were dispatched to San Francisco and working groups to examine the aircraft, crew, airport facilities, FAA services, evacuation, and all other aspects of the accident were established and continued the on-scene operation through August 16, 1971. The Federal Aviation Administration, Pan American World Airways, Boeing Company, Pratt and Whitney Division of United Aircraft, Air Line Pilots Association, Transport Workers Union, Flight Engineers International Association and the San Francisco Airports Commission participated and assisted the Board in this investigation.

2. Hearing

A public hearing was held at the Thunderbolt Hotel, Millbrae, California, from August 17 through August 20, 1971. The parties to the hearing were: Federal Aviation Administration, Pan American World Airways, Boeing Company, Air Line Pilots Association, Flight Engineers International Association, Transport Workers Union, and the San Francisco Airports Commission.

3. Reports

A combined preliminary report and summary of testimony taken at the hearing was released on September 29, 1971.

CERTIFICATED AIRMEN INFORMATION

CREW HISTORY

The crew of PA845 consisted of: Captain Calvin Y. Dyer, First Officer Paul E. Oakes, Second Officer Wayne E. Sager, First Flight Engineer Winfree A. Horne, Second Flight Engineer Roderic E. Proctor, and 14 stewardesses.

Captain Dyer began flying as a pilot with Pan American in 1939. He was in the first class of Pan American pilots to check out in the B-747. He attended and satisfactorily completed ground school in San Francisco during the month of December, 1969. then began his flight training in the B-747 at Roswell, New Mexico, on February 7. 1970.

The Chief Pilot for Training and Check for Pan American stated that: "Captain Dyer accrued 6.6 hours aircraft time as of February **13,** 1970. His instructor reported problems in approach slope recognition and control and requested an evaluation by a supervisor. The evaluation flight was not flown until February 21, due to supervisory nonavailability. After this flight, Captain Mills recommended one training flight to work on profile control, grading other areas as satisfactory. The subsequent training flight, pre-rating were satisfactory. Captain Dyer's progress was considered slow, however, there was continuing improvement. A contributing factor in the total time to rating of 13.2 hours was the delay in the evaluation."

First Officer Oakes was employed by Pan American in November 1955. He began his B-747 ground school training in December 1969 and his flight training in March 1970. He received his rating in the B-747 on March 14, 1970, after 9 hours of flight training. He received above average grades on both his rating and right seat qualification rides.

Captain

Name and Address		Calvin Y. Dyer 16200 Skyline Blvd. Redwood City, Cal.
Date of Birth		5/11/14
Total Flying Time		27,209 hrs.
Totd 747 Hours		868 "
Total last 30 days		60 "
Totd last 24 hours		None
Total this Flight		**2** "
Rest 24 hrs. Prior to Flt.	:	**24** "
Last FAA Physical		1st Class - 4/20/71
Waivers		Holder shall wear glasses for near & distant vision
Certificates & Ratings	:	ATR #61097 issued 2/25/70 SEMEL-B-377/707/720/747, DC-4/7 & Constellation, Navigator #1055344-11/18/57
Last Proficiency Check	:	3/26/71
Last Route Check		4/8/71

First Officer

Name and Address	Paul E. Oakes 14740 Chany Drive Reno, Nev. 89502
Date of Birth	12/16/30
Total Flying Time	10,568 hrs.
Totd 747 Hours	595 "
Total last 30 days	22 "
Total last 24 hours	None
Total this Flight	**2** "
Rest 24 hrs. Prior to Flt. :	24 "
Last FAA Physical	1st Class-5/21/71
Waivers	None
Certificates & Ratings :	ATR #1154840 issued 3/14/70. MES&MEL-SA-16 - B-707/720/ 747 Navigator# 1344598 7/9/56

Second Officer

Name and Address	Wayne E. Sagar 9010 W. 55th Ave. Arvada, Colorado 80002
Date of Birth	3/29/37
Total Flying Hours	3,230 hrs.
Total 747 hours	456 hrs.
Total 30 days	62 "
Total last 24 hours	None
Total this Flight	**2** "
Rest 24 hr. Prior to Flt. :	24 "
Last FAA Physical	1st Class-3/2/71
Waivers	None
Certificates & Ratings :	Commercial & Inst. #1568496 7/22/63
Last Proficiency Check :	5/7/71

Flight Engineer

Name and Address	Winfree **A.** Horne 23756 Topar **Los** Altos, Calif. 94022
Date of Birth	5/29/14
Total Flying Hours	23,569 hrs.
Total 747 hours	168 "
Total 30 days	40 "
Total last 24 hours	None

Total this Flight		**2** "
Rest 24 hr. Prior to Flt.	:	**24** "
Last FAA Physical		2nd Class - 11/10/70
Waivers		Holder shall possess correcting glasses for near vision.
Certificates & Ratings	:	Commercial & Inst. #1610699 issued 5/1/68 SEMEL Flt. Engr. #575268 issued 5/31/66
Last Proficiency Check	:	5/9/71

Second Flight Engineer

Name and Address		Roderic E. Proctor 951 Channing Palo Alto, Calif. 94301
Date of Birth		12/7/14
Total Flying Hours		24,576 hrs.
Total 747 hours		236 "
Total 30 days		51 "
Total last 24 hours		None
Total this Flight		**2** "
Rest 24 hrs. Prior to Flt.	:	24 "
Last **FAA** Physical		2nd Class - 5/15/71
Waivers		Holder shall possess correcting glasses for near vision
Certificates & Ratings	:	ATR #1522303 issued 8/10/66 SEMEL Flt. Engr. #765872 issued 5/16/66
Last Proficiency Check	:	10/9/70

APPENDIX B

TOWER CONTROLLERS

1.	Full Name	: Frank Wilbert Coil	James **L.** Wilbanks	Fred *G.* Bollman
2.	Current Address	: 561 Carlisle Way Sunnyvale, California 94057	34237 Auckland Place Fremont, California	3037 Los Prados Street, #222 San Mateo, California
3.	Date of Birth	: 5/19/24	3/8/43	8/4/46
4.	Date of Hire	: 4/9/51	8/26/67	2/8/71
5.	Total time employed	: 20 yrs. 3 mos.	4 yrs. 6 mos.	1 yr.
6.	Total time on job assignment	: 1 yr.	1 yr. 2 mos.	**1 yr.**
7.	Total military time, if any, in like job assignment	: 42 mos.	3 yrs.	2 **yrs.**
8.	Total military time, if any, as traffic controller	: 42 mos.	3 yrs.	2 yrs.
9.	Total time as senior controller duties	: 14 yrs.	2 **yrs.** 1 mo.	N/A
10.	(Mr. Coil) Length of time as Asst. Chief (or acting Asst. Chief)	: 6 mos. - SFO	N/A	N/A
11.	List FAA certificates and numbers	: CTO 1297731 ATCS Cert. 4-3520	ATC Cert. 1640815	ACT, Air Force 47012
12.	Date of last physical	: 2/2/71	3/22/71	8/12/71
13.	Waivers on last physical	: None	None	None

11. List **FAA** certificates and numbers	:	**CTO** 1297731 ATCS Cert. 4-3520	**ATC** Cert. 1640815	**ACT,** Air Force 47012
12. Date of last physical	:	2/2/71	3/22/71	8/12/71
13. Waivers **on** last physical	:	None	None	None
14. Date last recurrent training	:	3/11/71	12/17/70	In training
15. Date of last facility check	:	3/11/71	12/17/70	None
16. Rest time (time off) during 24 hrs. preceding the accident	:	16 hrs.	15 hrs.	16 hrs.
17. Duty time during the 24 hrs. preceding the accident	:	**9** hrs. 55 min.	8 hrs. **30** min.	8 hrs. 45 min.

APPENDIX B

1.	Full Name	: Murray D. Hess	Richard S. Bradley
2.	Current Address	: 4114 Vincente Fremont, California 94536	4746 Stratford Fremont, California
3.	Date of Birth	: 12/9/42	
4.	Date of Hire	: 9/4/68	
5.	Total time employed	: 3 yrs. 2 mos.	
6.	Total time on job assignment	: 1 yr.	
7.	Total military time, if any, in like job assignment	: 4 yrs.	
8.	Total military time, if any, as traffic controller	: 4 yrs.	
9.	Total time as senior controller duties	: 5 mos.	
10.	(Mr. Coil) Length of time as Asst. Chief (or acting Asst. Chief)	: N/A	N/A
11.	List FAA certificates and numbers	: ATC Cert. 1960220	ATC Cert. 1392730
12.	Date of last physical	: 12/70	
13.	Waviers on last physical	: None	
14.	Date last recurrent training	: 2/17/71	

12. Date of last physical : 12/70

13. Waviers on last physical : None

14. Date last recurrent training : 2/17/71

15. Date of last facility check : 2/16/71 (7/29/71 over-the-shoulder - CC Performance test, no deficiencies)

16. Rest time (time off) during 24 hrs. preceding the accident : 16 hrs. 30 min.

17. Duty time during the 24 hrs. preceding the accident : 8 hrs. 54 min.

PAN AMERICAN FLIGHT CONTROLLERS

Name and Address:	John L. Pepin 825 Holly Drive Belmont, Calif. 94132	Francis R. Keithey 2683 Summit Drive Burlingame, Calif. 94002	Edward J. Anderson 750 Gonzalez Drive, 3H San Francisco, Calif. 134712
Date of Birth:	July 9, 1911	May 17,1917	November 16,1907
Dispatcher (yrs)	29	28	31
Supervisory **(yrs)**	2	2	13
Hire Date	August 20,1942	May 3,1943	December 4,1939
Duty time 24 hrs. prior to accident	17 hrs.	17 hrs.	17 hrs.
Rest time 24 hrs. prior to accident	7 hrs.	7 hrs.	7 hrs.
Last Physical	July 13, 1971	July 30, 1971	October 23,1970
FAA Cert. & Nos.	378366	394185	134712
Qualification	B-747/707/ DC-8-63	B-7471707	B-747/707
Last Route Ck.	4/29/71	12/20/70	10/5/70
Last Prof. Ck.	6/7/71	1/22/71	1/22/71
Grd. School Re.	5/20/71	11/18/70	1/27/71

AIRCRAFT INFORMATION

HISTORICAL DATA

An inspection of company records pertaining to the involved aircraft revealed the following:

Aircraft

Boeing 747-121

Registration Number N747PA

Serial Number 19639

Date of Manufacture 1-29-70

Date of Transfer From the Boeing Company to Pan American World Airways, Inc., 10-3-70.

Total Aircraft Hours in Service at the Beginning of the Takeoff on PA845, 7-30-71, 2,898.45 and Termination, 2,900.14.

Last Major Inspection, B7, was performed at J. F. Kennedy International Airport, New **York,** 7-16-71 at aircraft hours 2,745.

Last Line Inspection was performed at Los Angeles, California, 7-30-71.

Airworthiness Directives according to company records were up to date as of 7-30-71.

Powerplants

Four Pratt & Whitney JT9D-3A powerplants were installed. The following information is related to the powerplants.

Engine Number 1

S/N 662386, date of manufacture 1-27-70. Total hours in service since new at time of takeoff on PA845 was 2,230.31 and at landing 2,232.

Engine Number 2

S/N 662383, date of manufacture 1-27-70. Total hours in service since new at time of takeoff on PA 845 was 3,819.31 and at landing 3,821.

Engine Number 3

S/N 662397, date of manufacture 2-6-70. Total hours in service since new at time of takeoff on PA 845 was 2,899.31 and at landing 2,901.

Engine Number 4

S/N 662389, date of manufacture 1-29-70. Total hours in service since new at time of takeoff on PA 845 was 2,227.31 and at landing 2,229.

Aircraft Empty Weight

Company records show that aircraft N747's empty weight was 319,440 pounds at the time of delivery *to* Pan American World Airways, Inc. Company configuration, since delivery, resulted in an increased empty weight to 322,300 pounds.

Inspection Records

The records of the last major inspection, B7, 7-16-71, were reviewed and no discrepancies were noted.

Weight and Balance

The Dispatch Release was completed about 1315 at which time operations was given the following information:

Maximum Takeoff Gross Weight	710,600 pounds
Less Required Fuel and Water	295,300 pounds
Dry Tank Weight Limited by TOGW	415,300 pounds
Destination Fuel	242,100 pounds
Water	3,500 pounds
Taxi Fuel	2,000 pounds
Full Tanks	311,600 pounds
Fuel Density	6.60 #/gal.

The dispatch office informed operations that they desired the tanks topped off if the payload dropped. Later they informed them that the Dry Tank Weight would have to be dropped by 1,000 pounds as they had been informed that the Main Entry Door had a hinge cover missing.

Operations found that the density of the fuel on board PA845, upon its arrival from Los Angeles, was 6.66 pounds per gallon. They fueled the aircraft to 293,800 pounds at the blocks with Nos. 1 and 4 tanks having a weight of 6.64 pounds per gallon and Nos. 2 and 3 tanks having a weight of 6.63 pounds per gallon.

The type of accident involved indicated that weight and balance could be suspect, so all of the cargo was weighed and a post-flight weight and balance was performed. It was found that 50 of 280 cardboard drums of empty medical capsules transhipped from another air carrier had not been loaded at Los Angeles. This account for the difference in the following Pre and Post-Flight weight and balance sheets:

	Final Pre-Takeoff			Post-Flight		
	Weight	Index	*C.G.*	Weight	Index	*C.G.*
Dry Tank Weight	412,702	5545	26.0%	410,337	5500	25.0%
Weight at Blocks	710,002	9282	14.85%	707,637	9228	13.9%
Takeoff Gross Weight	708,002			705,637		

AIRPORT SURVEY AND DAMAGE

Attachment 1 of Appendix D is a plan view and profile view bf Runway 01R - **19L** at the **San** Francisco International Airport indicating the measured position of the displaced threshold, tire marks on the blast pad and damaged portion of the ALS.

Attachment **2** is a diagram of the evidence on Runway 28L and in the dirt to the right side of the runway.

Attachment **3** is a diagram of the ALS debris penetration of the fuselage of N747PA.

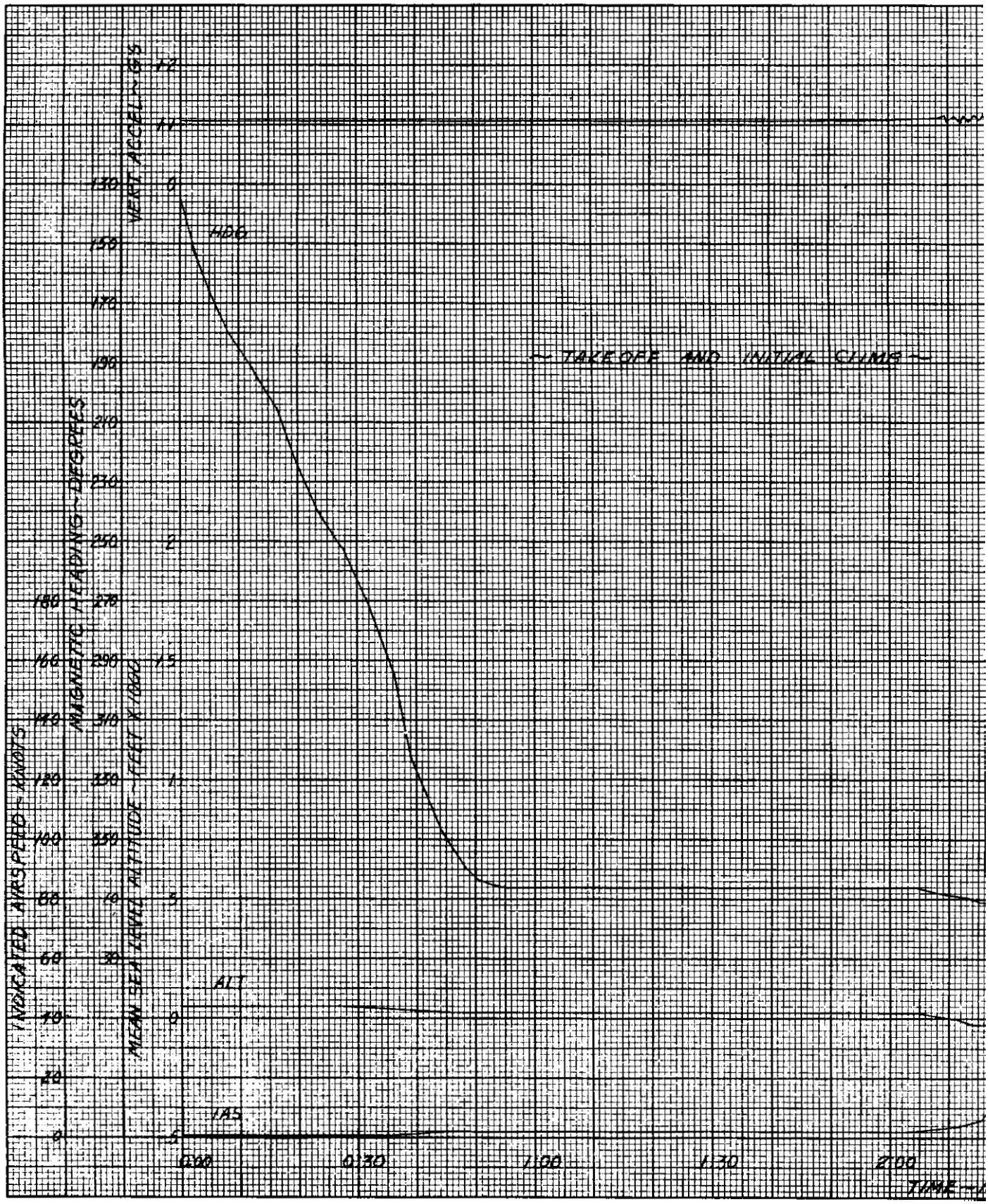
BOEING MODEL 747 PERFORMANCE
DISTANCE TO V_R, V_{LOF}, AND V_2

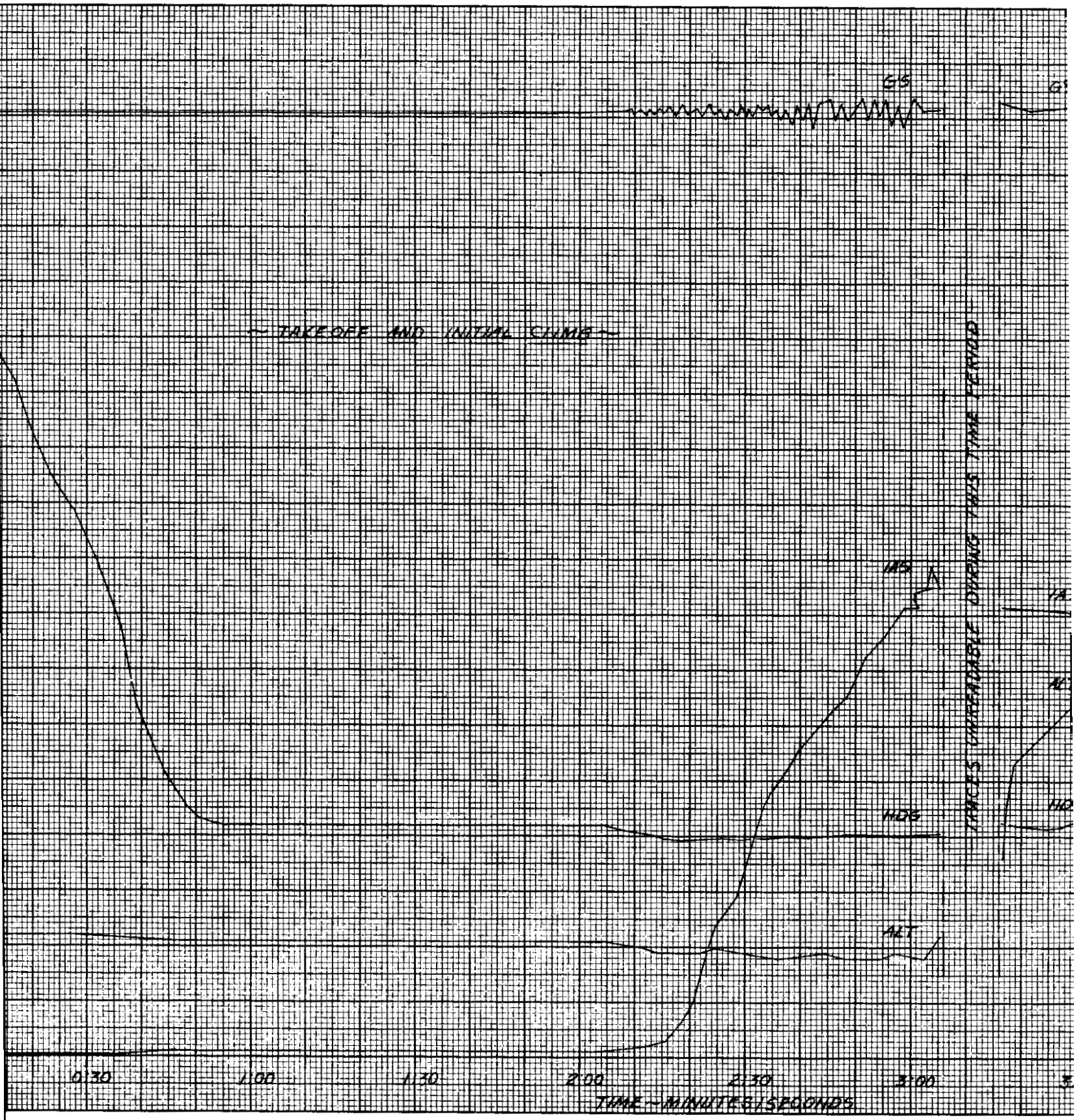
GROSS WEIGHT: 708,000 lbs.
ENGINES: JT9D-3A Wet
DENSITY ALTITUDE: Sea Level
SFO RUNWAY: 01

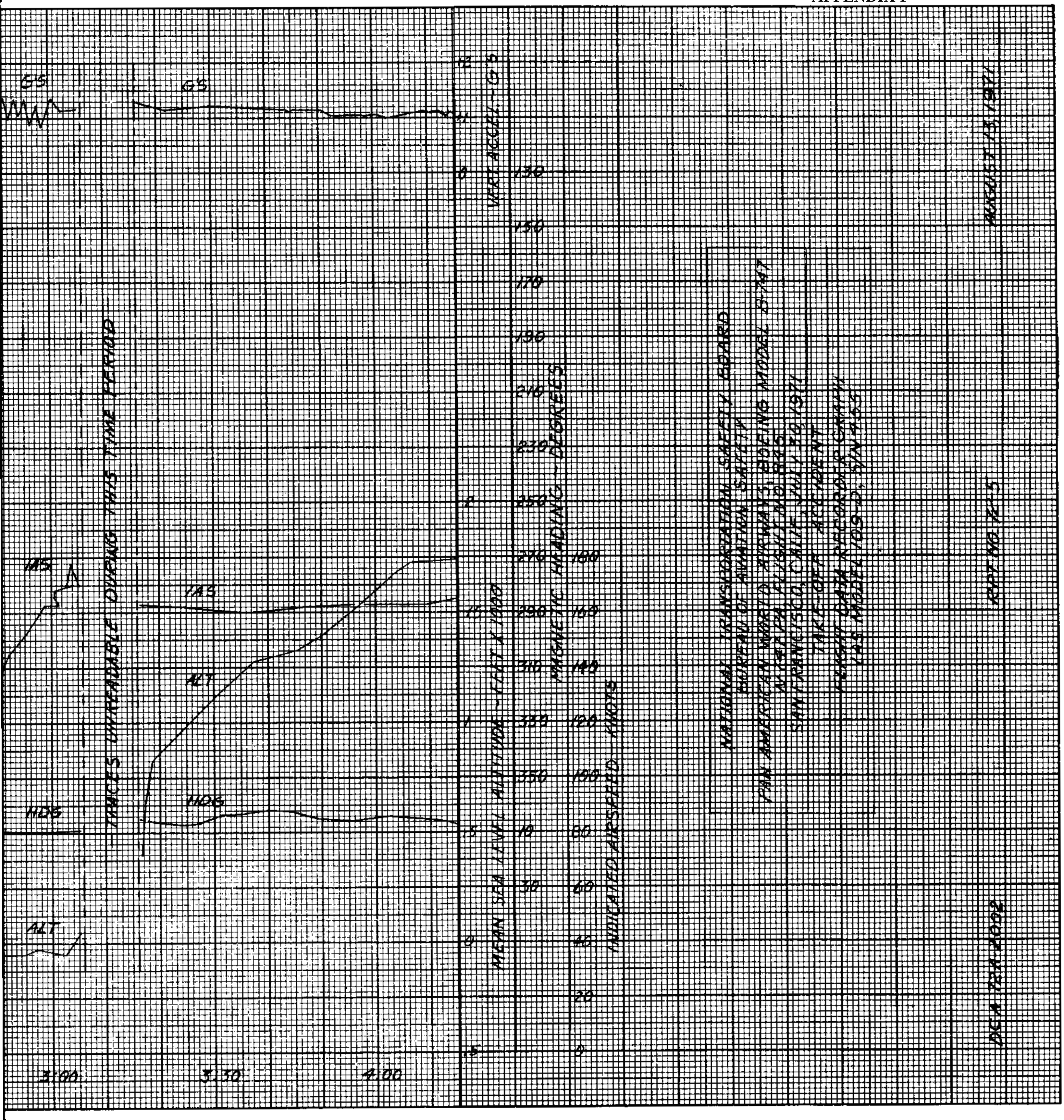
TEMPERATURE = 19°C = 66.2°F
RUNWAY GRADIENT: 0
AIR CONDITIONING PACKS: Off
DISTANCE TOLERANCE: ±200′

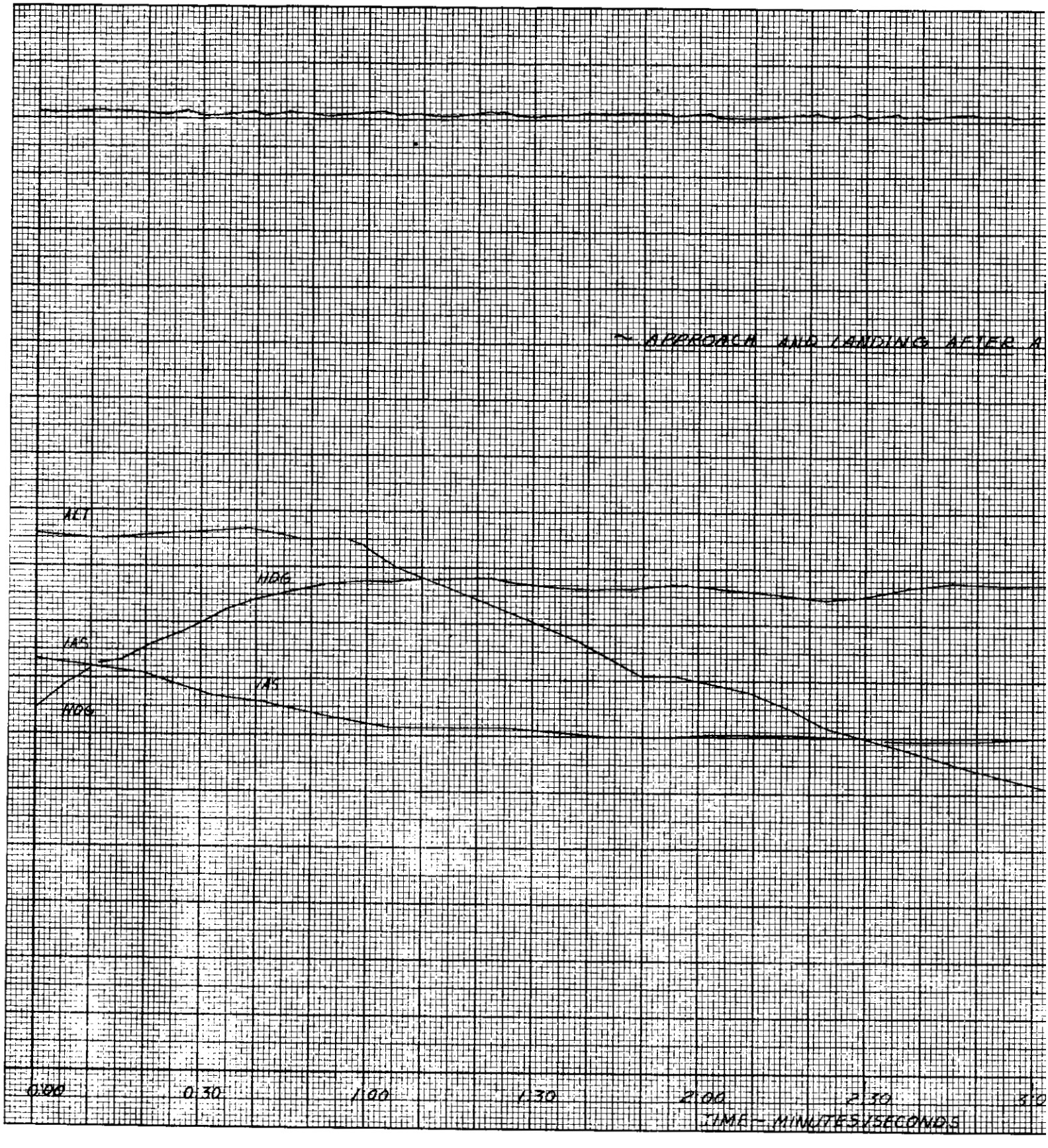
	WIND		DISTANCE TO V_R	DISTANCE TO V_{LOF}	DISTANCE TO V_2 (35′)
	FROM	KTS			
FLAPS 20°, SPEEDS FOR FLAPS 20°	–	0	5950	6900	7990
V_R=154 V_{LOF}=162	260°	20	6480	7430	8520
① $V^*_{2\text{-}3}$=162 $V^*_{2\text{-}4}$=165	270°	22	6230	7160	8230
V_{MU}=140	270°	15	6130	7050	8110
FLAPS 20°, SPEEDS FOR FLAPS 10°	–	0	6600	7600	8740
V_R=161 V_{LOF}=169	260°	20	7130	8130	9270
② $V_{2\text{-}3}$=169 $V_{2\text{-}4}$=172	270°	22	6880	7860	8980
V_{MU}=140	270°	15	6780	7750	8860
FLAPS 20°, SPEEDS HIGHER THAN ① or ②	–	0	7000	8010	9180
V_R=165 V_{LOF}=173	260°	20	7530	8540	9710
③ $V_{2\text{-}3}$=173 $V_{2\text{-}4}$=176	270°	22	7280	8270	9420
V_{MU}=140	270°	15	7180	8160	9300
FLAPS 10°, SPEEDS FOR FLAPS 10°	–	0	6500	7500	8640
V_R=161 V_{LOF}=169	260°	20	7030	8030	9170
④ $V_{2\text{-}3}$=169 $V_{2\text{-}4}$=172	270°	22	6780	7760	8880
V_{MU}=146	270°	15	6680	7650	8760
FLAPS 10°, SPEEDS SAME AS 3	–	0	6900	7910	9080
V_R=165 V_{LOF}=173	260°	20	7430	8440	9610
⑤ $V_{2\text{-}3}$ = 173 $V_{2\text{-}4}$=176	270°	22	7180	8170	9320
V_{MU}=146	270°	15	7080	8060	9200

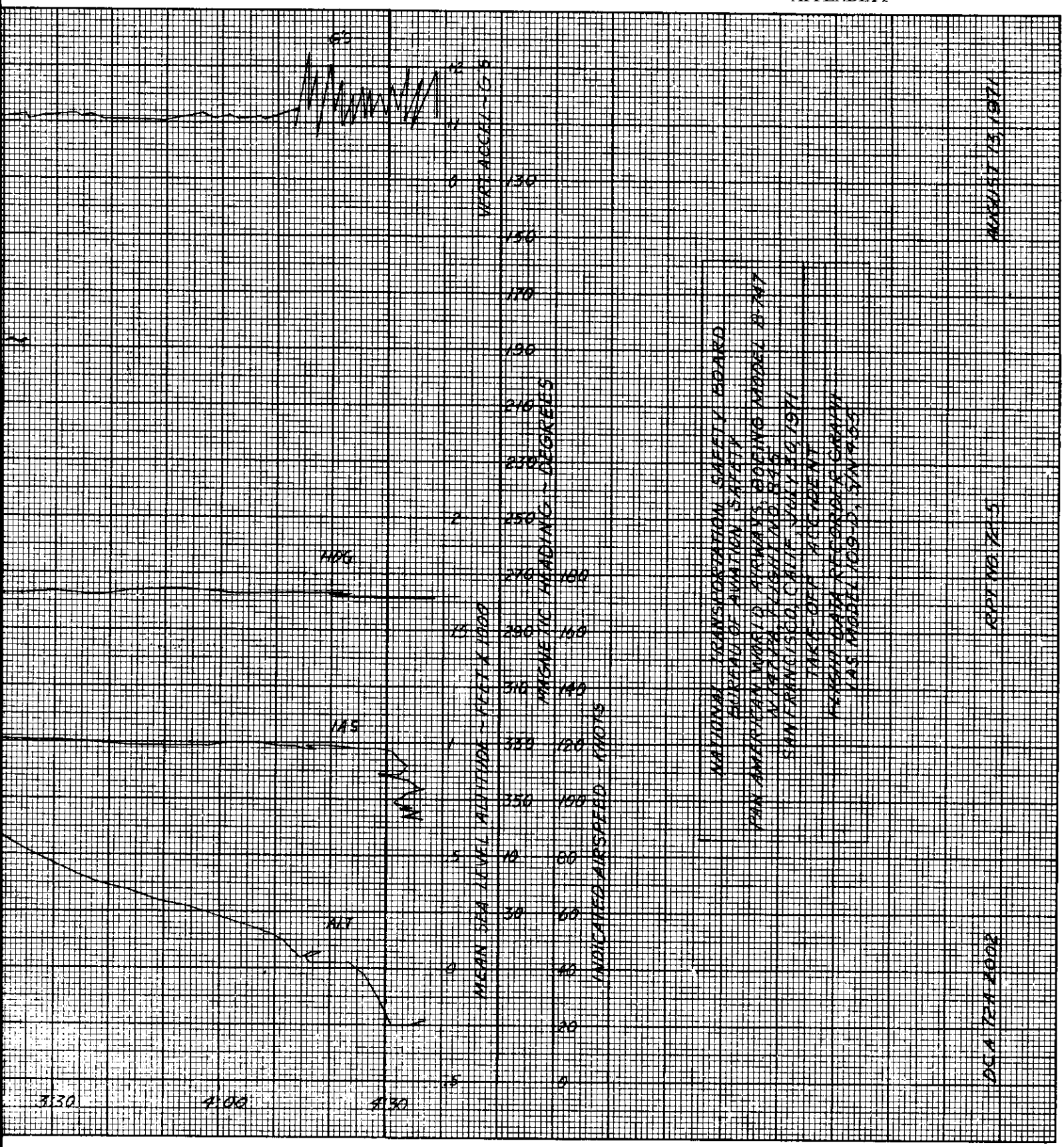
*$V_{2\text{-}3}$ - 3 Engine V_2 Speed
*$V_{2\text{-}4}$ - 4 Engine V_2 Speed


VERT ACCEL - G'S
MAGNETIC HEADING - DEGREES
MEAN SEA LEVEL ALTITUDE - FEET X 1000
INDICATED AIRSPEED - KNOTS
TAKEOFF AND INITIAL CLIMB
ALT
0:00
0:30
1:00
1:30
2:00
TIME


G'S
~ TAKE OFF AND INITIAL CLIMB ~
IAS
HDG
ALT
TRACES UNREADABLE DURING THIS TIME PERIOD
0:30
1:00
1:30
2:00
2:30
3:00
TIME ~ MINUTES/SECONDS


NATIONAL TRANSPORTATION SAFETY BOARD
BUREAU OF AVIATION SAFETY
PAN AMERICAN WORLD AIRWAYS, BOEING MODEL B-747
N747PA, FLIGHT NO. 845
SAN FRANCISCO, CALIF., JULY 30, 1971
TAKE-OFF ACCIDENT
FLIGHT DATA RECORDER GRAPH
AUGUST 13, 1971
RPT NO 72-5
DCA 72A-A002
TRACES UNREADABLE DURING THIS TIME PERIOD
VERT. ACCEL. - G'S
MEAN SEA LEVEL ALTITUDE - FEET X 1000
MAGNETIC HEADING - DEGREES
INDICATED AIRSPEED - KNOTS
GS
IAS
TAS
ALT
HDG
3:00
3:30
4:00


APPROACH AND LANDING AFTER A
ALT
HDG
IAS
IAS
HDG
0.00
0.30
1.00
1.30
2.00
2.30
3.10
TIME - MINUTES/SECONDS


NATIONAL TRANSPORTATION SAFETY BOARD
BUREAU OF AVIATION SAFETY
WASHINGTON, D.C. 20594
PAN AMERICAN WORLD AIRWAYS, BOEING MODEL B-747
N747PA, FLIGHT 845
SAN FRANCISCO, CALIF. - HONOLULU, HAWAII
TAKE-OFF ACCIDENT
FEBRUARY 3, 1971
LOS ANGELES, CALIF.
REPT. NO. 72-5
AUGUST 13, 1971
DCA 72A 2002
63
+2
0
-2
VERT. ACCEL. - G'S
130
150
170
190
210
230
250
270
290
310
330
350
5
0
-5
MAG
HDG
NE
E
SE
S
SW
W
NW
N
MAGNETIC HEADING - DEGREES
15
10
5
0
MEAN SEA LEVEL ALTITUDE - FEET X 1000
160
140
120
100
80
60
40
20
0
INDICATED AIRSPEED - KNOTS
IAS
ALT
3:30
4:00
4:30

USE OF RUNWAYS & CLEARWAYS

1. Use of Runways -Airman's Information Manual, Part I, Page 1-40
2. Clearways - C.F.R., Part 1
3. C.F.R. 91.37, (h), (4)
4. C.F.R. 125.113, (b)

1. USE OF RUNWAYS

Runways are numbered to correspond to their magnetic hearing. Runway 27, for example, has a bearing of 270 degrees. Wind direction issued by the tower is also magnetic.

1. . . .
2. . . .
3. At airports where a formal runway use program is established for airplanes over 12,500 pounds and all turhojct airplanes, ATC will assign noise abatement runways, when acceptable to the pilot, if: (1) runways are clear and dry; i.e., there is no ice, slush, etc., (2) wind velocity does not exceed 15 knots, and (3) any cross-wind does not exceed 80 degrees from either side of the centerline of the runway in the direction of use. The pilot of an aircraft subject to the formal runway use program will be informed that the runway specified is the noise abatement runway only when he requests the use of another runway which is more noise sensitive.
4. . . .
5. If a pilot prefers to use a different runway than that specified, he is expected to advise ATC accordingly. When use of a different runway is requested, pilot cooperation is solicited to preclude disruption of the traffic flow or creation of conflicting patterns.

2. CLEARWAYS

"Clearway" means:

(1) For turbine engine powered airplanes certificated after August 29, 1959, an area beyond the runway, not less than 500 feet wide, centrally located about the extended centerline of the runway, and under the control of the airport authorities. The clearway is expressed in terms of a clearway plane, extending from the end of the runway with an upward slope not exceeding 1.25 percent, above which no object nor any terrain protrudes. However, threshold lights may protrude above the plane if their height above the end of the runway is 26 inches or less and if they are located to each side of the runway.

(2) For turbine engine powered airplanes certificated after September 30, 1958, hut before August 30, 1959, an area beyond the takeoff runway extending no less than 300 feet on either side of the extended centerline of the runway, at an elevation no higher than the elevation of the end of the runway, clear of all fixed obstacles, and under the control of the airport authorities.

3. **C.F.R.** 91.37

91.37 Transport category civil airplane weight limitations.

(a) . . .

(b) **. . .**

(1) . . .

(2) . . .

(3) . . .

(4) Where the takeoff distance includes a clearway, the cleanvay distance is not greater than one-half of-

(i) The takeoff run, in the case of airplanes certificated after September 30, 1958 and before August 30,1959; or

(ii) The runway length, in the case of airplanes certificated after August 29, 1959.

4. C.F.R. 125.113

25,113 Takeoff distance and takeoff run.

(a) **. . .**

(b) If the takeoff distance includes a clearway, the takeoff **run** is the greater of-

(1) The horizontal distance along the takeoff path from the start of the takeoff to a point equidistant between the point at which V_{LOF} is reached and the point at which the airplane is 35 feet above the takeoff surface, as determined under 25.111; or

(2) 115 percent of the horizontal distance along the takeoff path, with the engines operating, from the start of the takeoff to a point equidistant between the point at which V_{LOF} is reached and the point at which the airplane is 35 feet above the takeoff surface, determined by a procedure consistent with 25.111.

UNITED STATES OF AMERICA
NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C.

ISSUED: January 3, 1972

Adopted by the NATIONAL TRANSPORTATION SAFETY BOARD
at its office in Washington, D. C.
on the 8th day of December 1971

FORWARDED TO:

Honorable John H. Shaffer
Administrator
Federal Aviation Administration
Washington, D.C. 20591

SAFETY RECOMMENDATION A-72-1 thru 5

Five items, which warrant corrective action, have come to the attention of the National Transportation Safety Board during the course of our investigation of the Pan American world Airways, Inc., B-747 accident that occurred on July 30, 1971, at San Francisco International Airport.

First, a difference of opinion exists between the airport management and the Flight Service Station personnel concerning what airport information should be published as a NOTAM. Consequently, the NOTAM and AIRAD service was discussed at length during the accident hearing, Each person queried gave a different interpretation of what could be designated as a NOTAM. We believe. therefore. that a review of the NOTAM system should be conducted to standardize the thinking within the industry concerning this useful safety tool.

Second, a perusal of the "Normal Procedures" portion of the Pan American B-747 flight manual showed that the V reference speed bugs were supposed to be set during performance of the "Pre-Start" checklist. They are not mentioned again until the "Approach" checklist. Since V reference speeds can be very critical at times, they should be included as an item on the last checklist used prior to taking the runway for departure.

Third, this accident provides further substantiation for our previous recommendations regarding the need for revised takeoff computation procedures. V reference speeds are of very

little value unless associated with time and/or distance along the runway. If runway distance markers had been installed at San Francisco, the crew of Flight 845 would have known that they had less than 9,000 feet of runway remaining at the initiation of takeoff, rather than the 9,500-foot figure given to them by the dispatcher. **Also,** runway distance markers could be used by landing aircraft to determine the adequacy of the remaining runway for landing and stopping. We believe this would assist in reducing the number of aircraft that slide off the ends of runways.

Fourth, this aircraft has an inertial navigation system installed. This system could be used quite advantageously as an acceleration check device, if associated with the concomitant institution of proper procedures. Without such procedures, however, the system capabilities are not fully utilized during an important part of the operation.

Fifth, there was no information readily available to the flightcrew of Pan American Flight 845, either on the flight deck or in their preceding training which described the controllability of the aircraft following the loss of control-related systems. In the instant case, the flightcrew knew what controls were still available but they were unable to assess rapidly the degradation of aircraft controllability and performance with only the No. **2** hydraulic system operable. Flightcrews should be prepared to cope with in-flight control system emergencies, regardless of whether the emergencies are generated by accidents or malfunctions during normal operations. Rapidity of assessment capability with respect to aircraft controllability and requisite operational procedures is vital. For this reason, we believe aircraft manufacturers should provide operational information regarding the handling of such emergencies for incorporation in airplane flight manuals.

The Board recommends, therefore, that the FAA:

1. Review the procedures for the issuance of **NOTAM** and AIRAD for standardized implementation within the appropriate FAA facilities and modify the procedures to assure that information pertinent to "Safety of Flight" is disseminated without delay.

2. Require that V reference speed checks be included on the last checklist used immediately prior to takeoff.

3. Require the installation of runway distance markers at all civil airports where air carrier aircraft are authorized to operate.

4. Require the use of takeoff procedures which will provide the flightcrews with time and distance reference to associate with acceleration to V_1 speed.

5. Require manufacturers to include information in the Aircraft Flight Manual concerning the aircraft controllability and performance characteristics with the loss of any system that involves flight controls. Consideration should be given in incorporating training in

such in-flight emergencies in all approved simulator programs at the earliest possible date.

Members of the Board and our Bureau of Aviation Safety staff will be available for consultation in the above matters if desired.

These recommendations will be released to the public on the issue date shown above. No public dissemination of the contents of this document should be made prior to that date.

Laurel, McAdams, Thayer and Burgess, Members, concurred in the above recommendations. Reed, Chairman, was absent, not voting.

/s/ John H. Reed
By: John H. Reed
Chairman

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

WASHINGTON, D.C. 20590

OFFICE OF
THEADMINISTRATOR

24 Feb 1972

Honorable John H. Reed
Chairman, National Transportation Safety Board
Department of Transportation
Washington, D. C. 20591

Dear Mr. Chairman:

This is in response to Safety Recommendations A-72.1 thru 5.

Recommendation No. **1.** The FAA has initiated a study to reevaluate the NOTAM system. Comments will be solicited from the FAA regions and be evaluated by a headquarters team. A manual which consolidates and standardizes all information concerned with Notices to Airmen will be developed. Comments from outside the agency will be solicited prior to publication.

Recommendation No. **2.** The procedures used by the airlines for setting and cross-checking takeoff V reference speeds have been considered acceptable. However, we believe that training programs should emphasize the necessity for flight crews to assure that these speeds include accurate resolution of all pertinent factors prior to initiating a takeoff. Accordingly, we plan to issue an operations bulletin to our field inspectors to accomplish this. Pan American plans to include "V reference speeds" on the before-takeoff checklist for all of their airplanes.

Recommendation No. *3.* Distance markers have been evaluated in the past and found lacking value for takeoff purposes. Several significant problems are listed below:

a. The pilot not in control would be required to monitor passage of the markers. This would divert his attention from adequately monitoring engine and flight instruments. This would increase the probability of his failing to call out the V speeds at the proper time during a most critical period of the takeoff and only aggravate the problem which we are trying to solve.

b. When a threshold is temporarily displaced, as was the case at San Francisco, the markers would not provide correct values.

c. Misreading of a marker in reduced visibility could result in a rejected takeoff too far down the runway to make a safe stop.

d. Use of distance markers presents the same problems with respect to acceleration, runway conditions, weight, etc., as discussed under Recommendation No. 4 below.

Recommendation No. **4.** We agree with the recommendation in principle. However, the many variables involved preclude practical application. An acceleration check was used by the airlines in the beginning of jet operations, however, the procedure was discontinued for the following reasons:

a. The acceleration check is invalid where slush or standing water is present. Drag rise due to slush or water often does not fully develop until the speed is near or just greater than V_1.

b. Some of the variables which affect acceleration are altitude, weight, wind, flap setting, runway slope, thrust setting and runway conditions. Neither wind nor runway slope can be assumed to be constant throughout the takeoff. In addition, the wind and/or temperature at the time of takeoff may not coincide with the values used to compute the acceleration check.

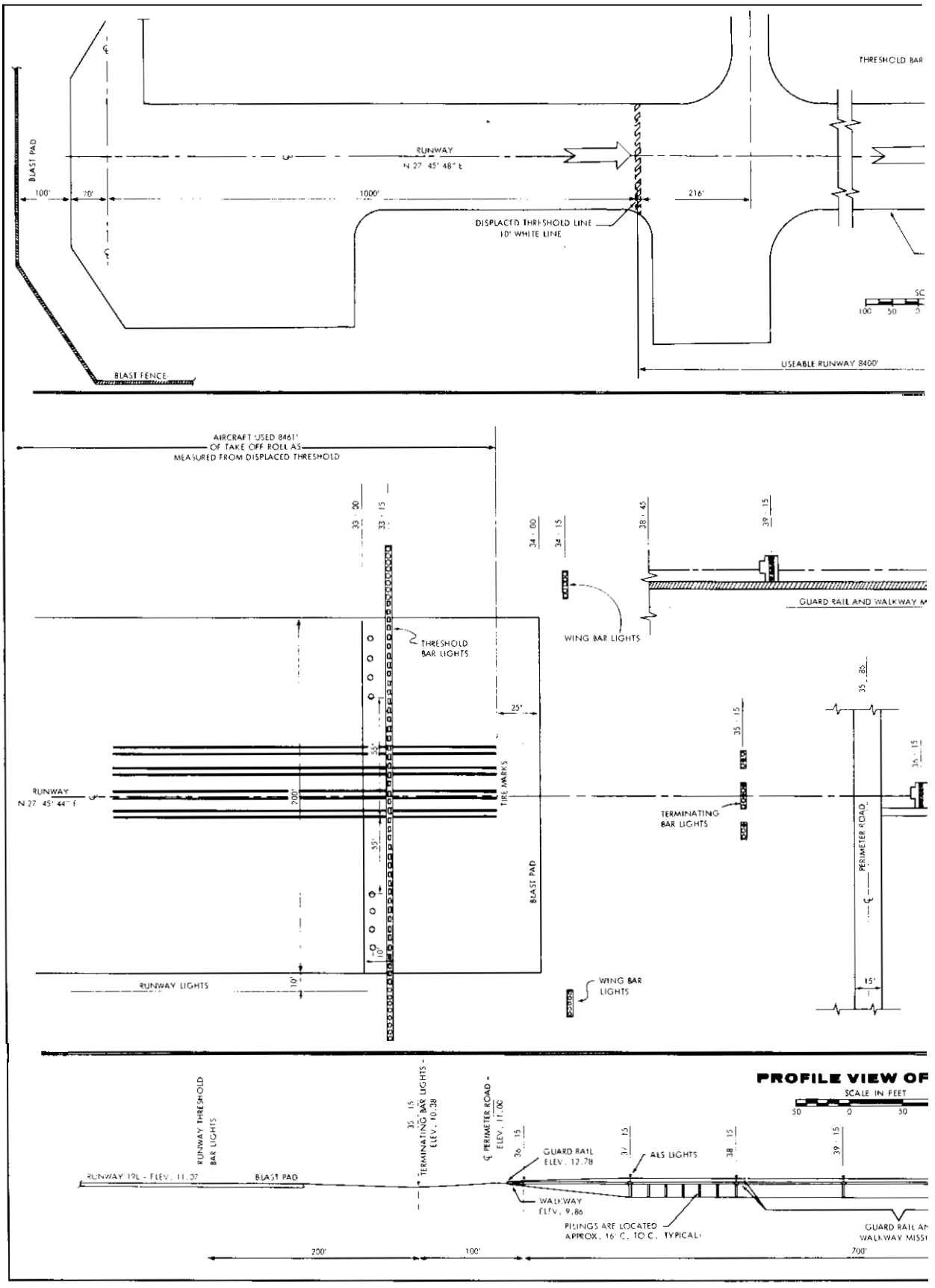
c. Inherent inaccuracies in acceleration data, i.e., rolling takeoff vs. brake release takeoff and rate of thrust application could result in misuse of acceleration checks and lead to unnecessary rejected takeoffs and increased exposure to overruns.

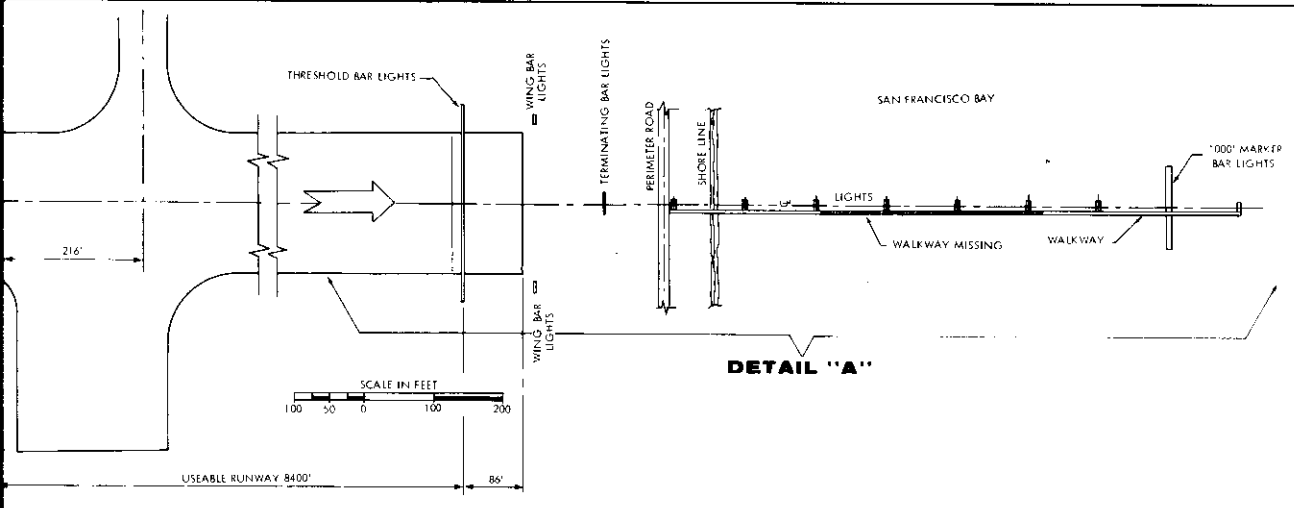
Finally this accident, in our view. would not have been prevented by an acceleration check. The use of systems to monitor takeoff performance are being investigated by various segments of the industry. We are following the developments of these systems and their possible application to everyday operations.

Recommendation No. **5.** FAA approved flight manuals and airline operations manuals contain normal, abnormal and emergency procedures and include information concerning the characteristics and handling of the aircraft when reasonably probable combinations of systems occur. Part 121 of the Federal Aviation Regulations requires pilots to receive initial and recurrent training on inflight emergencies. We believe that the present manuals and training procedures are satisfactory at this time.

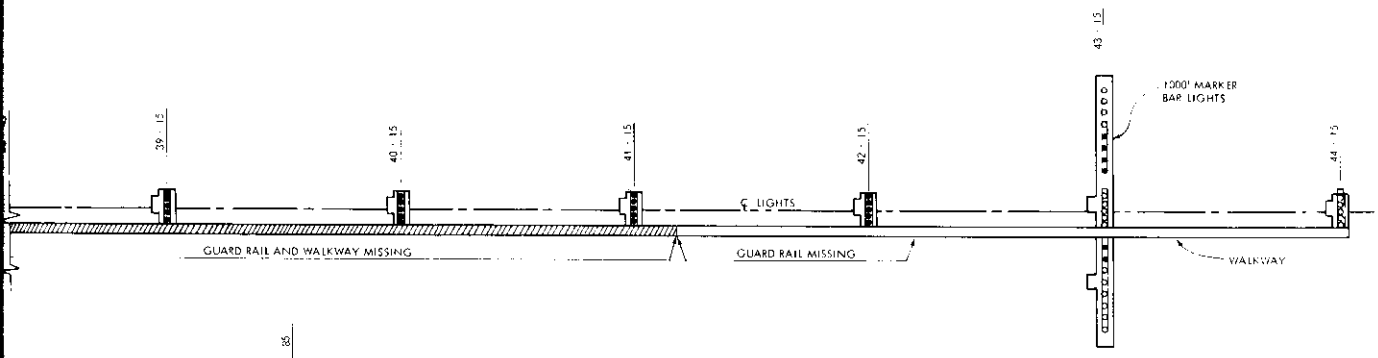
Sincerely,

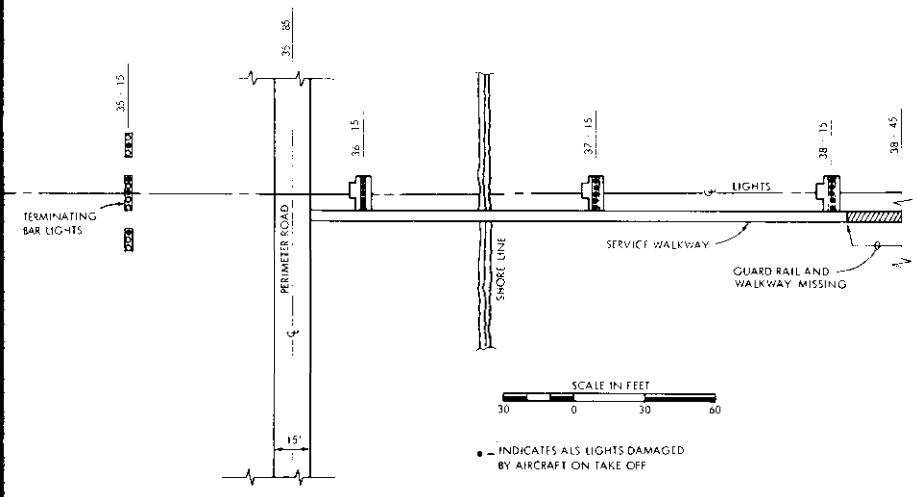
J. H. Shaffer
Administrator


BLAST PAD
RUNWAY
N 27° 45' 48" E
100'
20'
1000'
216'
DISPLACED THRESHOLD LINE
10' WHITE LINE
THRESHOLD BAR
BLAST FENCE
USEABLE RUNWAY 8400'
AIRCRAFT USED 8461'
OF TAKE OFF ROLL AS
MEASURED FROM DISPLACED THRESHOLD
33 - 90
33 - 15
34 - 00
34 - 15
38 - 45
39 - 15
WING BAR LIGHTS
GUARD RAIL AND WALKWAY M
THRESHOLD
BAR LIGHTS
25'
RUNWAY
N 27° 45' 44" E
200'
TIRE MARKS
35 - 15
35 - 80
36 - 15
TERMINATING
BAR LIGHTS
PERIMETER ROAD
BLAST PAD
RUNWAY LIGHTS
10'
WING BAR
LIGHTS
15'
PROFILE VIEW OF
SCALE IN FEET
50
0
50
RUNWAY THRESHOLD
BAR LIGHTS
RUNWAY 19L - ELEV. 11.07
BLAST PAD
35 - 15
TERMINATING BAR LIGHTS -
ELEV. 10.38
℄ PERIMETER ROAD -
ELEV. 11.00
36 - 15
GUARD RAIL
ELEV. 12.78
37 - 15
ALS LIGHTS
38 - 15
39 - 15
WALKWAY
ELEV. 9.86
PILINGS ARE LOCATED
APPROX. 16' C. TO C. TYPICAL
GUARD RAIL AN
WALKWAY MISSI
200'
100'
700'



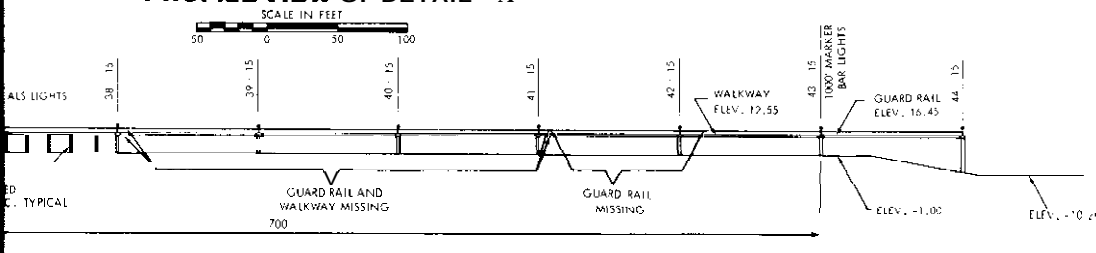
DETAIL "A"





PLAN VIEW OF DETAIL "A"

PROFILE VIEW OF DETAIL "A"

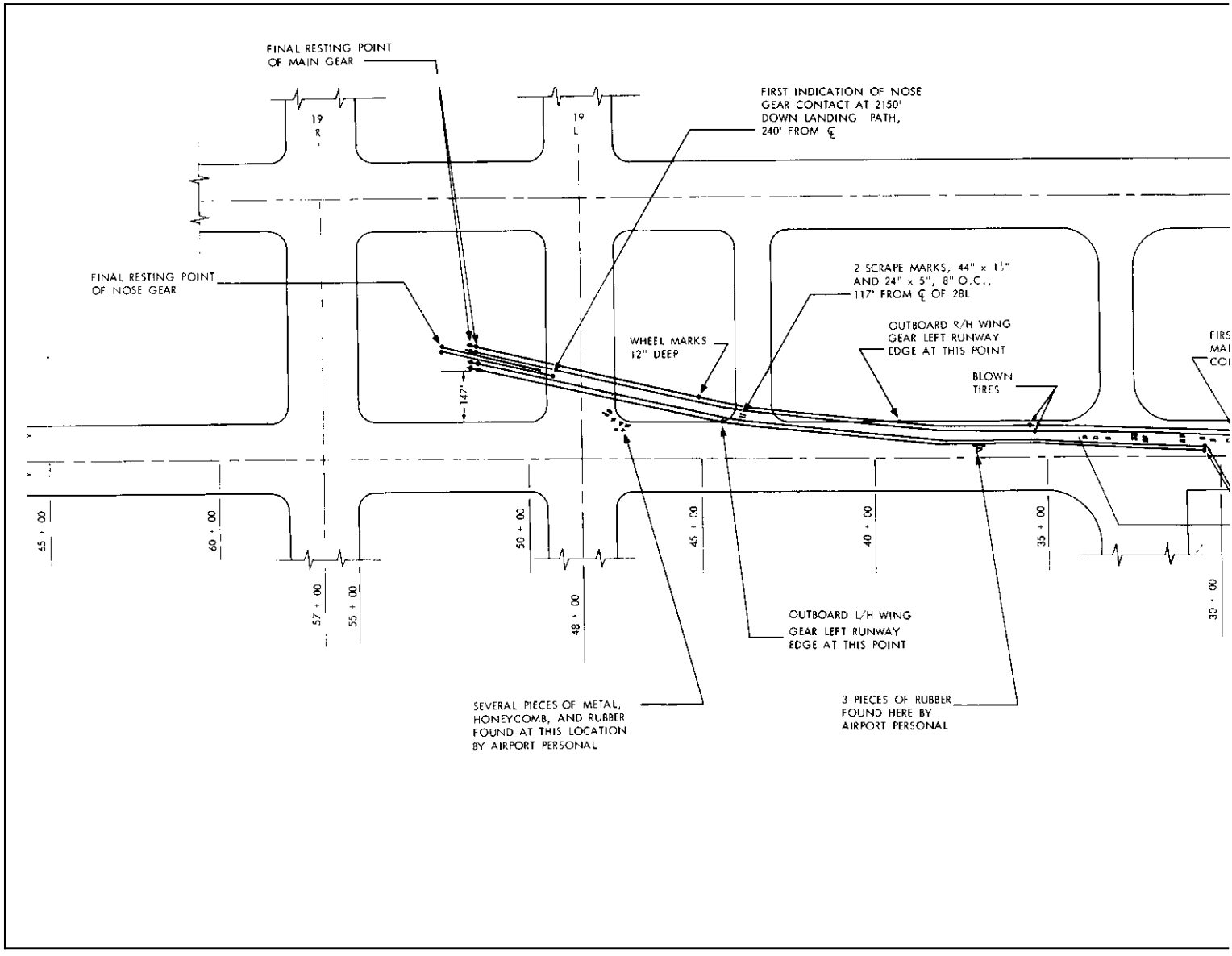


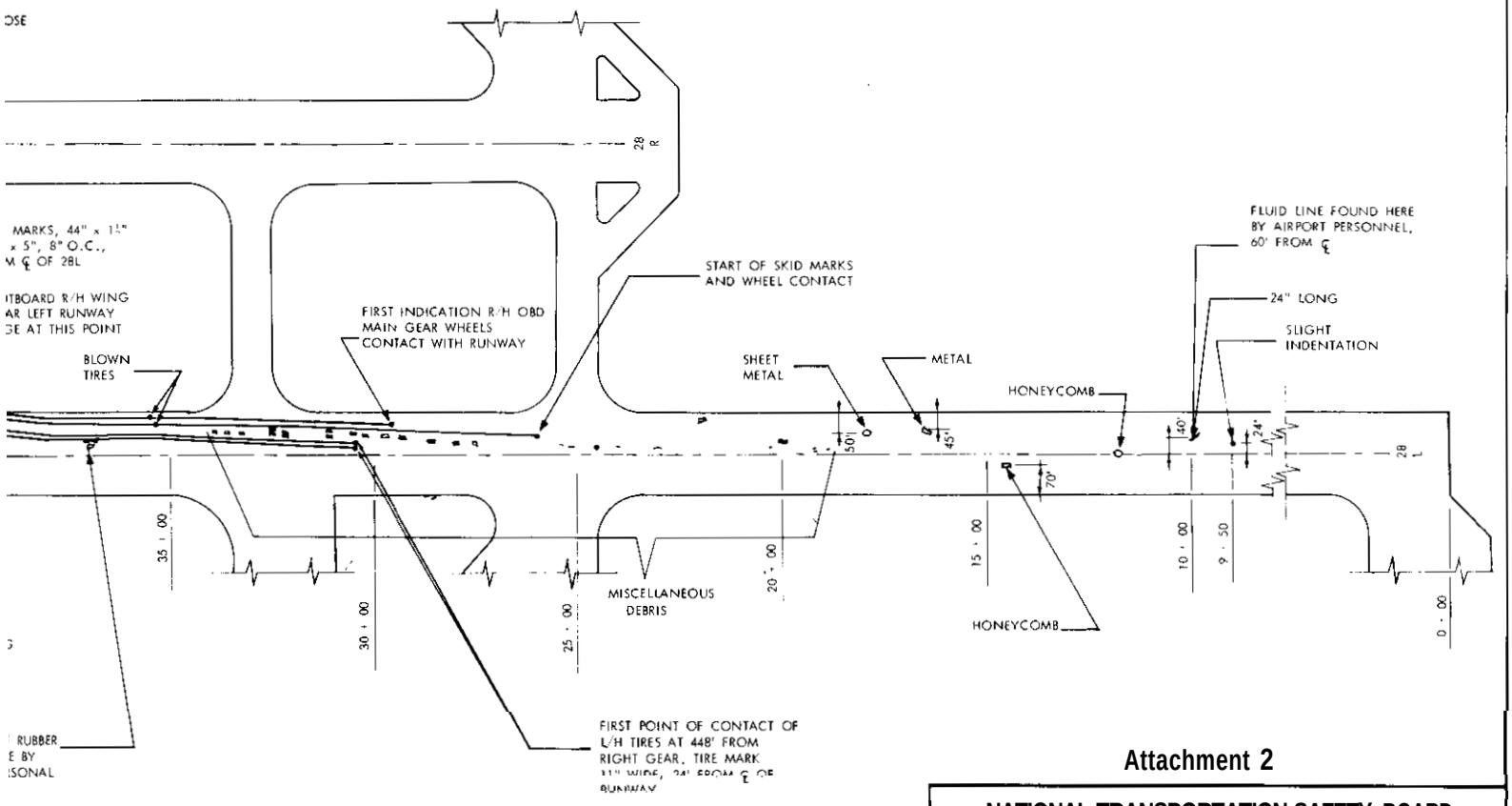
Attachment 1

NATIONAL TRANSPORTATION SAFETY BOARD
Washington, D.C.

DAMAGE TO APPROACH LIGHTING SYSTEM RUNWAY 19L

PAN AMERICAN AIRWAYS, INC. BOEING 747-121, N-747PA
SAN FRANCISISCO INTERNATIONAL AIRPORT
San Francisco, Calif.
July 30, 1971


FINAL RESTING POINT OF MAIN GEAR
19 R
19 L
FIRST INDICATION OF NOSE GEAR CONTACT AT 2150' DOWN LANDING PATH, 240' FROM ℄
FINAL RESTING POINT OF NOSE GEAR
2 SCRAPE MARKS, 44" x 13" AND 24" x 5", 8" O.C., 117' FROM ℄ OF 28L
WHEEL MARKS 12" DEEP
OUTBOARD R/H WING GEAR LEFT RUNWAY EDGE AT THIS POINT
BLOWN TIRES
147'
65 + 00
60 + 00
57 + 00
55 + 00
50 + 00
48 + 00
45 + 00
40 + 00
35 + 00
30 + 00
OUTBOARD L/H WING GEAR LEFT RUNWAY EDGE AT THIS POINT
SEVERAL PIECES OF METAL, HONEYCOMB, AND RUBBER FOUND AT THIS LOCATION BY AIRPORT PERSONAL
3 PIECES OF RUBBER FOUND HERE BY AIRPORT PERSONAL

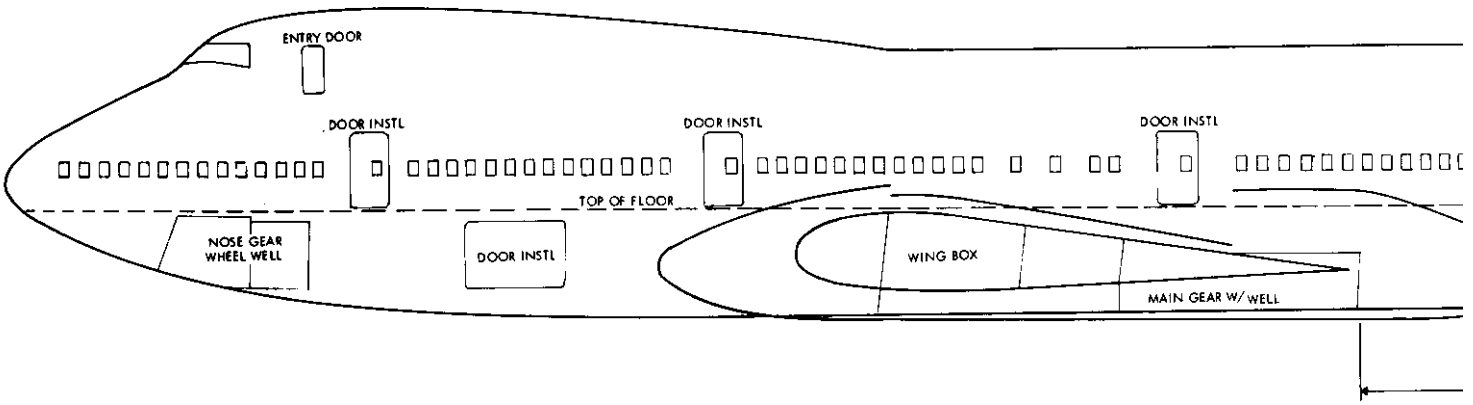


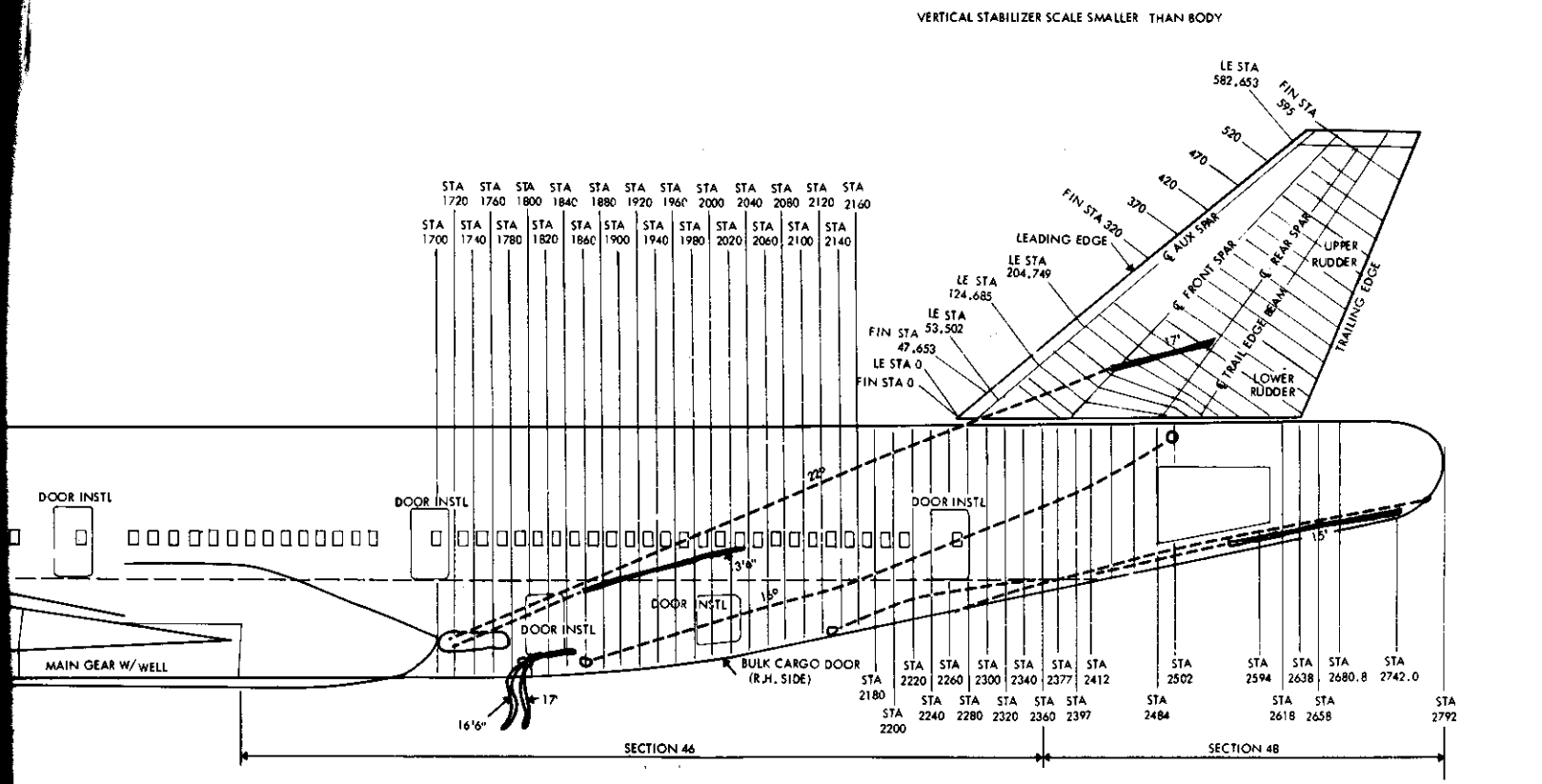
Attachment 2

NATIONAL TRANSPORTATION SAFETY BOARD
Washineton. D. C.

LANDING DATA AND WRECKAGE DISTRIBUTION ON RUNWAY 28L
PAN AMERICAN AIRWAYS, INC. BOEING 747-121, N-747PA

SAN FRANCISCO INTERNATIONAL AIRPORT
San Francisco. California
July 30. 1971


ENTRY DOOR
DOOR INSTL
DOOR INSTL
DOOR INSTL
TOP OF FLOOR
NOSE GEAR
WHEEL WELL
DOOR INSTL
WING BOX
MAIN GEAR W/ WELL



HANDRAIL PENETRATION INTO FUSELAGE

Attachment 3