File No.A-0001

AIRCRAFT ACCIDENT REPORT

Jugoslovenski Aerotransport (JAT)
Boeing 707-321, YU-AGA
John F. Kennedy International Airport
Jamaica, New York
August 13, 1972

Adopted: April 4, 1973

NATIONAL TRANSPORTATION SAFETY BOARD
Washington, D.C. 20591

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16. Abstract On August 13, 1972, at 0050 eastern daylight time, while aborting a takeoff from Runway 13R, John F. Kennedy International Airport, Jamaica, New York, Jugoslovenski Aerotransport (JAT) Flight 3410 ran off the end of the runway.

There were 175 passengers and a crew of 11 aboard the aircraft at the time of the accident; 15 passengers and a steward were injured during evacuation.

During the takeoff, the right cockpit sliding window came open, and made a loud noise. The captain initiated action to reject the takeoff. The aircraft ran off the end of the runway, struck the blast fence, and came to a stop approximately 120 feet from the end of the paved surface and 80 feet to the right of the runway. The left wing and engines Nos. 1 and 2 were damaged by impact and the ensuing fire. The crew and passengers successfully evacuated the aircraft by means of the emergency slides.

The National Transportation Safety Board determines that the probable cause of this accident was the unknown degraded capability of the heavily loaded aircraft's braking system, which precluded stopping the aircraft within the runway distance available. The reduced braking capability resulted from a malfunctioning V-3 relay in the left antiskid control shield of the aircraft's braking system, which rendered two of the eight-wheel brakes ineffective. A sound like that of an explosion in the cockpit during the takeoff roll caused the captain to reject the takeoff.

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BOEING 707-321, YU-AGA
JOHN F. KENNEDY INTERNATIONAL AIRPORT
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SYNOPSIS

Jugoslovenski Aerotransport (JAT) Flight 3410 was involved in an accident on August 13, 1972, at 0050 eastern daylight time during a rejected takeoff from Runway 13R at the John F. Kennedy International Airport, Jamaica, New York. There were 175 passengers and a crew of 11 aboard the aircraft at the time of the accident; 15 passengers and a steward were injured during the evacuation from the aircraft.

During the takeoff, the right cockpit sliding windown came open, which made a loud noise. This action occurred 3 seconds after the co-captain had called V1. The captain initiated action to reject the takeoff. The aircraft ran off the end of the runway, struck the blast fence, and came to a stop approximately 120 feet from the end of the paved surface and 80 feet to the right of the runway. The left wing and engines Nos. 1 and 2 were damaged by impact and the ensuing fire. The crew and passengers successfully exited the aircraft.

The emergency equipment from the Port of New York and New Jersey Authority arrived on the scene in approximately 4 minutes and extinguished the flames.

The National Transportation Safety Board determines that the probable cause of this accident was the unknown degraded capability of the heavily loaded aircraft's braking system, which precluded stopping the aircraft within the runway distance available. The reduced braking capability resulted from a malfunctioning V-3 relay in the left antiskid control shield of the aircraft's braking system, which rendered two of the eight-wheel brakes ineffective. A sound like that of an explosion in the cockpit during the takeoff roll caused the captain to reject the takeoff.

1. INVESTIGATION

1.1 History of the Flight

Jugoslovenski Aerotransport (JAT), a Boeing 707-321, YU-AGA, operating as Flight 3410 (JU3410) on August 13, 1972, was scheduled from the John F. Kennedy (JFK) International Airport to the Rijeka Airport, Rijeka, Yugoslavia.

JU3410 was an international operation transporting a charter group of 175 passengers from the United States to the Island of Krk on the Northern Adriatic Sea Coast of Yugoslavia and was scheduled for departure at 2330 1/, August 12, 1972. The actual departure from the British Overseas Airways Corporation (BOAC) terminal gate was at 0023:45.

The aircraft ran off the end of the 14,572-foot Runway 13R and impacted the blast fence at the end of the runway during an attempt to reject the takeoff.

An International Instrument Flight Rules flight plan was filed for JU3410 by the Pan American World Airways (PAA) New York dispatch office from JFK to Shannon, Ireland. This dispatching was done under contract arrangements between PAA and JAT. The crew's stated intention was to refile in-flight over Shannon for Rijeka or an alternate, depending on weather conditions.

The flight dispatch release for JU3410 of August 13, 1972, was prepared and signed by the PAA dispatcher on duty. The dispatch release was valid until 0030. However, in order for such a release to be in effect, it was necessary for the captain of the flight to sign, indicating that he concurred with the dispatcher that the contemplated operation could be safely conducted under the prevailing and forecast conditions. The captain did not sign the dispatch release for JU3410 of August 13, 1972.

The crew prepared a Yugoslav Airlines loadsheet at the BOAC Terminal and increased the fuel loading indicated on the PAA dispatch

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1/ All times herein are eastern daylight, based on the 24-hour clock.

release from 108,900 pounds to 137,000 pounds. This fuel, less 2,000 pounds necessary for taxi, placed the calculated gross weight of the aircraft at its maximum structural weight limit of 312,000 pounds for this takeoff. The FAA Dispatcher was not informed of these changes.

Upon boarding the aircraft, and during the cockpit check of the aircraft, the crew listened to the ATIS 2/ "Zulu," effective at 2251, August 12, 1972, which announced, among other airport data, that the wind was 220° (magnetic) at 8 knots. Neither the JFK Tower Ground Controller nor the JFK Local Controller volunteered any information that the wind was other than as had been given in the effective ATIS broadcast. The actual wind, as recorded by the National Weather Service at 0051, August 13, 1972, was 220° True (210° magnetic) at 8 knots.

BOAC, also working under contract with JAT, performed the aircraft preparation (i.e., fueling, maintenance release, required ramp maintenance, aircraft loading, etc., as well as passenger handling) for the flight.

The crew calculated the aircraft total weight at the beginning of the takeoff to be 311,725 pounds. The takeoff reference speeds (V speeds) 3/ for an aircraft of this weight with a temperature of 71°F. (21°C.) would be:

V_1 - 150 knots
V_R - 160 knots
V_2 - 170 knots

These speeds were obtained from the aircraft's operating manual and were placed on the takeoff data card by the flight engineer.

At 0015:20, the cocaptain for the flight, who was occupying the right seat and who was performing the duties of the copilot, called the JFK Clearance Delivery Controller for the flight clearance.

2/ ATIS - Automatic Terminal Information Service.

3/ V Speeds - V_1 - critical engine failure speed.
V_R - rotation speed.
V_2 - takeoff safety speed.

At 0020:00, the cocaptain called JFK Ground Control for pushback from the BOAC Terminal and asked for taxi clearance to Runway 13R. Runway 22R was in use at this time; however, JU3410, at the existing gross weight and the existing temperature, would have been at the maximum limit for a takeoff from the 11,350-foot Runway 22R. The crew requested the use of the 14,572-foot Runway 13R. This request was granted and the flight was cleared to taxi to Runway 13R at 0026.

At 0047:50, JU3410 was cleared into position to hold on Runway 13R and at 0049:05, the flight was cleared for takeoff.

As the aircraft accelerated, the cocaptain called 80 knots airspeed, followed 25 seconds later by the V1 call. Three seconds after the V1 call, the right cockpit sliding window opened, and created a loud noise.

The captain immediately initiated the reject takeoff procedures, deployed speed brakes, selected reverse thrust, and placed 100 percent N_1 [4/] on all four engines, and then applied the main wheel brakes. The aircraft continued along the runway and left tire skid marks for about the last 1.2 statute mile (see Appendix D). Near the intersection of Runway 13R and 4L, the skid marks arced slowly from astride the centerline to the right side of the runway. The aircraft ran off the right side of the paved surface at the end of the runway. The aircraft then continued through the blast fence to a point 120 feet from the end and 80 feet to the right of the runway. The aircraft came to a stop with the left outboard wing section engulfed in flames. The engines were shut down, and the fire extinguishing systems were activated for the Nos. 1 and 2 engines. The captain exited from the aircraft through the cockpit left sliding window to keep the passengers away from the fire and to expedite their movement away from the burning aircraft. The other flight crewmembers went to the passenger cabin to assist in passenger evacuation.

1.2 Injuries to Persons

Injuries	Crew	Passengers	Other
Fatal	0	0	0
Nonfatal	1	15	0
None	10	160	

4/ N_1 - engine low-pressure turbine speed.

1.3 Damage to Aircraft

The nose cowl sections of the Nos. 1 and 2 engines and the outboard section of the left wing received major damage in impacting the blast fence, and the left wing, outboard of the No. 2 engine was damaged by fire. The front and rear tires on the Nos. 2, 3, and 4 tandem wheels 5/ were flat and all but one tire contained evidence of even wear. All of the tires had tread remaining on the carcasses, and only the No. 3 rear tire had a "flat" spot worn into the cords of the tire body.

1.4 Other Damage

Thirty feet of the steel blast fence at the end of Runway 13R/31L was destroyed. Several frangible fittings, located about midway up the support brackets of the blast fence structure were separated by the impact.

1.5 Crew Information

The crewmembers were certificated in accordance with existing Yugoslavian regulations and International Civil Aviation Organization (ICAO) standards to perform the duties of flight crewmembers for this flight. (See Appendix B for details.)

1.6 Aircraft Information

Aircraft YU-AGA, A boeing 707-321, serial No. 17601 was leased by the Jugoslovenski Aerotransport (JAT) from the GATX Bulk Carrier Number Three of Monrovia, Liberia. The aircraft formerly had been owned and operated by PAA under United States Registry N723PA. At the time of the accident, the aircraft was registered in Yugoslavia. (See Appendix C for details.)

The aircraft cabin configuration had 177 passenger seats and four cabin crewmember jump seats.

The maximum design takeoff gross weight was 312,000 pounds. The center of gravity limits for the loading of this aircraft in a passenger configuration were 21 percent forward and 35 percent aft

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5/ The main landing gear consists of eight wheels that are arranged in a tandem series and are numbered from left to right.

Mean Aerodynamic Chord (MAC). The stabilizer trim was set at "21" during completion of the pretakeoff checklist. The trim setting was found at 22 percent MAC after the accident.

All baggage and spare parts were weighed after the accident. These weights, passenger normal weights, plus other operational weights (fuel, oil, crewmembers, etc.) combined to a calculated gross weight of about 311,000 pounds at the time the brakes were released to commence the takeoff.

1.7 Meteorological Information

JU3410 had been provided with meteorological data pertinent to the PAA computer flight plan to Shannon, Ireland, with an alternate of Heathrow Airport, London, England. No weather information was provided by PAA to the crew for the continuation of the flight from Shannon, Ireland, to Rijeka, Yugoslavia.

The crew, after boarding the aircraft, received the Kennedy Airport Terminal Information Service, as follows:

> "This is Kennedy Departure Information Service with Information ZULU. Departure Runway 22R. Wind 220° 6/ at 8. Altimeter 30.08. Temperature 71° at 0251 Z."

ATIS information was the only local weather provided to the crew after they had boarded the aircraft.

The National Weather Service 0051 local weather observation was in part:

> Ceiling measured 4,600 feet broken, 25,000 broken, visibility 8 miles, temperature 71° F., dewpoint 62° F., wind 220° 7/ 8 knots, altimeter setting 30.08 inches.

6/ Wind is reported by magnetic direction by tower personnel.

7/ Wind was recorded by true direction by weather observers. The magnetic variation for the JFK area was 10° W.

The local weather observation taken at 0101 was:

> Ceiling measured 4,600 broken, 25,000 broken, visibility 8 miles, temperature 70° F., dewpoint 62° F., wind 220°, 7 knots, altimeter 30.08, remarks - aircraft accident.

1.8 Aids to Navigation

Not involved.

1.9 Communications

No difficulties with communications between the flight and the air traffic control facilities were reported.

1.10 Aerodrome and Ground Facilities

Runway 13R/31L at the John F. Kennedy International Airport is 14,572 feet long and 150 feet wide. The runway is constructed of concrete and has a Federal Aviation Administration (FAA) gross weight strength limitation of 340,000 pounds for an aircraft with dual wheel tandem design. The surface of the runway contains numerous repair patches of an asphaltic material. The runway profile of 13R is undulating.

Steel blast fences were listed on the FAA Airport Master Record dated September 21, 1970, at 13R/31L; however, the only blast fence on this runway is at the end of Runway 31L.

Runway 13R was equipped with high-intensity runway lights that were controlled by a five-step intensity selector switch in the tower. The lights were set on "Step 1" which was the lowest intensity setting. All runway lights were operating at the time of the accident.

1.11 Flight Recorders

YU-AGA was equipped with a Lockheed Aircraft Service Co., Model 109-C Flight Data Recorder (FDR) and it was operating.

The altitude trace was constant and consistent with the runway elevation.

The airspeed trace showed an increasing airspeed from the time of brake release for a period of 54 seconds, attaining a maximum of 154 knots. The speed was then relatively constant for 3 seconds, followed by a constant rate of decline for 18 seconds, down to 70 knots. There were erratic excursions of the airspeed trace during the ensuing 3 seconds down to a speed of 34 knots, a straight-line excursion for 4 seconds, and a decrease in speed to 32 knots in the next 2 seconds. The trace then resumed approximately the same rate of decrease that was shown from 154 knots down to 70 knots and continued to decrease to about 10 knots; the rate of decrease then flattened and the speed decreased from 10 knots to 8 knots in 4 seconds.

The aircraft was also equipped with a Fairchild Model A-100 Cockpit Voice Recorder. The unit and the tapes were undamaged by the accident, and a transcription of the voices and sounds, commencing at the time of the crew's initial call to the JFK Tower, was made.

The tape disclosed that at 0049:05.5, JU3410 was cleared for takeoff and at 0049:26.5, the captain stated, "Let's go." The cocaptain, 23.7 seconds later, called 80 knots, and 24.03 seconds later, the V1. Three seconds after the V1 call, the noise of an explosion, followed by a continuing roar, was recorded. During the next 43 seconds, until the aircraft came to a stop, the following comments were recorded sequentially: "Window open ... engine down ... speed brakes ... reverse ... all reverse."

1.12 Wreckage

The aircraft sustained extensive damage to the left outboard wing panel, left aileron, and the left outboard wing flap as the result of impact with the steel blast fence and the ensuing fire.

The nose cowl sections of the Nos. 1 and 2 engines were crushed rearward to the compressor fan inlet area of the engines.

The lower wingskin between the No. 2 engine and the No. 1 engine was severely damaged by impact.

The Nos. 2, 3, and 4 front and rear brakes had been subjected to extremely high internal heat. The disc lugs for these brakes had been sheared and pieces of the lugs were found in the wheel slots. Numerous brake return springs were missing from these brakes; several were found along the runway, about 1,000 feet prior to the end of 13R.

1.13 Fire

A fire engulfed the left outer wing panel outboard of the No. 2 engine following impact of the aircraft with the blast fence. The left fuel tank was ruptured, and a ground fire developed from the spilled fuel.

1.14 Survival Aspects

The aircraft came to a stop in the sand off the end and to the right of the runway. Fires started in engines Nos. 1 and 2, the left outboard wing section, and on the ground underneath the left wing.

Five crewmembers occupied the cockpit, and six cabin attendants were stationed in the cabin. The cabin attendants were stationed as follows: two on the aft-facing jumpseat by the forward entry door, two on the forward facing jumpseat at the aft entry door, and two in the first passenger seats on the left side of the aircraft. Passengers occupied all of the remaining seats in the cabin.

A predeparture emergency briefing and information announcement was made by the No. 1 purser during the 26-minute taxi from the boarding gate to the runway. The passengers described a bumpy takeoff roll, followed by a rough bumpy deceleration until the time the aircraft came to a stop. None of the passengers or crewmembers reported receiving any injury during this portion of the occurrence. All cabin structure and furnishings remained intact, but pillows and blankets fell from the overhead storage racks into the center aisle. Stacks of extra meal boxes, numerous canned drinks, as well as ice from ice buckets were propelled into the aisles and galley areas. These items had not been secured prior to the takeoff. Several passengers reported that these loose objects impeded their exit from the aircraft.

The passengers began to evacuate the cabin on their own initiative when they observed flames outside the left side of the aircraft. No announcement was made over the public address system or the self-powered megaphones, even though this emergency equipment was available in the cabin.

The escape rope at the left sliding window of the cockpit, the inflatable slide at the forward entry door, and the slide at the forward galley service door were deployed and used during the evacuation of the aircraft. The slide for the aft galley service door was automatically deployed when the door was opened by the No. 4 steward; however, the

slide failed to inflate after he reportedly activated it. The steward and the aft purser, followed by several passengers, jumped from the aft galley exit to the ground. The distance from the floor to the ground was approximately 8 feet. A short time later, after all passengers had exited, this slide was observed to be inflated and holding pressure. Examination of this slide and its associated mechanisms after the accident did not disclose a discrepancy or malfunction of any component, and there was no explanation of the failure of the slide to inflate initially.

Several passengers evacuated through both overwing exists on the right side of the aircraft. No cabin crewmembers were at these exists and the escape rope was not deployed. Passengers reported that they jumped from the trailing edge of the wing, a distance of approximately 5 feet, and from the leading edge of the wing, which was approximately 7 feet above the ground. Eleven passengers and one stewardess reported that they received sprains, strains, and bruises of the extremities as a result of jumping to the ground from the right wing or the aft galley exit. No serious injuries were sustained by crewmembers or passengers as a result of the accident or as they disembarked from the aircraft.

The site where the aircraft came to a stop is located 1.8 statute miles from the JFK No. 1 Airport Fire Station and 1.9 statute miles from the JFK Satellite Airport Fire Station.

The airport crash alarm was sounded by FAA Tower personnel at 0050 and the airport emergency equipment was reported to have arrived at the burning aircraft at 0054. All occupants were out of the aircraft prior to the arrival of this emergency equipment. The fire was extinguished within 5 minutes after the arrival of the emergency equipment, with a minimal amount of fire damage to the aircraft.

1.15 Test and Research

The copilot's No. 2 sliding window came open 3 seconds after the aircraft had accelerated to V_1. The roll pin which secures the window handle to its shaft was found withdrawn approximately a quarter of an inch. The trigger lock bolt had evidence of wear on the bottom end; the window adjusting rod was out of adjustment, shortened by one full turn of the rod; and the window handle machanism had excessive play in it. The window was checked for operation. (The normal force required to place the handle in the locked position is 45 $\pm$ 15 pounds.) A force of 48 to 60 pounds was required to close and lock the window. The spring-loaded trigger in the handle hung in a midtravel position,

and the associated trigger lockbolt did not fully engage the lockplate hole. In this condition, the window would appear to be in the closed and locked position; however, any pressure on or movement of the handle would disengage the trigger lockbolt from the lockplate and the window could open.

After the accident, a pencil, fractured in several places, was found in the window track. Comparison tests were performed by inserting a pencil in the handle trigger lockplate and cover assembly hole adjacent to the handle. The window was then unlocked and opened. The pencil sheared in the same manner as the one initially found in the window track. This test was performed twice with the same results.

The brake-adjusting units were removed from the brake assemblies and checked for their functional capabilities. The units for the No. 2 forward and the No. 3 aft brake assemblies were found to have a slight hydraulic leak at high pressures. All other units were found to be normal in all aspects.

A rotation check of the flywheel detectors in the brake antiskid system between 500 and 1500 r.p.m. indicated a brake release condition on the No. 1 and the No. 4 forward and aft cockpit indicators. All of the detectors were removed and functionally tested with the following results:

Position	Findings
No. 1 Forward	Checked within specified limits
No. 1 Aft	High skid switch resistance between Pins C-D

Unit Clockwise Rotation

Test Speed	Limits	Findings
800 r.p.m.	.94 - 1.37 secs.	1.48 secs.
1,000 r.p.m.	1.18 - 1.72 secs.	1.76 secs.

Unit Counterclockwise Rotation

500 r.p.m.	.59 - .86 secs.	.91 secs.

No. 2 Forward	Slightly high-skid switch resistance between pins C-D and pins A-D
No. 2 Aft	Clockwise, clutch test indicated skid switch signal time in excess of limits

No. 2 Rear Unit Clockwise Rotation

Test Speed	Limits	Findings
500 r.p.m.	.59 - .86 secs.	.90 secs.
800 r.p.m.	.94 - 1.37 secs.	1.46 secs.

No. 3 Forward	Pins C-D and C-B closed circuit; unit inoperative when rotated clockwise.
No. 3 Aft	Skid-deceleration rate slow

No. 3 Rear Deceleration Limits	Findings
40 - 56 Radians	36 Radians

No. 4 Forward	Checked within specified limits
No. 4 Aft	Clockwise, clutch test indicated skid signal time in excess of limits

No. 4 Rear Clockwise Rotation

Test Speed	Limits	Findings
500 r.p.m.	.59 - .86 secs.	.90 secs.
800 r.p.m.	.94 - 1.37 secs.	1.45 secs.
1,000 r.p.m.	1.18 - 1.72 secs.	1.76 secs.

The brake system antiskid control shields were removed and functionally tested. The left control shield for the No. 1 forward and aft brakes had a defective "V-3" relay that prevented it from being energized. Under the circumstances, no matter how much pressure was applied to the brake pedals, the No. 1 front and rear brakes remained in a released condition.

The Boeing Company provided the following brake performance data:

1. Estimated energy for the six brakes working during the stop:

   39.28×10^6 foot pounds per brake. This value is based on Boeing estimates of the maximum effort stopping capability with reverse thrust rather than analysis of the flight recorder data.

2. Maximum energy level to which the brakes have been demonstrated as determined by analysis of the certification flight test data:

   38.7×10^6 foot pounds per brake. This is the brake energy value upon which flight manual limitation is based.

The Boeing Company also stated that the effect of a 10° change in wind direction, with the resulting 2-knot downwind component, would result in a negligible increase in the accelerate/stop distances for the aircraft.

The PAA Route Manual for a B-707 on Runway 13R at JFK shows a required maximum gross weight reduction of 5,000 pounds (i.e. 307,000 v. 312,000) with a 2-knot tailwind at 21°C., (71°F.). Boeing data show that the reduction of 5,000 pounds would be necessary only if the takeoff is limited by runway length. With 14,572 feet of runway available, no limitation on the aircraft was necessary.

2. ANALYSIS AND CONCLUSIONS

2.1 Analysis

The actual destination of the flight was Rijeka, Yugoslavia. Because the FAA dispatch computer does not have Rijeka, Yugoslavia

in its system, the aircraft was dispatched to Shannon, Ireland. In this case, if the computer-predicted fuel consumption was accurate, the aircraft would have been 20,000 pounds overweight on landing at Shannon. However, JAT company procedures allow -- depending upon the fuel remaining and the existing weather conditions -- the captain to refile in the air, to another destination.

The complex servicing, maintenance, and dispatching procedures being handled through contract and subcontract methods tend to remove or dilute the responsibility of the carrier for operations such as are involved in this accident. For example, an organization which operates an aircraft does not have the responsibility of time control on the components installed on the aircraft. Moreover, recordkeeping, replacement of parts, and maintenance of all types are taken care of by contract. Contractual agreement also places the responsibility for the spare parts carried aboard the aircraft on other than the operator. Finally, this method of dispatching separates the operator and his method of flight operation from the direct line control and supervision of the dispatch function. Although these areas of operational control and the observed weaknesses therein were not in the causal area of this accident, they are discussed in order that this operator, and other operators, may be aware of the possible problems of such complex arrangements.

The opening of the copilot's sliding window was the initiating factor in the captain's decision to reject the takeoff.

The condition of the locking mechanism in this window was such that all outward appearances convinced the cocaptain that his window was closed and locked. The facts, however, demonstrate that the locking mechanism was out of adjustment, the locking bolt trigger was hanging up in a midposition, and the locking bolt was not fully in place in the lockplate hole.

Based upon the data obtained from the tests with a pencil inserted in the cover assembly hole adjacent to the handle of the sliding window, the Board concludes that the pencil was not instrumental in preventing the window from being closed or locked.

The roughness and undulation of the surface of Runway 13R, discussed by the crew while taxiing to the runway, is considered to have been a factor in the opening of the cocaptain's window during the

takeoff, since the roughness of the runway would have been transmitted to the airframe while the aircraft was accelerating on the runway surface. This could have caused a flexing of the airframe. If the locking pin, because of the hanging trigger or the maladjustment of the locking rod, was only partially engaged, the flexing of the airframe could have been sufficient to disengage the lock completely and allow the outside air pressure to force the window open. If the aircraft had been pressurized, the positive pressure inside the aircraft would have resisted, if not totally overcome, the outside air pressure that was created by the velocity of the aircraft. This pressurization could have held the window in the closed position. Since the pressurization of the aircraft increases as soon as the aircraft leaves the ground, and the window is a plug type installation, it is probable, according to the aircraft manufacturer, that the cocaptain could have closed the window in flight. This could have been accomplished only if he were able to move the window into the window opening from a fully retracted position. If this condition could have been met, the positive air pressure inside the aircraft would then have assisted him in closing the window. This condition is purely analytical because the captain, before the cocaptain called, "Window-open," had initiated rejected takeoff procedures, and the problem was then confined to stopping the aircraft.

All pilots are keenly aware of the possibility of an explosive device being placed on board their aircraft. Any loud sound can logically cause a reflex reaction by a pilot to keep his aircraft on the ground if he has not yet lifted off. The pilot usually has no way of assessing immediately whether his aircraft has been rendered uncontrollable by an explosion or whether the loud sound was caused by something that would not affect control. Therefore, under the circumstances, the pilot's judgment to stop his aircraft on the ground rather than to continue the takeoff is understandable.

The crew knew that the flight manual performance charts for this aircraft indicated that they should be able to stop the aircraft from a V_1 speed of 150 knots within the confines of 11,400 feet of runway. This required distance allows for brake release at maximum gross weight of 312,000 pounds, reducing this weight by about 2,500 pounds due to fuel burn during the acceleration to 150 knots, then applying maximum hydraulic brakes and speed brakes in order to stop the aircraft. The crew was aware that Runway 13R was 14,572 feet in length and that under the conditions described above, the aircraft should come to a stop with

approximately 3,000 feet of runway remaining. The crew was also aware that the effect of engine reverse thrust was not considered in calculating the stopping distance from V_1. These factors all combined to allay any thought by the captain that he would have any difficulty in stopping his aircraft on this runway by the use of prescribed procedures.

In this instance, the sound of an explosion occurred 3 seconds after the cocaptain had called V_1. The aircraft had accelerated to 154 knots at that time. Considering all of these conditions, the aircraft with all brakes operating would have stopped 2,500 feet short of the end of the runway. Therefore, the captain's decision to reject the takeoff was reasonable.

The crew would have had an indication of the malfunctioning antiskid system by the "RELEASE" indicator in the antiskid annunciator located on the panel above the captain's head. This release indication would have appeared only during the takeoff run, and after the aircraft had accelerated to a speed in excess of 20 knots, but would not have been apparent during the routine cockpit checks by the crew. The annunciator is not in the direct or peripheral view of any crewmember, and it is not expected that any crewmember would be looking at the annunciator during a takeoff run.

A walk-around inspection would not have revealed the presence of this type of malfunction in the antiskid system. The only indication available through such inspection, in regard to the condition of the brakes, would be the wear indicator rods for each brake assembly. It was evident from the number of landings (559 on the No. 1 front and 913 on the No. 1 rear - Appendix C) that these brakes had not been functioning during the high-speed portions of the landings for a considerable period of time. The maintenance representative, as well as the crew, could only have assumed, by all outward indications, that the brakes were not worn below safe limits and were operating in a normal manner. There was no maintenance requirement nor was there a procedure by which the entire brake system was routinely checked. Only in the case of an entire landing gear change would there have been a functional check of the type necessary to determine the existence of a malfunction of the kind that was experienced in this accident. Progressive checks would be performed on the aircraft if a pilot reported a braking or antiskid problem that could not be isolated by a test of individual components in the system. This testing could eventually lead to the finding of a malfunctioning of the V-3 relay, as was experienced on this aircraft. There had been no pilot reports on this aircraft of any improper brake operation.

Normal procedures for landing preclude the use of brakes at speeds above 80 knots, and then, when the brakes are applied they are used only with sufficient pressure to slow the aircraft for a turnoff from the runway. The Board believes that under these conditions, it is doubtful that a pilot would be able to detect the differences between six- or eight-wheel braking. In actuality, the differences between a six- or an eight-wheel braking would become evident only when a maximum braking effort was made. A maximum braking effort would be made only during a rejected takeoff or a landing without reversers on a short runway.

At the time the rejected takeoff was initiated, the crew did not consider that an emergency situation existed; they were not aware that their braking capability was reduced, but they were aware that the selected runway was 3,200 feet longer than that required to meet the accelerate /stop criteria.

An analysis of the estimated stopping performance made by the manufacturer showed that the airplane might have accelerated to V_1 speed, under conditions approximating those which existed at the time of the accident, and still have stopped within the confines of the runway with all brakes operating.

However, several factors combined to prevent the crew from successfully stopping the aircraft short of the end of the runway.

One factor is that the rejected takeoff was initiated at a speed 4 knots above V_1. This excess speed alone required a theoretical 700-foot increase in stopping distance over that required for an abort initiated at V_1 speed.

Another factor was that the transition segment of the rejected takeoff was over 1,000 feet longer than that allowed by the accelerate/stop criteria. This increase might have been the result of increased transition times or the use of less-than-maximum braking effort by the crew during the transition period. Both of the aforementioned events might be attributed to the crew's lack of concern regarding their ability to stop the airplane on the remaining runway.

Another significant factor was the deterioration and subsequent destruction of the brakes as a result of high-energy inputs. However, the fact that the brakes were destructed was substantiated by the presence of numerous brake parts found on the last 1,000 feet of

Runway 13R. The deterioration occurred because the energy-absorption capacity of the six brakes was exceeded in the attempt to stop the airplane. The total energy required to stop the airplane (39.3 million foot-pounds for each of the six remaining brakes) was greater than the demonstrated capability of 38.7 million foot-pounds per brake.

The tire marks on the last portion of the runway were the result of side loading on the tires as the aircraft gradually turned to the right, plus the dragging produced by the six destroyed brakes. As the aircraft decelerated below 20 knots, the two good brakes on the No. 1 front and rear wheels would then become available but would have produced relatively little retarding force for the aircraft.

The tires became deflated after the aircraft came to a stop in the sand. The intense heat that had been generated in the brakes melted the fusible plugs in the wheels, and the tires deflated. The width of the tire drag marks on the runway were similar to those made by normally inflated tires. The tire marks also lacked the characteristic widening and narrowing made by a flat tire as it flops on a rotating wheel. This evidence, plus the lack of any pieces of tire carcass left on the runway, substantiated the conclusion that the tires were inflated until the aircraft came to a stop. Additionally, after the accident, the tire sidewalls were in good condition, with no marks or cuts that would have been produced by the weight of the aircraft wheel rolling on a flat tire.

Catering supplies stacked in the galley area were propelled into the aisles and galley exit area during aircraft deceleration, and, as a result, the movement of some passengers was impeded during the evacuation.

The right aft galley emergency slide was deployed, and, although reportedly activated by a crewmember, the slide did not inflate immediately. Further, early exit of the two midcabin crewmembers left no one in authority to direct the evacuation from this area. In other circumstances, these conditions could adversely affect passenger survival.

2.2 Conclusions

(a) Findings

1. The crew was trained, certificated, and qualified in accordance with existing regulations.

2. The aircraft was certificated and maintained in accordance with the existing regulations.

3. The aircraft weight and balance were within prescribed limits.

4. The flight was dispatched for a flight from JFK to Shannon, Ireland.

5. The crew planned a flight from JFK to Rijeka, Yugoslavia, overflying Shannon, Ireland.

6. The crew increased the fuel load without informing the dispatcher.

7. The copilot's sliding window was out of adjustment.

8. The trigger in the copilot's sliding window handle hung in a midposition.

9. The locking pin of the copilot's sliding window only partially engaged the lockplate receptacle.

10. The window appeared to be closed and locked prior to the takeoff roll.

11. The window came open during the takeoff run.

12. The opening of the window resulted in the sound of an explosion.

13. The aircraft had a malfunctioning V-3 relay in the left antiskid control shield.

14. The malfunctioning V-3 relay rendered the brakes inoperative above 20 knots on the No. 1 front and rear wheels.

15. The malfunctioning V-3 relay had existed for a considerable period of time.

16. There was no maintenance requirement for a routine check of the entire brake/antiskid system that would have detected the malfunctioning V-3 relay.

17. At the time of the attempted reject of the takeoff, the aircraft had six operating brakes.

18. The total brake energy required to stop the airplane on the remaining runway was greater than the demonstrated capability of the six operating brakes.

19. The overloading of the available brakes resulted in excessive heat and the destruction of the brakes prior to the aircraft's coming to a stop.

20. The crew was unaware of the six-wheel braking configuration when the captain initiated the rejected takeoff procedures.

21. The aircraft had accelerated beyond the V_1 speed of 150 knots when the window came open.

22. There was sufficient runway on which to stop the aircraft with normal eight-wheel braking capability from the 154 knot speed attained by the aircraft.

23. The crew followed the proper takeoff reject procedures.

24. The aircraft evacuation was accomplished in a timely fashion and was completed prior to the arrival of the airport emergency equipment.

25. The fire was effectively contained and extinguished by the airport fire department.

(b) Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the unknown degraded capability of the heavily loaded aircraft's braking system, which precluded stopping the aircraft within the runway distance available. The reduced braking capability resulted from a malfunctioning V-3 relay in the left antiskid

control shield of the aircraft's braking system, which rendered two of the eight-wheel brakes ineffective. A sound like that of an explosion in the cockpit during the takeoff roll caused the captain to reject the takeoff.

3. RECOMMENDATIONS

The FAA is now reviewing maintenance requirements to determine if the need for a periodic routine inspection of the entire brake and Mark I antiskid system is in order. The FAA will advise the Safety Board of the action they will take, when they have completed their review.

BY THE NATIONAL TRANSPORTATION SAFETY BOARD:

/s/ JOHN H. REED
Chairman

/s/ FRANCIS H. McADAMS
Member

/s/ LOUIS M. THAYER
Member

/s/ ISABEL A. BURGESS
Member

/s/ WILLIAM R. HALEY
Member

April 4, 1973.

APPENDIX A: INVESTIGATION AND HEARING

1. Investigation

The Board was notified of the accident at approximately 0115 on August 13, 1972, by the Federal Aviation Administration and the Board's New York Field Office. Personnel from the New York office dispatched to the scene established security and initiated the investigation. On Monday, August 14, 1972, three Washington based investigators were dispatched to assume control of the investigation. The team, assisted by the two New York based investigators established working groups for Operations, Systems, Human Factors, Cockpit Voice Recorder, and Flight Data Recorder. Parties to the investigation included an Accredited Representative from the Government of Yugoslavia, and representatives from Jugoslovenski Aerotransport, Federal Aviation Administration, Port of New York and New Jersey Authority, The Boeing Company, and the British Overseas Airways Corporation.

2. Hearing

No public hearing was held in connection with this investigation.

APPENDIX B: CREW INFORMATION

The following is the crewmember information:

1.	Pilot-in-Command:	Captain Konstantin Spasojevic
	Nationality:	Yugoslav
	Date of birth:	June 28, 1919
	Type of license:	Airline Transport No. 14
	Date of original issue:	September 1, 1951
	License valid to:	October 21, 1972
	Date license renewed:	April 18, 1972
	Last medical examination:	April 4, 1972
	Last B-707 in-flight check:	April 17, 1972
	Aircraft flown (types):	DC-3, CV-440, SE-210, B-707
	Total flying hours:	14, 943:37 hours
	Flight time B-707:	Not available
	Pilot & Copilot (day & night):	952:03 hours
	B-707 flight time, last:	Not available
	90-days:	230.48 hours
	Previous accidents:	None
	Flight time past 48 hours:	11:00 hours
	Rest after last flight:	30:00 hours

2. Copilot (Cocaptain):	Captain Radomir Petrovic
Nationality:	Yugoslav
Date of birth:	January 20, 1926
Type of license:	Airline Transport No. 42
Date of original issue:	July 30, 1957
License valid to:	December 30, 1972
Date license renewed:	June 27, 1972
Last medical examination:	June 22, 1972
Last B-707 in-flight check:	June 18, 1972
Aircraft flown (types):	DC-3, CV-440, IL-14, SE-210, B-707
Total flying hours:	11,302:58 hours
Flight time B-707:	Not available
Pilot & Copilot (day & night):	1,044:23 hours
Flight Time, B-707, last:	Not available
90-days:	210:36 hours
Previous accidents:	None
Flight time past 48 hours:	11:00 hours
Rest after last flight:	30:00 hours
3. Flight Engineer:	Nikola Jovanovic
Nationality:	Yugoslav
Date of birth:	February 24, 1927

Type of license:	Flight Engineer 696
Date of original issue:	May 22, 1970
License valid to:	December 30, 1972
Date license renewed:	June 22, 1972
Last medical examination:	June 14, 1972
Last B-707 in-flight check:	June 14, 1972
Aircraft flown (types):	DC-3, IL-14, CV-440, SE-210, B-707
Total flying hours:	14,359:29 hours
Flight time, B-707:	1,202:03 hours
Flight time, B-707, last:	Not available
90 days:	259:47 hours
Previous accidents:	None
Flight time past 48 hours:	11:00 hours
Rest after last flight:	30:00 hours

In addition to the flightcrew, there were two pursuers and six cabin attendants. All were currently qualified for the duties that they were performing, and they had received training within the specified time.

APPENDIX C: AIRCRAFT HISTORY

Aircraft YU-AGA, a Boeing 707-321, serial no. 17601, was manufactured on October 27, 1959. The last major inspection was made on the aircraft 3,398 hours prior to the accident. The last equalized service was accomplished 1,067 hours before the accident. The aircraft had accumulated 44,272 flying hours up to the time of the accident.

The aircraft was originally owned and operated by Pan American World Airways as N723PA. On May 14, 1970, the aircraft was leased to Jugoslovenski Aerotransport by the GATX Bulk Carrier Number Three of Monrovia, Liberia. The aircraft was then registered in Yugoslavia as YU-AGA.

JAT and PAA entered into a maintenance contract on May 18, 1970, whereby PAA would provide worldwide maintenance of the aircraft. All modifications spare parts, changes in configuration, and recordkeeping would be done by PAA, and all service would be done to maintain the aircraft in a state of airworthiness according to U.S.-FAA standards by means of scheduled and nonscheduled maintenance.

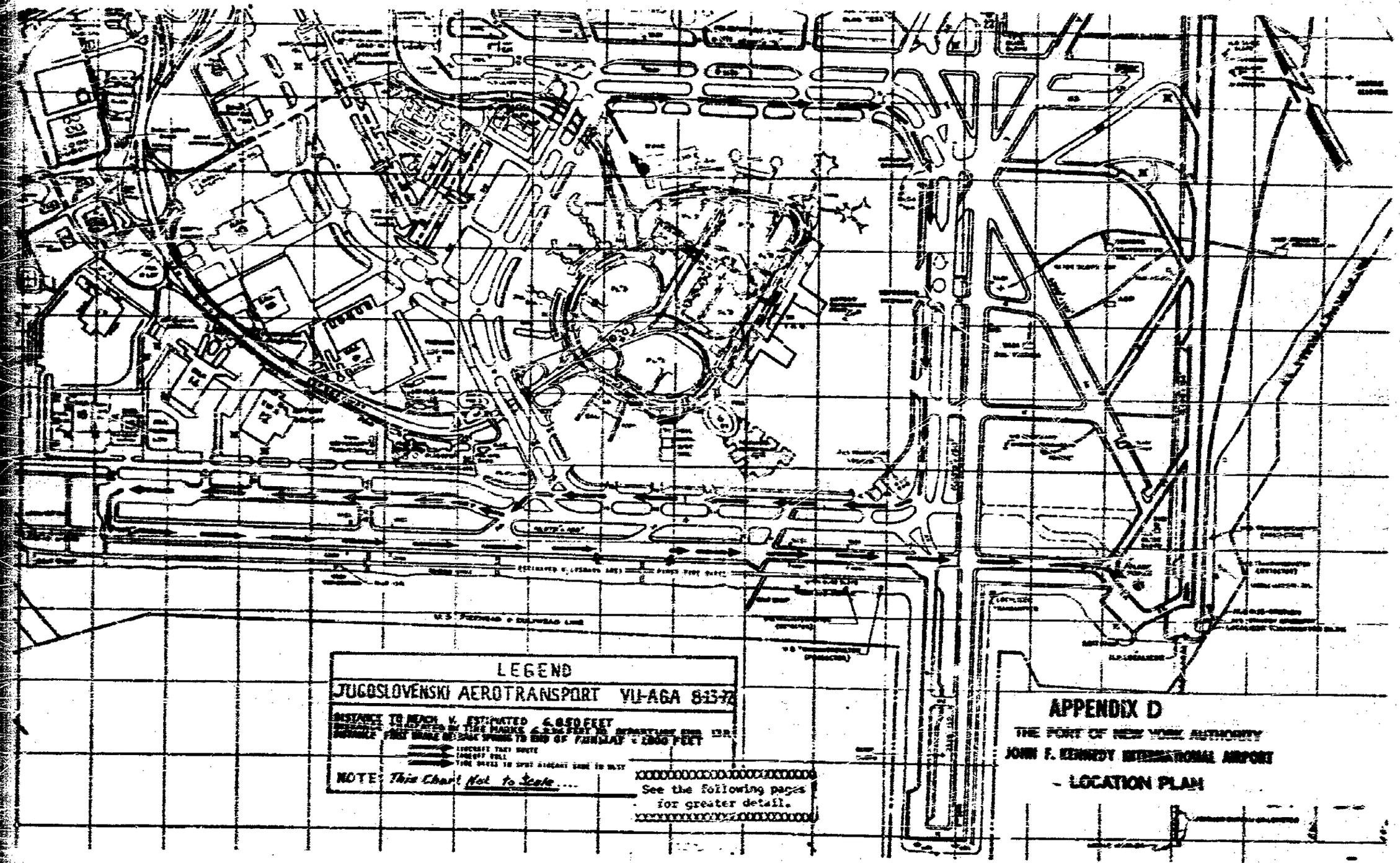
A review of the aircraft and component records showed that all required inspections and overhauls had been performed within the prescribed time limits and that the aircraft was maintained in accordance with the PAA procedures and the applicable FAA directives.

The PAA records of this aircraft disclosed the following:

Date of installation of brakes by wheel position and number of landings accumulated.

Position	Date	Landings	Position	Date	Landings
1 Front	1/3/72	559	3 Front	6/29/72	182
1 Rear	6/20/71	913	3 Rear	4/2/72	369
2 Front	7/30/72	48	4 Front	6/29/72	182
2 Rear	7/30/72	48	4 Rear	6/29/72	182

The aircraft manufacturer and the brake manufacturer stated that about 500 landings, under normal usage, comprised the average life of a brake unit.

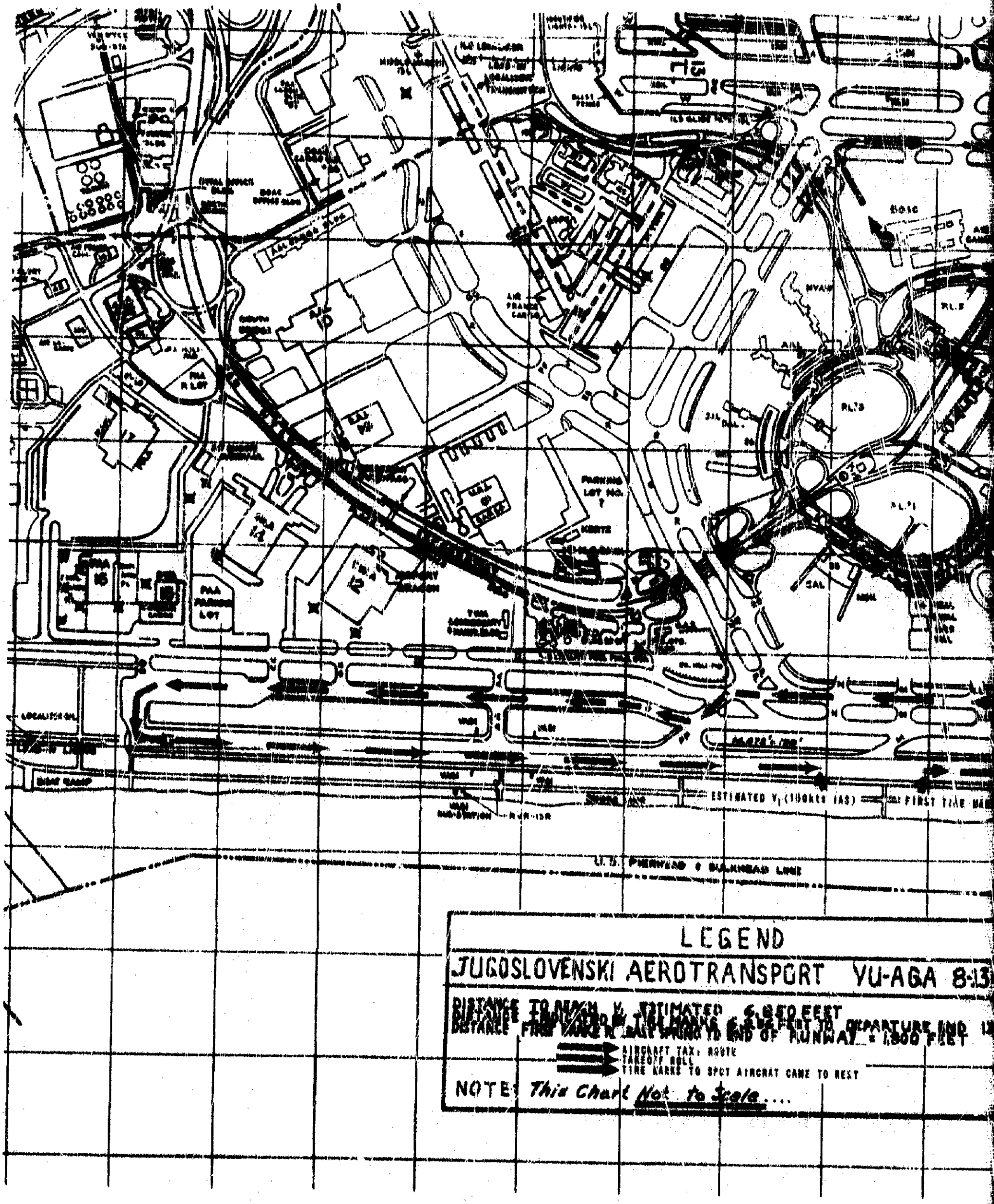


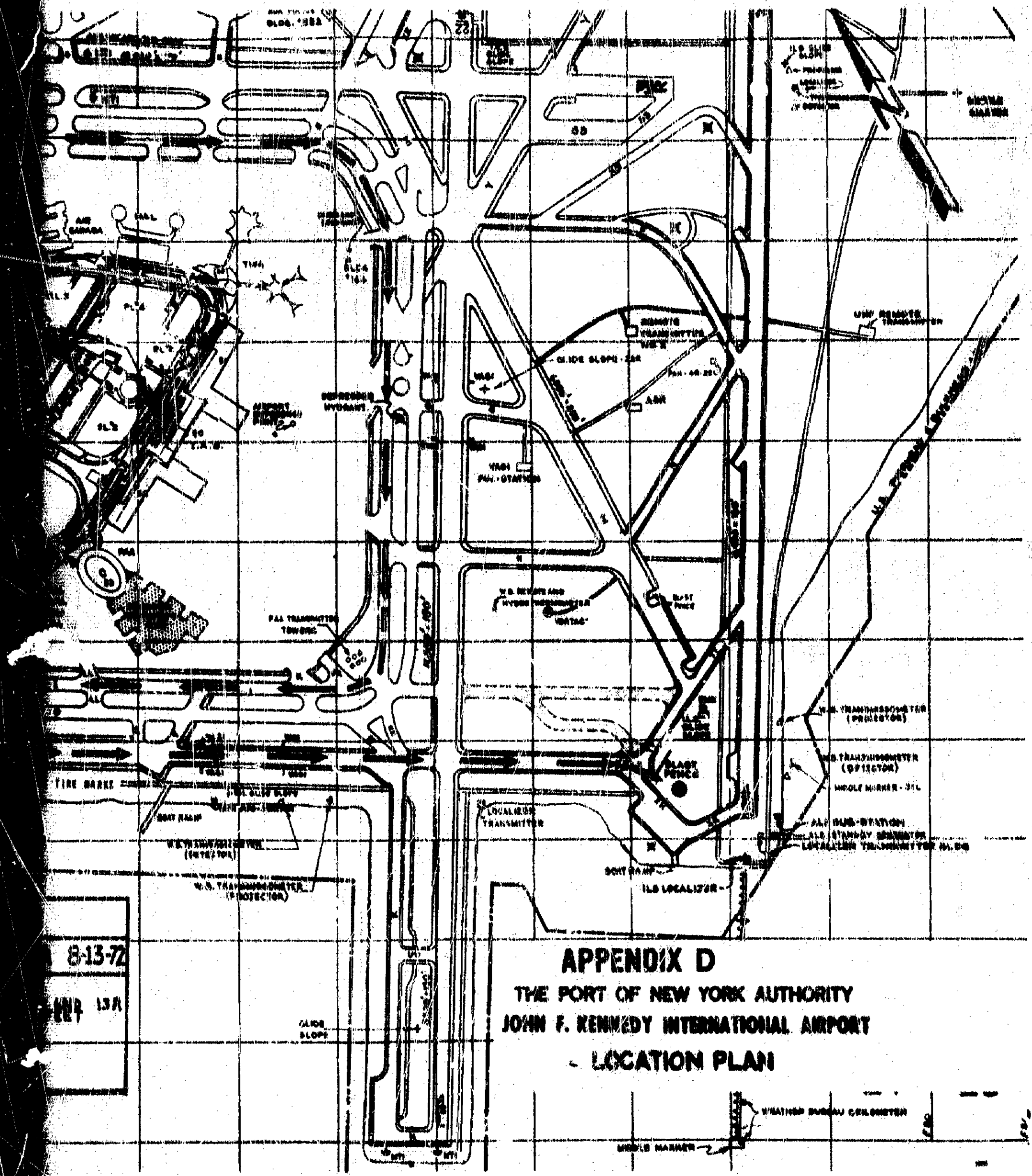
APPENDIX D

THE PORT OF NEW YORK AUTHORITY

JOHN F. KENNEDY INTERNATIONAL AIRPORT

- LOCATION PLAN


ESTIMATED V_1 (150kts IAS)
FIRST TIME
U.S. FORWARD & BLANKHEAD LINE
LEGEND
JUGOSLOVENSKI AEROTRANSPORT YU-AGA 8-13
DISTANCE TO MAIN W ESTIMATED 6,950 FEET
DISTANCE FROM
DISTANCE FIRST
AIRCRAFT TAXI ROUTE
TAKEOFF ROLL
TIRE MARKS TO SPOT AIRCRAT CAME TO REST
NOTE: This Chart Not to Scale...



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