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U. S CIVIL AERONAUTICS BOARD

AIRCRAFT ACCIDENT REPORT

Dec 16, 1960

ADOPTED: June 12, 1962 **RELEASED:** June 18, 1962

UNITED AIR LINES, INC , DC-8, N 8013U, AND
TRANS WORLD AIRLINES, INC., CONSTELLATION 1049A, N 6907C,
NEAR STATEN ISLAND, NEW YORK, DECEMBER 16, 1960

SYNOPSIS

On December 16, 1960, at 1033 e.s.t., a collision between Trans World Airlines Model 1049A Constellation, N 6907C, and a United Air Lines DC-8, N 8013U, occurred near Miller Army Air Field, Staten Island, New York. Trans World Airlines Flight 266 originated at Dayton, Ohio. The destination was LaGuardia Airport, New York, with one en route stop at Columbus, Ohio United Air Lines Flight 826 was a non-stop service originating at O'Hare Airport, Chicago, Illinois, with its destination New York International Airport, New York. Both aircraft were operating under Instrument Flight Rules.

Following the collision the Constellation fell on Miller Army Field, and the DC-8 continued in a northeasterly direction, crashing into Sterling Place near Seventh Avenue in Brooklyn, New York. Both aircraft were totally destroyed. All 128 occupants of both aircraft and 6 persons on the ground in Brooklyn were fatally injured. There was considerable damage to property in the area of the ground impact of the DC-8.

TWA Flight 266 departed Port Columbus Airport at 0900, operating routinely under Air Traffic Control into the New York area The New York Air Route Traffic Control Center (ARTCC) subsequently advised that radar contact had been established and cleared the flight to the Linden Intersection. Control of the flight was subsequently transferred to LaGuardia Approach Control. When the flight was about over the Linden Intersection, LaGuardia Approach Control began vectoring TWA 266 by radar to the final approach course for a landing on runway 4 at LaGuardia. Shortly thereafter TWA 266 was cleared to descend to 5,000 feet, and was twice advised of traffic in the vicinity on a northeasterly heading. Following the transmission of this information the radar targets appeared to merge on the LaGuardia Approach Control radar scope, and communications with TWA 266 were lost.

United Air Lines Flight 826 operated routinely between Chicago and the New York area, contacting the New York ARTCC at 1012 Shortly thereafter the New York Center cleared UAL 826 to proceed from the Allentown, Pa., very high frequency omni directional radio range station (VOR) direct to the Robbinsville, New Jersey, VOR, and thence to the Preston Intersection via Victor Airway 123. At approximately 1021, UAL 826 contacted Aeronautical Radio, Inc. (ARINC) to advise their company that the No. 2 receiver accessory unit was inoperative, which would indicate that one of the aircraft's two VHF radio navigational receivers was not functioning. A "fix" is established by the intersection of two radials from two separate radio range stations. With one unit inoperative the cross-bearings necessary can be taken by tuning the remaining receiver from one station to the other. This process consumes considerable time, however, and is not as accurate as the simultaneous display

of information on two separate position deviation indicators While UAL 826 advised the company that one unit was inoperative, Air Traffic Control was not advised.

At 1025 the New York ARTCC issued a clearance for a new routing which shortened the distance to Preston by approximately 11 miles. As a result, this reduced the amount of time available to the crew to retune the single radio receiver to either the Colt's Neck, New Jersey, or Solberg, New Jersey, VOR in order to establish the cross-bearing with Victor 123, which would identify the Preston Intersection. In the event the crew would not attempt to retune the single VOR receiver, cross-bearings on the Scotland Low Frequency Radiobeacon could be taken with the aircraft direction finding (ADF) equipment. This would be a means of identifying the Preston Intersection but, under the circumstances, would require rapid mental calculation in the interpretation of a display which could be easily misread. Several factors support the conclusion that this occurred.

Instructions had been issued to UAL 826 for holding at the Preston Intersection, the clearance limit, should holding be necessary. Clearance beyond Preston for an approach to Idlewild Airport would be received from Idlewild Approach Control and the transfer of control of the flight from the New York Center to Idlewild Approach Control would normally take place as the aircraft was approaching Preston. UAL 826 was not receiving radar vectors, but was providing its own navigation. After the flight reported passing through 6,000 feet the New York Center advised that radar service was terminated and instructed the flight to contact Idlewild Approach Control. UAL 826 then called Idlewild Approach Control, stating "United 826 approaching Preston at 5,000." This was the last known transmission from UAL 826.

At the time UAL 826 advised it was approaching Preston it had in fact gone on by this clearance limit several seconds before and was several miles past the point at which it should have turned into the holding pattern. This is confirmed by the data obtained from the flight recorder which had been installed in the UAL DC-8, as well as by analysis of the communication tapes At a point approximately 11 miles past the Preston Intersection a collision occurred between TWA 266 and UAL 826.

Weather at the altitude of the collision and at the time of the accident was such as to preclude flight by visual means.

The Board determines that the probable cause of this accident was that United Flight 826 proceeded beyond its clearance limit and the confines of the airspace allocated to the flight by Air Traffic Control A contributing factor was the high rate of speed of the United DC-8 as it approached the Preston intersection, coupled with the change of clearance which reduced the enroute distance along VICTOR 123 by approximately 11 miles

Investigation

History of TWA Flight (See Attachment I as reference)

Trans World Airlines Flight 266 was a scheduled passenger service originating at Dayton, Ohio. The destination was LaGuardia Airport, New York, New York, with one en route stop at Columbus, Ohio. The crew consisted of Captain David A. Wollam, First Officer Dean T. Bowen, Flight Engineer LeRoy L Rosenthal, and Hostesses Margaret Gernat and Patricia Post.

During the stopover at Columbus a scheduled equipment change was made. Flight 266 departed Columbus with the previous listed crew and 39 passengers, including two infants.

Flight 266 departed Port Columbus Airport at 0900[1]. The gross weight at takeoff was 101,444 pounds including 2,600 gallons of fuel. The aircraft was within weight and balance limitations in accord with current procedures. The time en route to LaGuardia was estimated to be one hour and 32 minutes.

The flight plan specified Instrument Flight Rules (IFR) at 7,000 feet altitude. The clearance was to the LaGuardia Airport via direct Appleton, Ohio, Victor 12 Johnstown, Pennsylvania, Victor 106 Selinsgrove, Pennsylvania, Victor 6 Victor 123 to LaGuardia Airport. Subsequent clearances changed the altitude to 17,000 feet, then to 19,000 feet. The flight was routine as it progressed toward the New York area. At approximately 1005, Flight 266 reported to the New York Air Route Traffic Control Center over Selinsgrove at 19,000 feet. Shortly thereafter the New York Center cleared Flight 266 to descend in stages, and to cross Allentown, Pennsylvania, at 11,000 feet.

At 1019 TWA 266 reported to the New York Center on 125.3 mcs. that it was passing Allentown, at 11,000 feet. In response, the New York Center advised that radar contact had been established, cleared the flight to Linden Intersection, and requested it to stand by for descent. At 1021, the New York Center further cleared TWA 266 to descend to and maintain 10,000 feet. The flight acknowledged this clearance and reported leaving 11,000 feet. At 1023, the New York Center advised the flight of the current LaGuardia weather Measured 500 overcast; one mile visibility in light snow, surface wind northwest 15 knots; altimeter setting 29.66. The flight acknowledged this weather and requested the runway in use. The Center advised that Instrument Landing System (ILS) approaches were being made to runway 4 and that the localizer was inoperative. Flight 266 acknowledged.

Between 1024 and 1026, the New York Center cleared TWA 266 to descend to and maintain 9,000 and to report leaving 10,000 feet. This was acknowledged. At 1027, TWA 266 advised the Center that it was past the Solberg, New Jersey VOR. The Center acknowledged. Shortly thereafter, the New York Center advised that radar service was terminated and to contact LaGuardia Approach Control on 125.7 mcs. TWA 266 acknowledged by repeating the frequency.

TWA 266 reported to LaGuardia Approach Control on 125.7 mcs. that it had passed Solberg at an altitude of 9,000 feet. The time, correlated with the Center tape, was 1026 22. LaGuardia Approach Control acknowledged, and issued the following clearance; "Maintain 9,000; report the zero one zero Robbinsville[2] ILS runway 4, landing runway 4, no delay expected. The wind is northeast at 15; altimeter 29.65. LaGuardia weather: Measured 500 overcast, visibility one mile; light snow; stand by." TWA 266 acknowledged the clearance. At 1028, TWA 266 reported passing the zero one zero degree radial of Robbinsville and requested information on the LaGuardia localizer. LaGuardia Approach Control advised that the glide slope rather than the LaGuardia localizer was inoperative as had been previously reported by a NOTAM, and cleared the flight to 8,000 feet. TWA 266 acknowledged and reported leaving 9,000 feet. At 1029, LaGuardia Approach Control cleared TWA 266 to descend to 6,000 feet and to advise passing through 8,000 feet. The transmission was acknowledged At 1029:49, TWA 266 reported "passing 8,000." LaGuardia Approach Control acknowledged and advised the flight to maintain present heading for a radar vector to the final approach course. TWA 266 acknowledged. At 1030:49, LaGuardia Approach Control advised TWA 266 to reduce to approach speed. The flight acknowledged. At 1032 09,

1/ All times herein are Eastern Standard based on the 24-hour clock.
2/ Zero one zero degree radial of Robbinsville, New Jersey Omni Range.

LaGuardia Approach Control advised TWA 266 to turn right to a heading of 130 degrees. The transmission was acknowledged by repeating the heading. LaGuardia Approach Control again advised that this would be a radar vector to the final approach course. TWA 266 acknowledged.

LaGuardia Approach Control then requested the flight's altitude. At 1032:20, the flight advised "6,000." At 1032·22, LaGuardia Approach Control acknowledged and cleared the flight to continue descent to 5,000. This clearance was acknowledged by the flight which then reported leaving 6,000 feet. Approach control acknowledged.

At 1032:37, LaGuardia Approach Control advised the flight to turn right to 150 degrees. The transmission was acknowledged by repeating the heading. At 1032:47, LaGuardia Approach Control advised "traffic at 2:30, six miles northeast-bound." At 1032:51, TWA 266 acknowledged. At 1033·08, LaGuardia Approach Control requested the flight's altitude. TWA 266 replied, "(garbled)....500." LaGuardia Approach Control asked if 5,500 was correct TWA 266 replied in the affirmative. At 1033:14, LaGuardia Approach Control issued clearance to continue descent to 1,500. At 1033:18, this was acknowledged. At 1033:21, LaGuardia Approach Control advised to "turn left now heading 130." At 1033:23, TWA 266 acknowledged by repeating the heading. At 1033 26, LaGuardia Approach Control advised· "Roger, that appears to be jet traffic off your right now 3 o'clock at one mile, northeast-bound." Following this transmission, at 1033:33, a noise similar to that caused by an open microphone was heard for six seconds duration. LaGuardia Approach Control then transmitted the following at 1033:43· "Trans World 266, turn further left one zero zero." Subsequently, LaGuardia Approach Control made numerous attempts to establish communications with TWA 266 until 1036:21, none of which was successful and during which time contact was established with another aircraft.

History of United Flight

United Air Lines Flight 826 was a scheduled nonstop passenger service originating at O'Hare Airport, Chicago, Illinois, with its destination New York International Airport, New York, New York. The crew consisted of Captain Robert H. Sawyer, First Officer Robert W. Fiebing, Second Officer Richard E. Pruitt, Stewardesses Mary J. Mahoney, Augustine L. Ferrar, Anne M. Bouthen, and Patricia A. Keller. The crew normally departed Los Angeles, California, as United Flight 856, with a two-hour stopover in Chicago and departing Chicago as United Flight 826.

Captain Sawyer, First Officer Fiebing, and Second Officer Pruitt had flown Flight 856 from Los Angeles to Chicago. They departed Los Angeles at approximately 0320 on December 16, 1960, and arrived in Chicago at approximately 0656. The stewardesses boarded United Flight 826 at Chicago.

Flight 826 departed O'Hare Airport with the previously listed crew and 76 passengers.

The actual takeoff weight was 214,790 pounds which included 63,700 pounds of fuel, 6,450 pounds of cargo, and the passengers. The maximum allowable takeoff weight was computed as 217,200 pounds. The aircraft was within weight and balance limitations in accord with current procedures.

The flight plan specified IFR at a flight level of 27,000 feet. The clearance was via Victor 55 and Jet 60 Victor to New York. The estimated time en route was one hour and 29 minutes; true airspeed 478 knots; ground speed 530 knots.

United 826 departed at 0911. Cruising flight level of 27,000 feet was attained at 0936. The flight to the New York area was normal. At approximately 1012 New York Air Route Traffic Control Center was contacted by Flight 826. The Center answered "United 826, New York Center, Roger, have your progress, radar service not available, descend to and maintain flight level 250, over." Flight 826 reported leaving flight level 270 at approximately 1014. At approximately 1015 New York Center advised "United 826, clearance limit is Preston Intersection via Jet 60 Victor to Allentown direct to Robbinsville, via Victor 123· maintain flight level 250." Flight 826 acknowledged.

At approximately 1021, United 826 called ARINC (Aeronautical Radio, Incorporated, operator of United Air Lines aeronautical communications system) and reported "No. 2 navigation receiver accessory unit inoperative." This transmission was acknowledged by ARINC and relayed to United Air Lines.

At approximately 1021, New York Center issued further clearance to descend to 13,000 feet. United 826 replied ". . . We'd rather hold upstairs . . . " Subsequent to this transmission the United flight was instructed to change to 123.6 mcs., the frequency of another center sector controller. At approximately 1022:41 the Center called Flight 826: "United 826 New York Center, radar contact." United 826 replied, "Roger, we're cleared to 13,000 to maintain 25,000 until we had conversation with you. If we're going to have a delay we would rather hold upstairs than down. We're going to need 3/4 of a mile, do you have the weather handy?" The Center replied, "No., but I'll get it, there have been no delays until now." At approximately 1023·30, United 826 reported over Allentown at flight level 250. The Center acknowledged. At 1024:37 the Center advised that the Idlewild weather was " . . . 1,500 feet overcast; 1/2 mile; light rain; fog; altimeter setting 29.65." Shortly thereafter the flight stated " . . . . we're starting down." At approximately 1025:09 the Center amended the ATC clearance as follows: "826 cleared to proceed on Victor 30 until intercepting Victor 123 and that way to Preston. It'll be a little bit quicker." (The new routing shortened the distance to the Preston Intersection by approximately 11 miles.) This was acknowledged at 1025:20. At approximately 1026:49 the flight was cleared to descend to and maintain 11,000 feet. The clearance was acknowledged and the flight reported leaving 21,000 feet at 1026:54. Then the Center advised at 1028:41 . . . "826, I show you crossing the centerline Victor 30 at this time." United 826 confirmed that it was established on Victor 30 and requested his distance from Victor 123. At approximately 1028:56 the Center said " . . . I show you 15, make it 16 miles, Victor 123." 826 acknowledged and then the Center advised "right now you're about 2 miles from crossing Victor Airway 433."

At approximately 1030:07, United 826 was cleared to "descend to and maintain 5,000 feet." This was acknowledged and 826 reported leaving 14,000 feet. The Center then asked, "Look like you'll be able to make Preston at 5,000?" The answer was that they would try. At approximately 1032:16 the Center stated "United 826, if holding is necessary at Preston, southwest one minute pattern right turns . . . the only delay will be in descent." The flight replied "Roger, no delay, we're out of seven." At approximately 1033:01 the flight reported passing 6,000 feet. At approximately 1033.08, the Center called, "826, I'm sorry I broke you up, was that you reporting leaving 6,000 for 5,000?" The flight replied "affirmative." The Center at approximately 1033:20 instructed: "826, Roger, and you received the holding instructions at Preston, radar service is terminated. Contact Idlewild Approach Control . . . " Flight 826 acknowledged "Good day" at approximately 1033·27.

In accordance with the terms of the then-current United States Standard Manual of Radar Air Traffic Control Procedures, paragraph 1.3, the responsibility of the controller is defined as follows: "A minimum of three miles separation shall be maintained between aircraft being controlled in accordance with the procedures authorized in this Manual and between such radar-controlled aircraft and other traffic being controlled in accordance with the Instrument Flight Rules unless standard non-radar separation is provided . . . " His area of responsibility is circumscribed by other provisions of the same paragraph as follows: "Air traffic control is not responsible for deviations from these standards which result from the failure of the pilot to respond to the measures taken to control them."

With respect to the separation afforded UAL 826, provision of at least the minimum required longitudinal separation was effected by the issuance of a clearance to a holding fix located at a point consistent with the minimum distance required between holding pattern airspace areas.

At approximately 1033:28 (timed from Idlewild Approach Control tape) Flight 826 called: "Idlewild Approach Control, United 826, approaching Preston at 5,000." This is the last known transmission from the flight. The transmission was acknowledged beginning at approximately 1033:33: "United 826, this is Idlewild Approach Control, maintain 5,000. Little or no delay at Preston. Idlewild landing runway four right. ILS in use. Idlewild weather: 600 scattered, estimated 1,500 overcast; visibility 1/2 mile, light rain and fog. Altimeter 29.63 over." The transmission was completed at approximately 1033 54. It was not acknowledged. Subsequent attempts to contact United 826 were unsuccessful. Radio communications with other aircraft during this period were normal. It was testified at the hearing that United 826 was not observed on the radar by any Idlewild Approach Control personnel.

CHRONOLOGICAL SEQUENCE OF EVENTS

	TWA Flight 266	UAL Flight 826
1023	Current LaGuardia Weather	
1023:33	----------	Over Allentown at 25,000 ft.
1027:58	Over Solberg at 9,000 ft.	
1028:41	----------	Crossing center line of Victor 30
1028:54	Leaving 9,000 ft.	
1028:56	----------	16 miles west of Victor 123
1029:58	Leaving 8,000 ft.	
1030:11	----------	Leaving 14,000 ft.
1031 02	Reduce to approach speed	
1032.25	----------	Leaving 7,000 ft.
1032 32	Leaving 6,000 ft.	
1033 01	----------	Leaving 6,000 ft.
1033 20	At 5,500 ft.	
1033 28	----------	Approaching Preston at 5,000 ft.
1033:33	Sound of the open microphone	

The Collision

LaGuardia radar observations indicated that the two targets merged approximately over Miller Army Air Field, New Dorp, Staten Island, New York. After the merged plot, one target broke away to continue northeast for a distance of 8 to 10 miles. The other target appeared momentarily nearly stationary and then commenced a slow right turn to a southwesterly heading, disappearing from the scope.

The target which continued northeast was United Flight 826. It remained airborne until crashing 8-1/2 miles northeast of Miller Field at the intersection of Sterling Place and Seventh Avenue in Brooklyn, New York. Witnesses in the area of impact stated that the DC-8 was headed in a northeasterly direction. They testified that one of the right engines was missing.

The target which continued in a slow right turn and disappeared from the scope in the vicinity of Miller Field was the TWA flight. The wreckage of the TWA Constellation was distributed about Miller Field. Several pieces of DC-8 structure and fragments of a jet engine were interspersed with the Constellation wreckage, confirming the collision of the aircraft.

Air Traffic Control

United Flight 826 expressed a desire on two occasions to remain at altitude if weather or traffic required holding prior to landing clearance. The flight was advised that traffic delays had not been encountered. United 826 started a descent in accord with the clearance given by Air Route Traffic Control. At 1022:41 the controller advised 826 that the flight was in radar contact. The flight progress was followed by a "shrimp boat"3/ marker. Radar separation was maintained between United 826 and following flights. Following the Allentown report the radar controller changed the clearance to a shorter routing so as to intersect Victor 30 airway and proceed via Victor 123. The purpose of the change in routing was to increase longitudinal separation between United 826 and the succeeding aircraft which were cleared to Preston at higher altitudes than the United Flight. This change in routing was not made known to the Idlewild Approach Controller, nor was it reflected on the Idlewild flight progress strip by way of advancing his expected time of arrival over Preston by approximately five minutes. UAL 826 was previously estimating over Preston at 1039. At an Approach Control fix where a transfer of control is taking place the estimated time of arrival over that fix is used primarily for radio failure and also for sequencing purposes. Separation at each feeder fix is not based on an estimated time of arrival, but rather on the basis of vertical separation effected through discreet altitude assignment.

The Center Controller advised United 826 at 1028·41 that it was crossing the centerline of Victor 30. This position was acknowledged and the distance from Victor 123 was requested. At 1028·56 the center controller advised United 826 that it was then 16 miles west of Victor 123 and shortly thereafter advised that it was two miles west of Victor 123. The controller stated at the hearing that he observed United 826 one to three miles southwest of Preston at the time the flight reported out of 6,000 feet. This was between 1033·01 and 1033 14. At 1033·20 the center controller instructed Flight 826 to contact Idlewild Approach Control and advised "radar service terminated."

At 1033·28, United 826 called Idlewild Approach Control and stated "approaching Preston at 5,000 feet."

The Idlewild Approach Controllers testified that they did not observe United 826 in the Preston area. Idlewild Approach Control acknowledged the call with weather and runway information.

3/ Transparent marker used to record identity of and to follow radar target on a horizontal radar display.

At the time of the communication between United 826 and Idlewild Approach Control, the only information which had been received from the New York Center which would have indicated a transfer of control was the estimate which was forwarded at 1029. The interphone was not used nor was a light received on the General Railway Signal altitude interlock system.

Since only one aircraft was involved at the time of transfer of control of UAL 826 from the New York Center to Idlewild Approach Control, the use of the General Railway Signal (GRS) altitude interlock lights was not required. Therefore, the failure of the Center Controller to indicate change of control by activating the amber GRS transfer light had no significant meaning, as UAL 826 had been afforded standard non-radar separation from all other known IFR traffic. Had several aircraft been cleared to the Preston fix with discreet altitude assignments, it would then have been incumbent upon the Center Controller to indicate, by the use of the GRS lights, the control of which of these aircraft were being transferred and at what altitude.

At approximately 1029 the Center advised Idlewild Approach Control that United Flight 826 was estimated over Preston at 1039 via Colts Neck. Idlewild Approach Control received the 1033.28 transmission stating, "approaching Preston at 5,000," from United 826 about 4-1/2 minutes prior to the estimated time of arrival.

Flight 826 was operating the transponder which was properly received as a target on New York Center's scope. There was no evidence that the transponder signal appeared on Idlewild Approach Control equipment. This situation, however, is not abnormal since a normal method of operation of the secondary radar receiving equipment associated with an approach control radar requires that the aircraft's transponder be set to an assigned select code in order that its response to an interrogation from a specific ground location will appear on the primary radar indicator as a coded target. In order to accomplish this setting the pilot must be instructed to change his equipment to the desired code assigned to the next subsequent control function. This action was not a part of the routine transfer of control function between the Center and Idlewild Approach Control and was not accomplished in connection with this flight.

During the time United 826 was progressing toward and beyond Preston, Trans World Airlines Flight 266 was under control of LaGuardia Approach Control. A series of radar vectors was given to TWA 266, and apparently properly executed. The controller observed a target approaching from the southwest and informed TWA 266 of the target information on two occasions.

The Weather

A summary of inflight reports from 51 aircraft which had operated within a 30 nautical mile radius of the accident site within one hour of the time of the accident, shows that 45 flights were in clouds at altitudes ranging from 300 feet to 18,000 feet. One pilot reported on top of all clouds at 31,000 feet. Four of the five remaining reports indicated some ground contact up to altitudes ranging from 4,000 to 5,000 feet. One pilot reported between layers from 4,000 to 5,000 feet and from 13,000 to 15,000 feet.

Flight Recorder Readout

The Waste King Flight Recorder aboard the United DC-8 was read out under the supervision of the Civil Aeronautics Board. The parameters recorded relating to an elapsed time base are: altitude, airspeed, heading, and vertical acceleration. Some degree of fire and impact damage was present although the last part of the record foil was covered with products of combustion and chemical reaction.

All measurements along the length of the tape (time base) were made with respect to a hole corresponding in time to just prior to takeoff in Chicago. The average distance between the adjacent holes was determined from measurements of the length composed of 36 holes. One millimeter of length along the tape is equal to 0.19661 of a minute of time. This factor was used in computing the time for all events.

The data obtained relative to altitudes, indicated airspeeds, and headings are illustrated in Attachment 2. The flight recorder values between 72 minutes after takeoff and the time of collision are plotted as a track profile in Attachment 1. This track was plotted in reverse from the point of collision determined by a trajectory study of the DC-8 No. 4 engine and the TWA Constellation No. 3 engine.

The engines were detached in flight upon collision and impacted on Staten Island. Analysis of the trajectory of DC-8 engine indicated a fall of 5,575 feet on a course of 050 degrees magnetic. Analysis of the Constellation No. 3 engine indicated a 3,470-foot fall on an estimated course of between 110 degrees to 130 degrees magnetic. The intersection of the two trajectories determined the collision area of approximately 1,200 square feet, the center of which is located on a 315-degree magnetic bearing of 6,555 feet from the center of Miller Field.

The altitude at the instant of collision was computed to be 5,175 to 5,250 feet above mean sea level as would be indicated by an altimeter setting of 29.65 inches of mercury. The indicated airspeed of the DC-8 at the point of collision was 301 knots. This was the lowest airspeed subsequent to passing Allentown, Pennsylvania. The elapsed time of Flight 826 from "wheels up" in Chicago to collision was 82 minutes and 32 seconds. United's time of "wheels off" at O'Hare Airport was 0911. Adding the elapsed time of 82 minutes and 32 seconds, the time of collision as determined by the flight recorder readout was 1033 32.

As previously stated, the indicated airspeed of United at the point of collision was computed as 301 knots. The reduction in airspeed over a 70-second period prior to collision is illustrated below:

	Time Lapse	Speed	Speed Reduction
1032:22		356 knots	
1032:55	33 seconds	338 knots	18 knots
1033:04	9 seconds	332 knots	6 knots
1033:12	8 seconds	325 knots	7 knots
1033:20	8 seconds	318 knots	7 knots
1033:29	9 seconds	309 knots	9 knots
1033:32	3 seconds	301 knots	8 knots
		TOTAL	55 knots

Structures - TWA Constellation

The majority of the force of collision impact on the Constellation was centered on the following points.

Upper right section of passenger compartment between Fuselage.

Stations 1030 and 1060.

Right vertical fin, rudder, and right outboard portion of the right horizontal stabilizer.

Right wing flap.

Right wing between the engines.

The Constellation broke into three main sections following the collision an impacted into the Miller Field area. The aft section, including the empennage, separated from the forward portion of the aircraft. This section impacted in a flat attitude right side up. The center vertical stabilizer bore evidence of impact force resulting in bending 45 degrees to the left approximately two feet from the top. The right vertical rudder and stabilizer and 12 feet of the right horizontal stabilizer were torn free. Inflight fire was evidenced by soot and scorching. There was no evidence of ground fire about the aft fuselage. There was, however, evidence of fire in the interior of the aft fuselage section. The right wing and No. 4 engine separated at Wing Station 242 and impacted 600 feet east of the aft fuselage section. This wing section evidenced severe fire and explosion damage. No. 3 engine and nacelle detached and fell about 600 feet northwest of the aft fuselage. The forward section of the fuselage and the left wing, including the two engines, impacted approximately 1,100 feet north of the aft fuselage.

Numerous pieces of aircraft structure were strewn over a wide area in the vicinity of Miller Field. Many of these pieces were identified as parts of a DC-8.

Nos. 1 and 2 Wright C18CB-1 powerplants were located in their normal positions relative to the wing spar. The No. 3 powerplant had separated from the wing. No. 4 powerplant remained attached to the wing which had separated from the aircraft. Detailed examination was conducted after removal of the powerplants to LaGuardia Airport. There was evidence of ground impact damage on all powerplants. Some evidence of ground fire damage was noted only on No. 4. Internal examination of the powerplants revealed no evidence of frictional overheat, lack of lubrication or internal failure.

DC-8 Structures

There were six general areas of the DC-8 which furnished evidence of a collision:

1. Left wing leading edge.
2. Left landing gear door .

3. Right landing gear door.
4. No. 4 engine, nacelle, and pylon
5. Right wing outboard of the No. 4 engine.
6. Belly antenna.

Following the collision the DC-8 continued on a northeasterly heading and ·ed into the heavily populated area of Brooklyn at the intersection of ıng Place and Seventh Avenue. The ensuing ground fire was prolonged and e, consuming a large part of the aircraft's structure and causing extensive to property on the ground.

he aft section of the passenger cabin structure impacted and slid, coming ·st facing in a northerly direction on Sterling Place. Impact and subse- ground fire consumed the greater part of the passenger cabin structure. of the right wing and the attached No. 3 engine sliced through the Pillar re Church. The flight deck crashed into the same area and was largely con- by ground fire. The left wing, except for the outer 15 feet, came to rest ıe intersection of the two streets with the outermost end aligned in a south- sterly direction. This missing outer 15-foot section cut through, and came to est in a building at 126 Sterling Place, leaving two feet of the wing tip otruding through the roof.

The empennage and fuselage aft of Fuselage Station 1490 was found on Sterling Place on the south side of Seventh Avenue and facing approximately north. Examination of this section revealed that in addition to the impact damage there was evidence of fire damage. Areas of the empennage were heavily sooted and the paint was blistered.

Soot was found on the ground impact fracture areas, indicating that some of the soot was a result of the ground fire. However, the direction of the soot on the upper and lower skin of the intact left horizontal stabilizer indicated an inflight fire. Also, the paint on both sides of the vertical fin and rudder was blistered as the result of heat. The upper 24 inches of the paint-blistered rudder was damaged on ground impact when it contacted a truck at the south corner of the Sterling Place and Seventh Avenue intersection. The paint on the truck, exposed to the same ground fire heat, showed no evidence of blistering or any other heat or fire damage.

The left horizontal stabilizer and elevator received little damage other than a two-foot tear in the lower skin of the elevator and a damaged outboard elevator section. The right horizontal stabilizer and elevator sheared off seven feet from the fuselage. Most of the parts of the right elevator were found. However, the severed horizontal stabilizer was not located.

Both main landing gear doors, the outboard section of right wing, part of the leading edge of the left wing, and the No. 4 engine impacted in the Miller Field area.

Nos. 1 and 2 Pratt & Whitney JT3C-6 powerplants were severely damaged by ground impact. The No. 3 powerplant remained an integral unit, although the low pressure turbine shaft was twisted. The No. 4 engine separated at the intermediate and diffuser cases, severing the attaching bolts.

The red paint marks found on the No. 4 engine at the compressor inlet were of the same material as the paint used on the TWA Constellation. Human remains and Constellation cabin insulation material were removed from the diffuser case of No. 4.

Internal examination of Nos. 1, 2, and 3 powerplants revealed no evidence of inflight failure. The damage of the No. 4 powerplant was attributed to inflight and ground impact forces.

Evidence of Air Collision

Examination of the wreckage of the DC-8 and the Constellation substantiated the evidence of an air collision. The Constellation examination indicated the impact was from outboard toward the inboard on the right rear quarter at an angle of 110 degrees relative to the course line. The DC-8, as indicated by the flight recorder, was in approximately straight and level flight at the moment of impact. The Constellation was in an approximate 22-degree left bank relative to the DC-8 flightpath and maintaining approximately the same altitude.

Several pieces of DC-8 engine pod titanium, engine accessory fragments, and cowling material were found in the passenger cabin area of the Constellation. A fragment of fiberglass from the DC-8 tower antenna cover was found embeded in the right stabilizer of the Constellation. Pieces of DC-8 wiring and structure of the No. 4 pylon were found embeded in the Constellation flap panel. DC-8 wing spar fragments were found in the wing of the Constellation.

A portion of the DC-8 left wing leading edge and a section of the right wing were sheared off and fell in the area of the Constellation wreckage.

Systems - TWA

The TWA Constellation navigation, communication, and flight instrument equipment were closely examined. Compass heading information was displayed on three instruments. The captain's radio magnetic indicator (RMI) heading card, the master direction indicator (MDI) and the copilot's RMI heading card, all receive their input from the fluxgate compasses. The first officer's RMI heading indication was 188 degrees; the captain's MDI was 190 degrees. Both of these units receive their inputs from the same fluxgate compass. The captain's RMI heading indication was 062 degrees. No. 2 VOR/ADF pointers on each RMI each indicated 100 degrees. Examination of the selector switch could not determine whether the pointer system was selected to automatic direction finder (ADF) or VHF omni range (VOR). The frequency setting of 232 kilocycles was found on the radio control panel of the ADF No. 2 system. The internal receiver mechanism was determined as having been tuned to between 227 kilocycles and 233 kilocycles. The No. 1 ADF control panel indicated only that the receiver was tuned to between 200 and 410 kilocycles. Internal examination of the ADF receiver indicated a frequency of 320 to 326 kilocycles. No. 1 ADF loop indicated a relative bearing of 98 degrees and No. 2 ADF loop 77.5 degrees. No. 2 VOR control panel was found to be set to a frequency of 115.9 mcs. and the internal examination of the receiver indicated frequency of 113.9 or 115.9 mcs.

Examination of the VHF communications system indicated that the No. 1 VHF communications system was tuned to 128.9 mcs. This frequency was set on the receiver panel, the receiver mechanism, and the transmitter. The No. 2 VHF communications system panel setting was 125.7 mcs., the receiver and transmitter mechanisms were also 125.7 or 125.8 mcs.

Systems - UAL

The United DC-8 navigational and communication equipment was also closely examined. Primary navigation equipment of United 826 was a typical DC-8 installation incorporating minor changes in accord with United Air Lines policy. Navigation equipment consisted of the ADF, very high frequency omni directional range (VOR) receivers, and ILS receiver, and a gyro stabilized compass system. Two complete sets of these units form the navigation system and they are referred to as System No. 1 and System No. 2. The DC-8 was equipped with a weather radar for storm monitoring. Components of all navigational systems were found and identified except for components of the weather radar. Any component which could possibly aid in determining a setting, measurement, or indication, was dismantled and inspected at the place of manufacture.

Normal procedure in tracking and determining cross bearings along an airway is to use the pictorial deviation indicator (PDI) and the VOR pointers on the RMI. Two pictorial deviation indicators display an aircraft's position relative to the selected stations by presentation of the VOR information on a V-shaped pointer which rotates with heading changes and points to the selected station. The R-1 (PDI) indicators in the United Air Lines DC-8s are modified in that the indicator always points to the selected radial. There is no provision for a reciprocal switch. Compass heading information is supplied to the rotating mask which revolves with the V-bar pointer. A digital course indicator is located in window on the upper part of the indicator. Magnetic bearing to the station set by the knob on the face of the instrument. A miniature aircraft is attached to the dial representing the relationship of the aircraft to the VOR radial.

United DC-8 aircraft are equipped with two RMI-VOR indicators, and two C-6A Crosyn compass indicators with pointers for the ADF. The captain's panel has a RMI which presents compass heading and VOR information plus a C-6A indicator for display of ADF and compass information. A similar presentation is displayed on the first officer panel. Each indicator has two pointers and a rotating azimuth card from which the aircraft's heading is read at 12 o'clock position.

The captain's RMI indicator has a single or narrow pointer which operates with inputs from System No. 1. The double or wide pointer operates with inputs from System No. 2. The first officer has an identical display. The display is similar to the V-bar pointers of the No. 1 and No. 2 pictorial deviation indicators. As an example: When the No. 1 VOR unit is tuned to a frequency, the No. 1 pointer of the RMI and the V-bar of the captain's No. 1 PDI present the same data. Two C-6A ADF indicators are independent of the VOR indicators.

Pertinent New York area navigational facilities in the vicinity of the Preston Intersection are listed with the charted frequencies in effect at the time of the accident:

Scotland Radiobeacon	294 kilocycles
Robbinsville Omni	109.0 megacycles
Colts Neck Omni	115.1 megacycles
Solberg Omni	114.7 megacycles
Idlewild Omni	115.9 megacycles
Idlewild Localizer (Runway 4 Right)	109.5 megacycles
Idlewild Glide Slope	332.6 megacycles
Idlewild Outer Marker Locator	373 kilocycles
Idlewild Middle Marker Locator	353 kilocycles

Navigational and communications radios of United 826 were examined and their frequencies as of the time of impact were noted. The captain's No. 1 VOR receiver was tuned to approximately 109.7 megacycles. The first officer's No. 2 VOR receiver was tuned to 110.45 megacycles. The No. 2 accessory unit had been reported as being inoperative prior to the collision. The captain's PDI omni bearing selector was determined to be approximately 039 degrees. The PDI of the first officer was set to approximately 036 degrees. The only ADF equipment recovered was the captain's ADF receiver and the first officer's ADF control head. The captain's ADF receiver was tuned to 293 kilocycles. The first officer's ADF control head was set at 103 kilocycles.

VOR Navigational Facilities

The Preston Intersection is defined by the intersection of the 346-degree radial of the Colts Neck Omni and the 050-degree radial of the Robbinsville Omni. The 120-degree radial from the Solberg Omni may be used in conjunction with the Robbinsville radial. These three VOR stations are operated and maintained by the Federal Aviation Agency. VOR stations are located on carefully selected sites and transmit signals in the very high frequency radio spectrum between 108 and 118 megacycles.

The basic principle of VOR navigation is the emission of a 360-degree structure of radial lines of magnetic bearing about a known point. It differs from the older aural four-course radio range in that it offers an infinite choice of radial courses.

The primary navigational signal consists of a reference modulation and a variable modulation. The phase (or timing) of the variable modulation with respect to the reference modulation is a function of azimuth or magnetic bearing from the station. The airborne receiver performs a phase comparison between the variable and reference signals by which the magnetic bearing of the aircraft from the station may be determined.

Under normal conditions of propagation the range of a VOR station is 1/3 greater than the line of sight distance. The upper limits of range vary from approximately 45 miles for an aircraft at an altitude of 1,000 feet, to 200 miles or more for an aircraft at an altitude of 20,000 or more. The location of station sites generally precludes the necessity of using facilities in ranges in excess of 50 to 100 miles. Nevertheless, to minimize the possibility of interference at high altitudes, stations with similar frequencies are normally separated by 480 miles or more.

The Board conducted ground monitor checks on the VOR stations at Colts Neck, Solberg, and Robbinsville. Nothing abnormal was noted during the monitorings.

Flight checks were made using Colts Neck, Solberg, and Robbinsville VOR radials composing the Preston Intersection. These flight checks revealed no abnormalities. Preston Intersection as determined by the VOR radials was found to be geographically as plotted on current air navigation charts.

Analysis and Conclusions

TWA Flight 266

TWA Flight 266 operated routinely as it approached the New York area on Victor Airway 6, at 8,000 descending to 6,000 feet on an approximate heading of 096 degrees. Radar vectors to the ILS final approach course to LaGuardia Airport were commenced in the vicinity of the Linden Intersection. TWA 266 was advised by LaGuardia Approach Control to turn right to a heading of 130 degrees; his altitude at this time was 6,000 feet. He was then cleared to descend to 5,000 feet and advised to turn further right to a heading of 150 degrees. The next transmission by LaGuardia Approach Control constituted an air traffic advisory, "traffic at 2:30, 6 miles northeast-bound." This traffic information was not relayed as unidentified traffic, nor was it given as conflicting traffic. Surveillance radar in current use is unable to provide information concerning an aircraft's altitude. Approximately 39 seconds after initially advising TWA 266 of traffic, the flight was again advised of the same traffic in the same relative position, at a distance of one mile. At no time prior to the one-mile advisory of traffic was any information furnished to Flight 266 which could have alerted it to a possible conflict. The last traffic advisory was transmitted to TWA approximately 5 seconds subsequent to a 20-degree heading change issued by LaGuardia Approach Control. The flight was conducted in conformance with the headings and clearances issued by Approach Control.

United Flight 826

United Flight 826 operated routinely as it progressed toward the New York area with one exception. The flight reported the No. 2 navigational receiver accessory unit as inoperative. This information was received by ARINC and relayed to the company. However, Air Route Traffic Control was not advised of the fact that United 826 was operating with a single omni receiver.

The New York Center originally cleared United 826 to the Preston Intersection (the clearance limit) via Jet 60 Victor to Allentown direct to the Robbinsville omni, Victor 123 to Preston, to maintain flight level 250.

Prior to reaching Allentown the New York Center advised United 826 that it was in radar contact and issued a descent clearance to 13,000 feet. United 826 elected to remain at flight level 250 in the event of a delay due to weather. Shortly after passing Allentown the flight started its descent to 13,000 feet and was recleared via a shorter route to proceed on Victor 30 until intercepting Victor 123. This new routing shortened the distance to the Preston Intersection by approximately 11 nautical miles. However, it did not alter the Preston clearance limit. The New York Center advised United 826 to maintain present heading from Allentown until intercepting Victor 30, and then cleared it to descend to and

maintain 11,000 feet. Subsequently, United 826 was advised by New York Center that it was crossing the centerline of Victor 30. United 826 confirmed establishment on Victor 30 and requested his distance from Victor 123. The New York Center advised that the flight was 16 miles from Victor 123 and about 2 miles from crossing Victor 433. This information, showing the proximity to Victor 123 and the Preston Intersection, should have alerted the United crew of the rapid approach to the clearance limit.

After United 826 was established on Victor 30, the New York Center cleared the flight to descend to 5,000 feet. United 826 acknowledged and reported leaving 14,000 feet. New York Center than asked if United 826 could make Preston at 5,000. United indicated it would try. A transfer of control could not be effected to Idlewild Approach Control until United 826 vacated 6,000 feet.

To assure that United 826 understood the clearance limit, the New York Center provided holding instructions for the Preston Intersection. The flight was advised at this time that the only delay would be in the descent. United 826 reported leaving 7,000 and 6,000 feet. United's report leaving 6,000 feet was acknowledged by the New York Center which then instructed the flight to contact Idlewild Approach Control. New York Center did not furnish radar vectors to United 826. United 826 was doing its own navigation and the radar service thus far provided was in the form of advisories. United 826 contacted Idlewild Approach Control and reported approaching Preston at 5,000. When United 826 advised approaching Preston, it had already passed Preston by several miles. In accordance with the information relayed to Idlewild Approach Control by the New York Center, United 826 would be approaching Preston from the southeast. However, the revised clearance via Victor 123 would have United 826 approaching from the southwest. This revised routing was not relayed by the New York Center to Idlewild Approach Control.

The area which would normally be observed by the approach controller on radar in an effort to identify aircraft approaching Preston would have been from a southerly direction. According to the position report transmitted by United 826, and the clearance limit issued by ATC, the approach controller would have normally expected to observe a target approaching Preston. No target was observed. Aircraft must be positively identified and radar contact established by the controller before radar vectors are commenced. Positive radar contact is accomplished by several means:

1. By the aircraft reporting over a known radio fix which the controller has described on his scope.

2. By ascertaining the heading of an aircraft and requesting a turn to a designated heading for identification.

3. By a coded Beacon transponder response.

A radar handoff would be effected in somewhat the same manner, the only exception being that both facilites, New York Center and Idlewild Approach Control, would simultaneously observe the aircraft during these procedures and the controlling facility would not relinquish control until the receiving facility had the aircraft positively identified. It was testified that radar handoffs are the exception rather than the rule. Their use is not mandatory in the air traffic control system.

Radar handoffs may be used at the discretion of the controller with prior coordination between facilities, or in the event of an emergency. A radar handoff was not used for United Flight 826.

Since United 826 did not advise ATC of a failure of a component or components of the No. 2 omni receiver or request radar assistance, ATC could only assume that he was capable of providing his own navigation. Therefore, there was no requirement to effect a positive radar handoff procedure between New York Center and Idlewild Approach Control.

Air Traffic Control

Victor Airway 123, upon which United 826 was proceeding, is utilized and chartered as a one-way, inbound airway serving LaGuardia and Idlewild Airports. Under IFR, aircraft traversing this airway are controlled by the New York Air Route Traffic Control Center. Under VFR weather conditions, aircraft may traverse this airway without an ATC clearance, in which event ATC would not have knowledge of such aircraft's position, altitude, destination, or identification. Further, air traffic procedures do not provide for the separation of en route IFR and VFR traffic except in designated positive control airspace. In view of the fact that the weather in the New York area on December 16, 1960, during the period 1000 to 1100, was not conducive to VFR operation, it is highly improbable that VFR traffic would have been traversing Victor 123 on approach control radar. On the basis of all available meteorological information, it is concluded that the weather conditions in the New York area were such that between the altitude of 300 feet and 18,000 feet, VFR flight could not have been employed.

The New York Center records indicate that there were no IFR aircraft overflying the New York Metropolitan area via Victor 123 during the period 1000 to 1100 on December 16, 1960. Consequently, the aircraft observed on radar by LaGuardia Approach Control could only have been traffic destined for one of two airports, LaGuardia or Idlewild, or an unidentified aircraft. Since LaGuardia Approach Control did not have a flight progress report on the unidentified traffic, they were aware that the traffic on Victor 123 was not destined for their airport. In order to have been certain of the destination of the unidentified aircraft, the approach controller could have requested this information from the New York Center. It is doubtful that LaGuardia Approach Control could have established communication with the New York Center, identified the aircraft, and transmitted effective instruction in approximately 39 seconds. The only immediate alternative action that could have been taken by the LaGuardia Approach Controller would have been to provide evasive radar vectors to TWA 266 on the assumption that the unidentified traffic was conflicting traffic. This provision of evasive vectors to TWA 266 would not be incumbent on the controller inasmuch as the airspace in the area in which TWA 266 was operating had been assigned to LaGuardia Approach Control.

The New York Center RR5A Radar Controller's testimony that he observed United 826 on his scope 1 to 3 miles south of Preston at the time the flight reported out of 6,000 feet is inconsistent with the facts concerning the time

of collision It must be concluded that the controller's memory of the position of United 826, or the time of observation, is in error. If he were correct there could not have been a collision at the time and place it occurred. The Board concludes from the foregoing that the controller did not observe 826 at this location.

The transmission "No. 2 navigation receiver accessory unit out" has raised the question as to its precise meaning An inoperative accessory unit is a term which cannot be accurately applied to this DC-8. It appears that the description of the malfunction relates to the VOR instrumentation in earlier aircraft on which the crew had more operating experience. The comparable unit installed on the DC-8 would have been correctly named the VHF navigation No. 2 instrumentation unit, however, the function of the units in both aircraft was basically the same. Assuming that this unit was inoperative due to a loss of power, the following effects might have been observed by the crew·

Condition	Indication to Crew
1. VHF NAV-2 115V Circuit Breaker (OA Bus 3) Open	a. No. 2 PDI red warning flag visible.
	b No. 2 RMI-VOR (double barred) pointers became sluggish.
	c. No audio signal.,
2. VHF-NAV-2 28V. D. C. Circuit Breaker (DC Bus 3) Open	a. No. 2 PDI red warning flag visible.
	b. No. 2 RMI-VOR (double barred) pointers drift.
	c. No audio signal.
3. First Officer's heading output radio fuse open	a. No. 2 PDI red warning flag visible.
	b. No. 2 RMI-VOR (double barred) pointers will not respond to change in heading or frequency selection.
4. VHF NAV Transformer No. 2 Circuit Breaker Open	a No. 2 PDI red warning flag visible.
	b. First officer's RMI-VOR card and No. 2 RMI-VOR (double barred' pointers will not respond to change in heading or frequency selection.

These conditions were likely the result of a faulty unit or wiring and resulted in a red warning flag, open circuit breaker or blown fuse. Admittedly this would

have been an obvious sympton of a malfunction to the extent that the crew would have recognized the failure without the appearance of a red warning flag.

Derivation of Flightpaths in Attachment 1

Prior to the clearance via Victor 30, United Flight 826 had been cleared Allentown VOR direct Robbinsville VOR. Accordingly, the flightpath after passing the Allentown VOR was projected on the basis of a turn to a direct heading to Robbinsville VOR, and this heading maintained until intercepting Victor 30. The transcriptions indicate that the aircraft was established on Victor 30, and at 1029·02 was given a position by the New York Center as approximately two nautical miles from crossing Victor 433. It was assumed that the aircraft would be flown within the confines of Victor 30 airway until the turnoff to intercept Victor 123. In considering that one VOR receiver may have been inoperative, the turn onto Victor 123 was plotted as a gradual turn to the 050-degree radial of Robbinsville in order not to overshoot the centerline of Victor 123. From the point of interception of Victor 123, the flightpath was projected in a straight line to the collision point computed as approximately 6,555 feet from the center of Miller Field on a bearing of 315 degrees magnetic. This flightpath was derived independent of the flight recorder information.

TWA Flight 266 had been cleared from Allentown VOR via Victor 6 to the Linden Intersection. It was assumed that the aircraft would be flown along the centerline of Victor 6 until being vectored for an approach to the LaGuardia Airport. At 1030.49 TWA Flight 266 was requested to reduce to approach speed, and subsequently given turns to headings of 130 degrees, 150 degrees, and 130 degrees. These turns to headings were properly executed. Accordingly, a ground speed of 160 knots was considered reasonable in projecting the probable path of flight while being vectored, and the path was plotted from the estimated collision point back to Victor 6 on magnetic headings of 310 degrees, 330 degrees, and 310 degrees.

The time of collision utilized is not intended to mean that this is the precise time of collision. In order to have a starting point for the purpose of establishing approximate geographical positions at one-minute intervals, 1033·39 was selected as a reasonably within-range figure for the following reasons:

1. It marks a definite point in the transcript of the recordings, i.e., the end of the "open mike" sound.

2. This time point was selected as within reasonable limitations based upon.

   a. At 1033:42 TWA 266 was instructed to turn left to a heading of 100 degrees. This instruction was neither followed nor acknowledged, according to the transcript, and;
   b. At 1033·26 TWA 266 was advised of traffic at 3 o'clock one mile Assuming the accuracy of the one-mile figure and using a ground speed range from 240 knots to 320 knots for the unidentified target, the time to collision is 1033:26 plus 10 seconds equals 1033·36, or 1033:26 plus 15 seconds equals 1033·41.

3. United Flight 826 reported approaching Preston at 1033·28. Detailed landing information to United 826 ending at 1033·54 was given by Idlewild Approach Control, but was not acknowledged, although all previous instructions had been acknowledged in approximately six seconds or less. It was therefore considered that the Collision occured within the time interval 1033·30 - 1034:00.

Since the time of 1033:39 represented a definite time point in the transcribed recording tapes approximately midway between the foregoing time computations, it was selected for the purpose of plotting the approximate geographical positions of the aircraft along the flightpath at one-minute intervals.

The flightpath of United 826 as derived from the flight recorder readout was plotted independently of the information obtained from the communications tapes. The two tracks depicted in Attachment 1 are similar. The starting point of each track was the point of collision as determined by the trajectory study. The flightpath was then worked out in reverse from this point using the information obtained from the flight recorder readout. The successive points were determined and plotted back along the flightpath to Allentown. The data points were then joined in a faired curve.

Flight recorder tapes of selected flights making ILS approaches under instrument weather conditions to New York International Airport from the areas of airways Victor 30 and Victor 123 between December 8 and December 16, 1960, were plotted. Only two of the 31 computed ground tracks included a holding pattern at Preston. Most of the remaining tracks indicated turns at or in the general vicinity of Preston. However, possible track inaccuracies resulting mainly from tolerances in indicated airplane headings and possible differences between actual and reported winds preclude determination of the exact distance from Preston at which these turns were made.

VOR Stations

United Air Lines Flight 826 did not enter a holding pattern at Preston Intersection but proceeded northeast on Victor 123. This raised the question of the reliability and integrity of the VOR radio navigation signals transmitted from Robbinsville, Colts Neck, and Solberg which define the Preston Intersection. Many theories have been advanced to explain how incorrect navigation information could have existed in the vicinity of Preston at the time of the accident. It has been suggested that false radio bearing information existed at Preston and could have been caused by co-channel interference, harmonics, industrial radio noise, reflections, vertical polarization, and a transmitter malfunction. To properly appreciate and evaluate each theory, a brief review of VOR operating principles is presented.

VOR stations at the above three locations are operated and maintained by the Federal Aviation Agency and transmit signals in the very high frequency radio spectrum. Each station is located at a carefully selected site. The structure houses the transmitting equipment beneath a domed housing or counterpoise which serves as part of the antenna system. A 360-degree signal radiates from antennas sheltered beneath a cone which is situated in the middle of the

counterpoise. The bearing information is transmitted via signals that are unique for each azimuth. Should a signal of specific bearing peculiarities be changed from its proper azimuth by some reflecting phenomenon it would still retain its original bearing information regardless of its final alignment. A monitoring device which is attached to the counterpoise edge alerts the proper personnel by "alarming" when certain signal characteristics change, when the bearing information is in error plus or minus one degree, and when the signal is not present. In addition, this monitor immediately shuts the transmitter off when any of the above occur. There was no record of such an irregularity on any of the above facilities on the date of the accident.

The pattern of signal strength developed in space is the algebraic addition of signals direct from the antennas and signals reflected by the counterpoise. In addition, relections of the signals by the earth contribute to the form of the signal strength pattern. The varying surface character of the earth will cause the pattern to differ slightly with each azimuth. Hills, trees, fences, and buildings can all vary the reflecting ability of the earth. A weak signal space in the signal pattern is called a "null" and the pattern of stronger signals is called a "lobe." The reflective quality of the earth's surface varies, but normally the strength of signals reflected is low in comparison with the direct signals so that variations in the earth's reflecting ability would result in slight changes in the signal pattern. Therefore, the general pattern of the VOR signal strength is a lobe filling the space surrounding the station from the horizon to an elevation angle of approximately 75 degrees. Normally, the station signals fill the space about a station and a nonnavigable signal is developed 10 degrees to 15 degrees either side of the vertical over the station. This null is termed the cone of ambiguity.

The even distribution of snow on the counterpoise may cause a very small change in the signal pattern. Testimony received at the second public hearing disclosed that approximately two inches of snow were on the counterpoise of the Colts Neck VOR several hours after the accident. Tests previously conducted by the FAA during the winter of 1949-50 concluded that although snow on the counterpoise is undesirable it is not a serious source of error unless the height of snow exceeds the height of the antennas (approximately 48 inches).

The theory of co-channel interference suggests the possibility that another VOR station operating on the same frequency as Colts Neck transmitted its signal by some phenomenon into the Preston area. Due to the numerous VOR stations in the United States and because of the limited number of radio frequencies available, the same frequency must be occasionally assigned to more than one station. However, since radio signals in this frequency spectrum are receivable only in an approximate line of sight path, the difficulty of sharing frequency is eliminated by placing stations using the same frequency a great distance apart. Theoretically it is possible to receive signals of this radio band over a distance substantially greater than the line of sight path, but authorities believe that required conditions rarely occur and then only occasionally during the summer months. Nevertheless, assuming that such a phenomenon did exist on December 16, the resultant signal formed by the combination of two different station signals would depend on the quartz crystals being of the same calibration frequency values for each transmitter and on the phasing of the modulated bearing intelligence to form a flyable signal. For such coincidental phenomena to occur over the distance

and altitudes flown by United Flight 826 as it went through the Preston area is considered highly improbable.

Several industrial processes are known to generate radio signals, harmonics of which fall in the VOR frequency band. The existence of such signals is known to have occurred in the New York City area and the strength of such signals would permit their reception in the Preston area. The possibility that such signals caused erroneous bearing information to be received by the United flight is extremely unlikely. American Flights 46 and 100, following the United flight over Preston by four and seven minutes respectively, reported no interference.

The possibility of interference to the proper reception of VOR signals caused by other strong radio signals such as those transmitted by the Voice of America station WBOU at a nearby location was considered. Flight checks of the VOR stations defining Preston, with WBOU operating at the frequencies and power used at the time of the accident, found no evidence of interference.

One of the most serious conditions that can arise once a null or weak signal zone is developed in the VOR pattern is the reflection of a signal of another azimuth into the null. To aid in resolving this possibility the Colts Neck site was studied for landscape, structure, or device which would act as a reflector and retransmit a signal into a null at or near the Preston Intersection. Two objects, a metal-roofed barn, and an amateur radio station antenna, were considered as possible reflectors. To ascertain the effect of these objects as reflectors, a mathematical analysis disclosed that the signal received by any aircraft following the path the United flight is believed to have followed would be unflyable and instrument reaction would certainly alert the crew to unusual conditions. It was suggested that two hills in the area of the Colts Neck station may have reflected undesired azimuth signals into the Preston area, but again the character of the resultant signals received by an aircraft would be unusual and noticeable to a flight crew. The reception of a satisfactory signal by American Flights 46 and 100 over Preston a short time after the passage of Flight 826 indicated that such a condition did not exist at 4,000 or 6,000 feet.

Normally, the signal transmitted by a VOR station is predominantly horizontally polarized. However, some vertical polarization exists to a small degree. The vertically polarized wave component of a signal is transmitted in the same azimuth as the horizontally polarized portion, yet its bearing information is 90 degrees greater or less than the actual azimuth. Theoretically, the vertically polarized signal is generated by a separate portion of the antenna structure, which would cause the formation of a separate and distinct signal pattern. This then would make the result of such polarization more effective in changing the resultant bearing received by an aircraft. A review of the flight check data of the Colts Neck station indicates a below-normal level of vertical polarization throughout its history. Such a condition could go undetected by station monitoring equipment, but the lack of such polarization before and after the accident is a strong indication that it did not occur during the period when Flight 826 was near Preston. The two American flights experienced no failure or noticeable signal variation as they followed United 826 up Victor 123.

An extensive investigation was made of the transmitting equipment and station logs of the three stations involved. Signals from each station were monitored

for a considerable period of time. One period of monitoring was conducted at the geographical position of Preston. There was no evidence disclosed by this phase of the investigation to indicate that any of the three stations was malfunctioning prior to, at the time of, or subsequent to, the accident.

The Board believes that the failure to solve the time and distance problem associated with the clearance, in conjunction with the apparent failure of the No 2 VOR accessory unit and resultant instrument pictorial display, caused the passing of the Preston Intersection to be unobserved by the flight crew. The flight was proceeding normally on the original clearance via Allentown, Robbinsville to Preston. En route to Allentown at 1021 the DC-8 reported the No. 2 navigation receiver accessory unit to be inoperative. The message directed to United maintenance personnel via ARINC radio was an alert that either the cockpit instrumentation, the navigation equipment, or both, would require attention during the ground stay of the aircraft at Idlewild. There was no report to the effect that navigation was difficult or impossible.

While en route from Allentown to Robbinsville, Flight 826 received an amended clearance via Victor 30 and to intercept Victor 123 with further clearance to be expected at Preston. There was no delay expected. This new clearance necessitated a rapid descent and maneuvering in order to position the flight at 5,000 feet over Preston. When the clearance was changed, with the subsequent short cut of approximately 11 nautical miles, the crew apparently made no notation of the shortened time and distance from the interception of Victor 123 to the Preston Intersection.

The crew committed a primary error by apparently failing to record and note the time and distance required to comply with their new clearance. It is logical, in view of the rapidity with which the flight was being maneuvered, to assume that the time and distance from the intersection of Victor 30 and Victor 123 to Preston was not corrected from the original time and distance associated with the Robbinsville/Preston clearance. This original time and distance was probably embeded in the crew's mind and, time-wise, they would have believed that Preston had not been reached. Logically, since the No. 2 VOR accessory unit and associated instruments were undependable, the captain would be expected to use a substitute method for determining Preston by retuning the No. 1 VOR to Colts Neck or Solberg or by tuning the No. 1 ADF to the Scotland Radiobeacon. If tuned to Scotland, the crew could have observed the pointer for the identification of Preston by reading a magnetic bearing on the No. 1 ADF. The ADF is considered the logical instrument to use inasmuch as the flight would normally proceed toward Scotland after receiving a clearance to depart Preston.

If the crew retuned the operable No. 1 VOR after establishing their position on Victor 123, they could have received the appropriate radial of the Colts Neck omni by selecting 166 degrees in the window and tuning to the Colts Neck frequency. If this were accomplished before passing the intersection at Preston, they would have had an indication of the intersection by the floating pointer when passing Preston. If they had already passed Preston when the selection was completed, the indication on the dial would have been a full deflection of the pointer, at which time they could have taken some action to discontinue further flight in a northeasterly direction.

Normally, with both VOR units operating properly, the No. 2 VOR floating pointer would pass across the centerline when the aircraft passed the Preston Intersection provided that the unit were tuned to Colts Neck and the window setting was 166 degrees to the station. Simultaneously, the No. 2 pointer on the captain's VOR RMI would, when operating correctly, point to 166 degrees on the VOR azimuth at the time of passing Preston. The crew would be accustomed to this instrument display.

If the No. 2 VOR accessory unit were dependable, the captain would use his No. 1 VOR and his PDI on Robbinsville and expect to see the double pointer on his No. 1 VOR pointing to 166 degrees on the rotating azimuth when crossing Preston and at the same time the copilot's PDI would be indicating the crossing of Preston. It is believed that since Colts Neck facility was apparently operating normally and that the crew had used this facility while operating the flight on Victor 30, it would have been the logical aid for establishing the Preston fix. Since it is believed that the ADF was used for navigation, it is probable that the captain was transitioning to the ADF and pictorially associated this instrument with the VOR RMI. In such a case he would continue his flight until the No. 1 pointer of the ADF indicated 166 degrees on the RMI. With the No. 1 ADF tuned to Scotland, the collision occurred when the single pointer was indicating approximately 153 degrees and had not reached the erroneously desired 166 degrees. This, coupled with the facts that the crew had informed approach control that they were coming up on Preston, that the altitude at time of collision was a little over 5,000 feet, that radar service had been terminated, and that the crew had not reported over Preston, all tend to support the conclusion that the crew believed they had not yet reached the Preston Intersection when the collision occurred.

Also, the flight had remained on the 050-degree radial of Robbinsville while proceeding northeastward and little deviation from course was recorded. The time to point of collision was nearly the same as time normally required to fly from Robbinsville to Preston. The distance from normal interception of Victor 123 via the clearance to Robbinsville to Preston is approximately the same distance that the flight made from intercepting Victor 123 via Victor 30 to the crash site. Therefore, the time to travel from Robbinsville to Preston would approximate the elapsed time from Victor 30 intersection to the crash site.

The Board believes with the above conditions prevailing the captain would be operating the controls depending upon the copilot to tune the navigational equipment, record new clearances, and keep him advised of other operational data. It is further logical to assume that the captain would use his No. 1 VOR pointer and the PDI unit tuned to Robbinsville frequency to maintain his position on Victor 123, and hold if necessary.

The crew had flown this air route many times and were familiar with the time and distance from Robbinsville to Preston. Also, at the Preston Intersection and tuned to Colts Neck the captain, when navigating with both VOR units, was accustomed to seeing the No. 2 VOR pointer in a southeast direction and to reading 166 degrees on the No. 1 or captain's VOR azimuth. The pictorial display by the captain's ADF when tuned to Scotland with the aircraft over the crash site would resemble the VOR display when at Preston with the No. 2 VOR tuned to Colts Neck. The Preston Intersection would be identified while holding the outbound radial of 050 degrees of Robbinsville and by a 100-degree indication on the RMI tuned to Scotland. It is realized that the New York area charts do not indicate

specifically the bearing of Scotland from Preston, but by inspection a very close approximation of the correct bearing could be obtained.

From the foregoing, the Board concludes that the crew of United 826 did not take note of the change of time and distance which would be associated with the new clearance and probably confused the ADF display with the anticipated VOR display, thereby exceeding the clearance limits.

The Board concludes that while with this type aircraft it is possible to navigate with one VOR navigational unit, the high degree of cockpit occupation during the approach to Preston Intersection indicates that a second operable VOR unit would have assisted in a positive identification of the Preston Intersection The change of clearance from the original "Allentown, direct Robbinsville, Victor 123 to Preston" to the short cut clearance "present heading, to Victor 30, Victor 30 to Victor 123 to Preston," added to the workload of revising and recomputing the navigational problem during a very small interval of time.

The Board further concludes that the New York Center Controller did not observe United 826 proceeding through the Preston Intersection before he had advised the flight to contact Idlewild Approach Control and prior to the termination of radar service. When radar service was being terminated at 1033·20, Flight 826 had already proceeded eight or nine miles beyond Preston. United 826 acknowledged this transmission at 1033 27, seconds before the collision.

The Board notes that during the course of this investigation the Federal Aviation Agency took various steps to improve and strengthen the efficiency and effectiveness of its Air Traffic Control System, including the following:

1. A special regulation (SR-445) was issued which requires pilots operating under instrument flight rules to report in-flight malfunctions of navigation or communication equipment.

2. A program has been established for all turbine-powered aircraft to be equipped with distance-measuring equipment (DME) by January 1, 1963. One year later all aircraft of over 12,500 pounds maximum takeoff weight must be so equipped.

3. Radar handoff service for arriving and departing aircraft in the New York area is being performed to a much greater extent than was practiced before the accident. On a national basis, full-time radar handoff service has increased to a great extent.

4. Controllers have been instructed to issue an advisory to arriving jet aircraft to "slow to holding pattern airspeed at least 3 minutes before reaching holding fix."

5. The Stroudsburg, Pennsylvania, VOR name and identification signal (SSB) have been changed to Taunersville (TVE) because of potential confusion with Solberg VOR (SBJ).

6. The Agency has issued a speed rule which prohibits aircraft from exceeding 250 knots when within 30 nautical miles of a destination airport and below 10,000,

except where the safety requirement of tactical military jets dictates a higher minimum speed, which then applies to these aircraft.

Probable Cause

The Board determines that the probable cause of this accident was that United Flight 826 proceeded beyond its clearance limit and the confines of the airspace allocated to the flight by Air Traffic Control. A contributing factor was the high rate of speed of the United DC-8 as it approached the Preston intersection, coupled with the change of clearance which reduced the en route distance along Victor 123 by approximately 11 miles.

BY THE CIVIL AERONAUTICS BOARD:

/s/ ALAN S. BOYD
Chairman

/s/ ROBERT T. MURPHY
Vice Chairman

/s/ CHAN GURNEY
Member

/s/ G. JOSEPH MINETTI
Member

/s/ WHITNEY GILLILLAND
Member

S U P P L E M E N T A L D A T A

Investigation and hearing

The Civil Aeronautics Board was notified that there was apparently an aircraft collision over Staten Island, New York, approximately 1050, December 16, 1960 Investigators were immediately dispatched from the Washington office to aid the New York office investigators who were already on the scene. The investigation was initiated in accordance with the provisions of section 702(a)(2) of the Federal Aviation Act of 1958

A public hearing was ordered by the Board and was held in the ballroom of the St. George Hotel, Brooklyn, New York, on January 4 through January 13, 1961. Seventy-nine witnesses were interrogated and a large amount of documentary material was received in evidence

A second public hearing was held at Civil Aeronautics Board Headquarters in the Universal Building, 1825 Connecticut Avenue, Washington, D. C., on July 21 and 22, 1961, at which time fifteen additional witnesses were interrogated and several witnesses recalled. Additional exhibits were introduced into evidence.

Air Carriers

Trans World Airlines, Inc , a Delaware corporation, is a scheduled air carrier with its principal offices located at Kansas City, Missouri. It possesses a currently effective certificate of public convenience and necessity issued by the Civil Aeronautics Board and an air carrier operating certificate issued by the Federal Aviation Agency These authorize the carrier to transport by air persons, property, and mail over various routes including that from Dayton, Ohio, to New York, New York.

United Air Lines, Inc , is a Delaware corporation with its corporate offices in Chicago, Illinois. The company is engaged in transporting by air persons, property, and mail It holds a currently effective certificate of public convenience and necessity issued by the Civil Aeronautics Board and an air carrier operating certificate issued by the Federal Aviation Agency. These authorize operation over a number of routes including that of Los Angeles, California, to New York, New York.

Flight Personnel

1. Trans World Airlines, Inc

Captain David A. Wollam, age 39, was employed by Trans World Airlines on May 23, 1945. He held a valid airman certificate with a currently effective airline transport certificate No. 261640. His ratings included DC-3, Martin 202 and 404, and Lockheed Constellation aircraft. Captain Wollam had a total of 14,583 flying hours, of which 267 were in the Constellation. He qualified in this type equipment on September 9, 1952. He was current in the requirements of proficiency checks, line checks, route qualifications, and recurrent training His last Federal Aviation Agency physical was passed on October 31, 1960.

First Officer Dean T. Bowen, age 32, was employed by Trans World Airlines on July 13, 1953. He held a currently effective airline transport certificate No. 1261217. He was rated on Lockheed Constellation aircraft.

First Officer Bowen had a total of 6,411 flying hours, of which 268 were in the Constellation He qualified in this type equipment on May 13, 1959. He was current in all Federal Aviation Agency and company requirements. His last Federal Aviation Agency physical was passed on September 17, 1960

Flight Engineer LeRoy L. Rosenthal, age 30, was employed by Trans World Airlines on January 3, 1956. He held a currently effective airframe and powerplant certificate No. 1329810 and flight engineer certificate No. 1340774. Mr. Rosenthal qualified as a flight engineer with the company on May 9, 1956. He had a total of 3,561 flying hours, of which 204 were in Constellation equipment.

Stewardess Margaret Gernat, age 24, was employed by Trans World Airlines on October 13, 1958.

Stewardess Patricia Post, age 21, was employed by Trans World Airlines on January 1, 1960

2. United Air Lines, Inc.

Captain Robert H. Sawyer, age 46, was employed by United Air Lines on January 2, 1941. He held a valid airman certificate with a currently effective airline transport certificate No 70677. His ratings included DC-3, B-247, DC-4, DC-6, DC-7, and DC-8 type aircraft. Captain Sawyer had a total of 19,100 flying hours, of which 344 were in DC-8 type aircraft. He qualified in DC-8 type aircraft on June 6, 1960. He was current in the requirements of proficiency checks, and route qualifications. His last Federal Aviation Agency physical examination was on September 26, 1960.

First Officer Robert W. Fiebing, age 40, was employed by United Air Lines on May 1, 1951. He held a currently effective airline transport certificate No. 439262. His ratings included· DC-3, DC-4, DC-6, DC-7, and DC-8 aircraft. First Officer Fiebing had a total of 8,400 hours, of which 416 were in DC-8 type aircraft. He was rated in DC-8 aircraft on May 3, 1960. His last Federal Aviation Agency physical was August 23, 1960.

Second Officer Richard E. Pruitt, the flight engineer, age 30, was employed by United Air Lines on September 15, 1955. He held an airline transport certificate No 1161137 and flight engineer certificate No. 1329809. His ratings included: DC-6, DC-7, and DC-8 type aircraft. Second Officer Pruitt had a total of 8,500 hours of flying time, of which 379 were as flight engineer in DC-8 type aircraft He was rated in DC-8 type aircraft on December 15, 1959. His last Federal Aviation Agency physical was August 23, 1960.

Stewardess Mary J. Mahoney, age 24, was employed by United Air Lines on October 31, 1955.

Stewardess Anne M. Bouthen, age 29, was employed by United Air Lines on August 25, 1954.

Stewardess Patricia A. Keller, age 26, was employed by United Air Lines on July 28, 1960.

Stewardess Augustine L. Ferrar, age 22, was employed by United Air Lines on May 30, 1956.

The Aircraft

1. Trans World Airlines, Inc.

N 6907C, a Lockheed Constellation, model L-1049A, manufacturer's serial No. 4021, was delivered to Trans World Airlines on October 16, 1952. At the time of the accident the aircraft had a total of 21,555 flying hours. A line maintenance operation had been conducted 149 hours prior to the accident. The aircraft had been flown 3,955 hours since its last overhaul. The aircraft was equipped with Wright engines, model WAD 975C18CB-1 and Hamilton Standard propellers model 43E60 with model 6901-0 blades.

2. United Air Lines, Inc.

N 8013U, a Douglas DC-8, manufacturer's serial No. 45290, was delivered to United Air Lines on December 22, 1959. At the time of the accident the aircraft had a total of 2,434 flying hours. The aircraft had been flown 42 hours since the last overhaul. The aircraft was equipped with Pratt & Whitney JT3C-6 turbojet engines.

GLOSSARY

Air route traffic control center (Center).

An FAA facility established to provide air traffic control service to IFR flights operating within controlled airspace and principally during the en route phase of flight.

Air traffic clearance (Clearance).

Authorization by air traffic control facilities, for the purpose of preventing collision between known aircraft, for an aircraft to proceed under specified traffic conditions within controlled airspace.

Air traffic control (Control).

An FAA service provided for the purpose of promoting the safe, orderly and expeditious flow of air traffic including airport, approach and en route air traffic control services.

Air traffic control specialist (Controller).

A duly authorized person employed by the FAA providing air traffic control service.

Approach Control.

Air traffic control service, provided by a terminal area traffic control facility, for arriving and/or departing IFR flights and, on occasion, VFR flights

Center's area.

The specified airspace within which an air route traffic control center provides air traffic control and flight advisory service.

Clearance limit.

The fix to which an aircraft is issued an air traffic clearance.

Holding.

A predetermined maneuver which keeps an aircraft within a specified airspace while awaiting further clearance.

IFR conditions

Weather conditions below the minima prescribed for flight under Visual Flight Rules.

IFR flight.

Flight conducted in accordance with instrument flight rules.

Radar handoff

That action whereby radar identification and control or advisory jurisdiction over an aircraft is transferred from one controller to another without interruption of radar surveillance.

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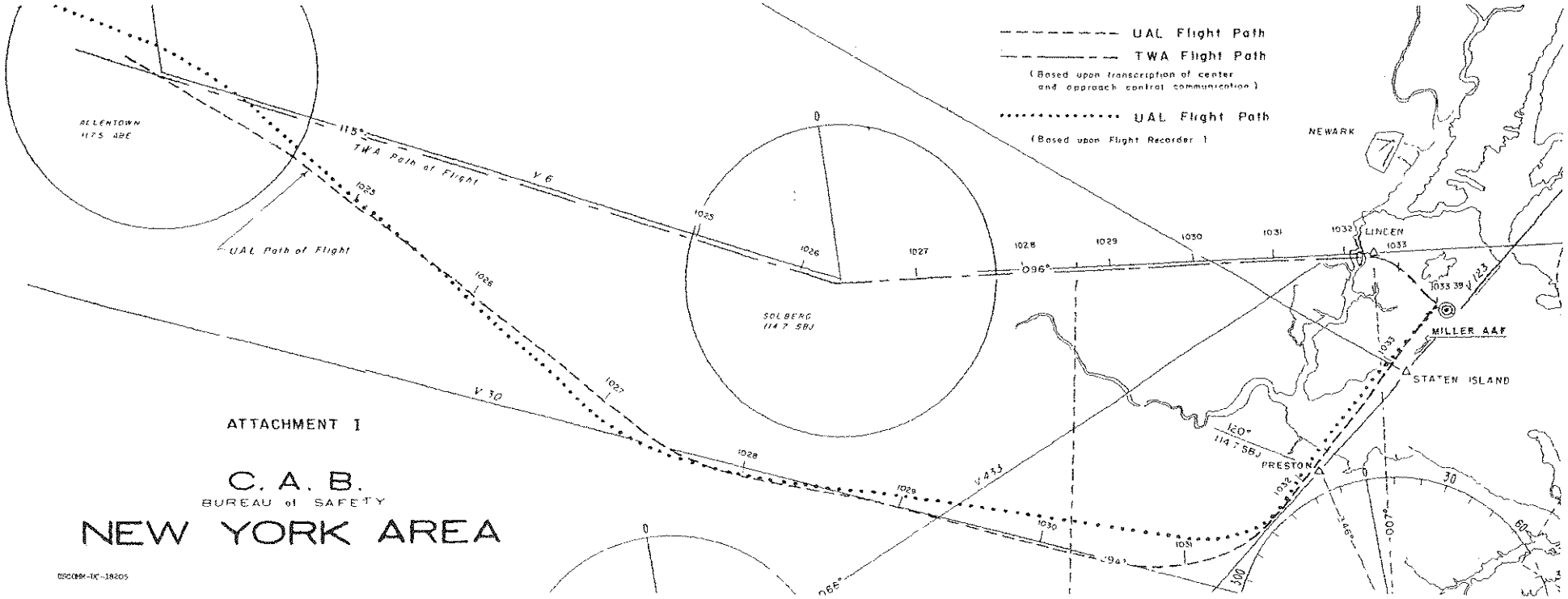
UAL Flight Path
TWA Flight Path
(Based upon transcription of center and approach control communication)
UAL Flight Path
(Based upon Flight Recorder)
NEWARK
LINDEN
MILLER AAF
STATEN ISLAND
PRESTON
SOLBERG
114.7 SBJ
TWA Path of Flight
UAL Path of Flight
V 6
V 30
V 433
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096°
120°
114.7 SBJ
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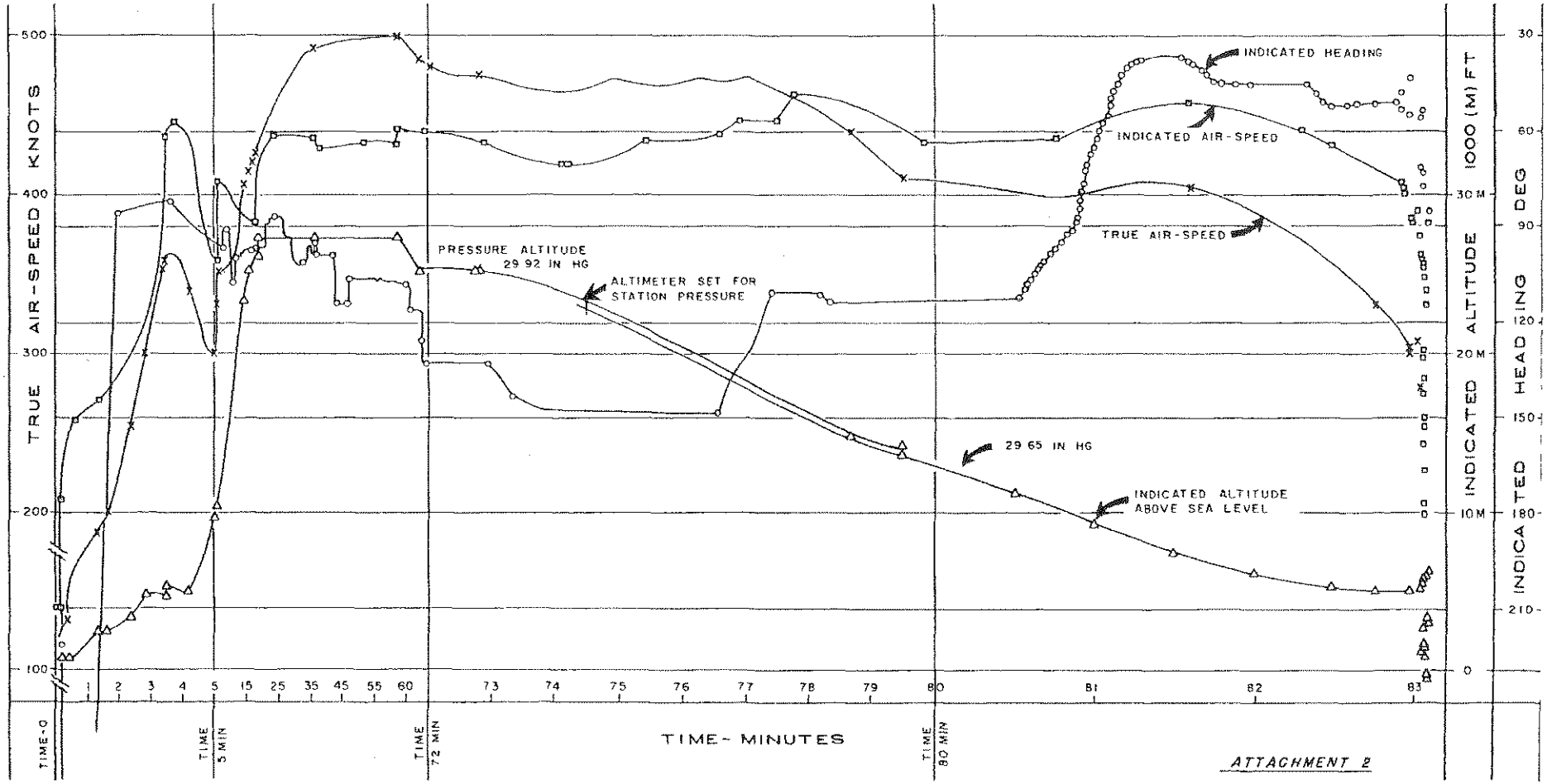
ATTACHMENT I
C. A. B.
BUREAU of SAFETY
NEW YORK AREA



ATTACHMENT 2