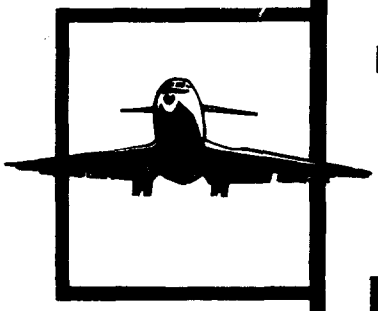

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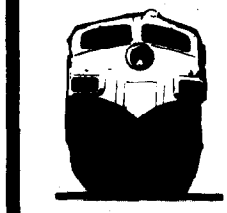
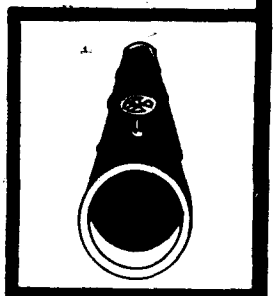


WASHINGTON, D.C. 20594

SPECIAL INVESTIGATION REPORT

RUNWAY INCURSIONS AT CONTROLLED AIRPORTS IN THE UNITED STATES



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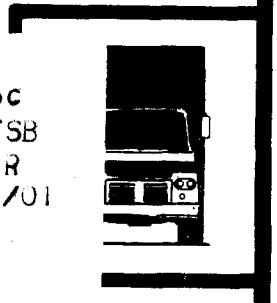

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16. Abstract The special investigation discusses the problem of runway incursions based on the results of the Safety Board investigations of 26 selected incidents. Details of the 26 incursions are summarized in an appendix to the report. The report discusses the issues that the Safety Board found most relevant to the runway incursion problem at controlled airports in the United States. The report includes a review of previous runway incursion incidents and accidents that led to recommendations to the Federal Aviation Administration for remedial actions. The effectiveness and status of the remedial actions are evaluated in the report, which concludes with new safety recommendations for actions that the Board believes would significantly reduce the frequency of runway incursions.

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NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C. 20594

SPECIAL INVESTIGATION REPORT

Adopted: May 6, 1986

RUNWAY INCURSIONS AT CONTROLLED AIRPORTS IN THE UNITED STATES

INTRODUCTION

The collision of two airplanes operating on or near the same runway at an airport presents the potential for tremendous loss of life. The collision of two Boeing 747's on a runway at the Tenerife, Canary Islands, Spain, airport on March 27, 1977, caused 583 fatalities--more fatalities than in any other accident in the history of aviation. Fortunately, there have been few such ground collision accidents. However, there have been many close encounters, and the number of reported near-collision ground incidents has increased significantly in the past 2 years.

On March 31, 1985, two Northwest Airlines DC-10's nearly collided at the Minneapolis-St. Paul International Airport, Minneapolis, Minnesota. One airplane, flight 51, was taking off from a runway after having been cleared for takeoff by the local controller. The other airplane, flight 65, was taxiing across the same runway after having been cleared to cross the active runway by the ground controller. The captain of flight 51 averted a collision by rotating to a takeoff attitude and lifting off below the recommended takeoff speeds. Because of poor braking conditions and limited space in which to stop, he had no alternative. Flight 51 lifted off and overflew flight 65, reportedly clearing the other DC-10 by 50 to 75 feet. There was a total of 501 persons aboard the two airplanes. There were no reported injuries and neither airplane was damaged.

Because of the Minneapolis incident and the frequency and the potential severity of similar incidents, in July 1985 the Safety Board initiated a special investigation of runway incursion incidents and accidents. 1/ The purpose of the special investigation was to investigate selected runway incursions to determine their underlying causes and to recommend appropriate remedial actions.

The Safety Board investigated 26 runway incursions for the special investigation. The Board selected the incidents on the basis of preliminary information and availability of investigative personnel. While the special investigation may not statistically represent all runway incursion incidents, the Board believes that the factors involved in these incidents are indicative of the causal factors in other incidents. Details of the 26 incursions are summarized in the appendix of this report of the special investigation and are cited throughout this report by case number. Each summary has pertinent facts about the incursion and a discussion of how it occurred.

1/ For the purpose of its special investigation, the Safety Board defined a runway incursion as any occurrence involving an aircraft, vehicle, person, object, or procedure that impedes the takeoff, intended takeoff, landing, or intended landing of an aircraft.

The FAA identified 17 of the incidents as controller-induced incursions and 9 as pilot-induced incursions. Despite the FAA categorization of incursions, the Safety Board determined that many incursions actually involved combinations of pilot and controller factors. The Board's special investigation included interviews with controllers, pilots, airport managers, airline management staff, and personnel from the Federal Aviation Administration's (FAA) Air Traffic and Flight Standards Services. A Board investigator led the investigation of each of the 26 incursions, aided by Board investigators specializing in air traffic control (ATC) and in human performance. The Board investigators were accompanied by FAA personnel in all of the investigations and by airline and pilot union representatives in selected investigations.

Of the 17 incidents attributed to controller error, 6 involved incomplete or misunderstood coordination between two controllers and 11 resulted from the actions of individual controllers. In seven incidents controllers stated they had forgotten about an aircraft or about previously effected coordination with other controllers. Six of the incidents involved a runway/taxiway crossing, four involved a single runway, three involved crossing runways, three involved an aircraft that had been given a "position and hold" clearance, and one involved a helicopter that started to cross a runway and conflicted with a fixed-wing aircraft.

Of the nine incidents attributed to pilot error, seven involved unauthorized runway crossing or entry for takeoff and two involved unauthorized takeoffs. In several of these incidents, runway and taxiway signs were missing or inadequate. In at least two incidents, pilots did not comply with controller clearances that the pilots had acknowledged receiving and understanding. The pilots contributed to some incursions by failing to communicate properly with ATC and failing to be vigilant and to scan runways and taxiways before moving their aircraft.

As part of the special investigation, Safety Board investigators visited the FAA's Mike Monroney Aeronautical Center (ATC Academy) at Oklahoma City, Oklahoma, where FAA controllers receive initial training. Board investigators also visited the United States Air Force ATC training center at Keesler Air Force Base, Mississippi, to compare the training of military controllers to the training of civilian FAA controllers. Board investigators examined policies and programs regarding FAA on-the-job training of controllers; human performance factors, including the effect of memory limitations; and the role of supervisory personnel in ATC towers. The FAA's runway incursion incident reporting and investigation programs also were examined.

This report of the special investigation discusses the issues that the Safety Board found most relevant to the runway incursion problem at controlled airports in the United States. The report includes a review of previous runway incursion incidents and accidents investigated by the Safety Board that led to recommendations to the FAA for remedial actions. The effectiveness and status of the remedial actions are evaluated in this report, which concludes with new safety recommendations for actions that the Board believes would significantly reduce the frequency of runway incursions.

BACKGROUND AND SCOPE OF INVESTIGATION

The following incidents and accidents are examples of runway incursions that were investigated by the Safety Board before the special investigation. The incidents and accidents were significant in that they led to Board recommendations that attempted to reduce the risk of a more widespread runway incursion problem.

On December 20, 1972, a DC-9 collided with a Convair CV-880 on a runway at O'Hare International Airport, Chicago, Illinois, 2/ killing 10 passengers aboard the DC-9 and seriously injuring 15 other occupants. The DC-9 was on takeoff when it struck the tail of the CV-880, which was taxiing across the active runway in front of the DC-9. Visibility was limited by dense fog. The Safety Board determined that the probable cause of the accident was:

> . . . the failure of the traffic control system to insure separation of aircraft during a period of restricted visibility. This failure included the following: (1) the controller omitted a critical word which made his transmission to the flightcrew of the Delta CV-880 ambiguous; (2) the controller did not use all the available information to determine the location of the CV-880; and (3) the CV-880 flightcrew did not request clarification of the controller's communications.

On June 21, 1978, a departing Cessna Citation and a taxiing DC-9 nearly collided at LaGuardia Airport, Flushing, New York. 3/ The Safety Board determined that the probable cause of the incident was the failure of the ground controller and local controller to effect the required coordination before using the active runway to accommodate ground movements of an aircraft. Contributing to the incident was a coordination procedure that did not require the local controller to establish direct communication with the DC-9 pilot, who was cleared to use the active runway for taxi operations.

On February 15, 1979, a Boeing 727 and a Boeing 747 nearly collided on a runway at O'Hare International Airport. 4/ The Boeing 727 had been cleared by the ground controller to taxi across the active runway while the Boeing 747, having received a landing clearance from the local controller, was landing on the same runway. The Boeing 727 crew did not see the Boeing 747 as they taxied onto the runway. During its landing rollout, the Boeing 747 crew observed the Boeing 727 and veered off the runway to avoid a collision.

On December 23, 1983, a DC-10 cargo flight collided head-on with a Piper PA-31 on a runway at Anchorage International Airport, Anchorage, Alaska. 5/ Both airplanes were

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2/ For additional information, read Aircraft Accident Report--"North Central Airlines, Inc., McDonnell-Douglas DC-9-31, N954N, and Delta Air Lines, Inc., Convair CV-880, N8807E, O'Hare International Airport, Chicago, Illinois, December 20, 1972" (NTSB-AAR-73-15, issued July 5, 1973).

3/ For additional information, read Aircraft Accident Report--"E.S.M. Groups, Inc., Cessna Citation, N51MW, and North Central Airlines, Inc., DC-9-30, N957N, La Guardia Airport, Flushing, New York, June 21, 1978" (NTSB-AAR-79-3, issued February 22, 1979).

4/ For additional information, read Aircraft Accident Report--"Near Collision of Delta Air Lines, Inc., Boeing 727-200, N467DA, and Flying Tiger, Inc., Boeing 747-F, N804FT, O'Hare International Airport, Chicago, Illinois, February 15, 1979" (NTSB-AAR-79-11, issued August 2, 1979).

5/ For additional information, read Aircraft Accident Report--"Korean Air Lines McDonnell Douglas DC-10-30, HL7339, South Central Air Piper PA-31-350, N35206, Anchorage, Alaska, December 23, 1983" (NTSB/AAR-84/10, issued August 9, 1984).

destroyed by impact and/or the effects of a postcrash fire. Three crewmembers aboard the DC-10 were seriously injured, and three passengers aboard the Piper PA-31 were slightly injured. The accident occurred because, in reduced visibility, the DC-10 captain was unsure of his position on the airport and entered an intersection of the wrong runway for takeoff. He discussed his uncertainty with his copilot, who assured the pilot they were on the correct runway. The captain then elected to take off. The DC-10 subsequently collided with the Piper PA-31, which was holding in position on the opposite end of the runway awaiting takeoff clearance. The Safety Board concluded that the DC-10 crew's confusion may have been caused, in part, by some runway and taxiway signs that were difficult to see because they were dirty and not fully lighted and because other signs were not in place to mark part of the taxi route.

On October 8, 1984, the pilot of a Cessna Citation executed an abnormally steep climb at near stall speed during takeoff in order to avoid colliding with a Douglas DC-9 that had taxied onto the active runway at William P. Hobby Airport, Houston, Texas. The Citation cleared the DC-9 by less than 10 feet. Visibility was reduced to about 2,400 feet runway visual range (RVR) because of fog. The control tower did not have either aircraft in sight and was not equipped with Airport Surveillance Detection Equipment (ASDE) to assist controllers in monitoring ground traffic in low-visibility conditions. The incident occurred, in part, because the DC-9 crew was unfamiliar with the taxi route and because the taxi route was not marked adequately with taxiway and runway signs.

The Safety Board investigated three runway incursions that involved ground vehicles in late 1983 and early 1984. In the first, a Boeing 747 collided with a pickup truck after completing an instrument landing system (ILS) approach and landing at Anchorage International Airport on December 19, 1983. Night instrument meteorological conditions prevailed, and the RVR was reported as 1,000 feet. The airplane was substantially damaged, but the three crewmembers were not injured. The pickup truck was demolished and the driver was seriously injured.

On December 20, 1983, a DC-9 collided with a snowsweeper after an ILS approach and landing at Joe Foss Field, Sioux Falls, South Dakota. 6/ Instrument meteorological conditions prevailed and the RVR was 3,500 feet. Prevailing visibility was reported as 1 mile with light snow. Although the airplane was substantially damaged, the 5 crewmembers and 81 passengers evacuated the airplane without injury. The snowsweeper was demolished and its driver was killed.

On March 8, 1984, the pilot of a Boeing 737 executed an emergency go-around after the airplane touched down on a runway at the Greater Cincinnati International Airport, Covington, Kentucky, when the flightcrew saw flashing amber lights on eight pieces of snow removal equipment on the runway about 1,000 feet ahead. The airplane lifted off the runway and missed the equipment by about 10 feet. There were no injuries. Instrument meteorological conditions prevailed, and the RVR was reported as 1,200 feet.

The incident at Minneapolis on March 31, 1985, (see case No. 1) was one of several near-collisions in the first few months of 1985 that prompted the Safety Board to initiate its special investigation of runway incursions. By early July 1985, the Board had investigated eight runway incursion incidents and one accident since the Minneapolis incident. Investigators found a variety of causal factors emerging from these incidents, but could not determine why controllers were making errors such as forgetting about aircraft under their control. In order to evaluate the runway incursion problem more

6/ For additional information, read Aircraft Accident/Incident Summary Report--"Sioux Falls, South Dakota, December 20, 1983," (NTSB/AAR-85/01/SUM, issued September 30, 1985).

thoroughly, the Board expanded the scope of the investigation to include controller training and FAA runway incursion reporting and investigation programs. Since the Board had already investigated runway incursion incidents and accidents that involved vehicles on runways and had made recommendations to the FAA on that subject in 1985, incidents of this type were not included in the special investigation. The selected incursions all occurred at controlled airports.

REPORTING AND INVESTIGATION OF ATC SYSTEM SAFETY INDICATORS

General

An essential factor in aviation safety is the ability of the ATC system to prevent collisions both in the air and on the ground. Fortunately, actual collisions with catastrophic aftermath are rare. However, increasing levels of air traffic are placing more demands upon controllers and pilots. It is essential that the ATC system be monitored to detect unsafe practices or conditions and to correct these practices or conditions before they result in accidents. One way to accomplish this objective is to require the investigation and analysis of near-collisions and other potentially serious incidents to determine trends and to identify accident prevention measures.

The FAA currently imposes two reporting requirements that provide data to evaluate the safety of the ATC system. The first requirement involves the reporting of incidents where a controller's actions cause a compromise of safety. These reports, referred to as "operational error" reports, and the associated data base are the responsibility of the FAA's Air Traffic Service. The second requirement involves the reporting of incidents where a pilot's actions, in violation of safe practices, regulations, or a controller's clearance, cause a hazardous situation. These reports, termed "pilot deviation" reports, and the associated data base are the responsibility of the FAA's Flight Standards Service.

In addition to operational error and pilot deviation reports, the FAA also has a near-midair collision (NMAC) reporting and investigation program. The NMAC program requires pilots involved in an NMAC to report the incident to Air Traffic personnel who, in turn, report the NMAC to Flight Services personnel who are required to investigate it. Since many, if not most, NMAC's occur while one or both aircraft are operating under visual flight rules (VFR), the NMAC data base alone cannot be viewed as an accurate assessment of the ATC system performance. Nonetheless, the data do reflect a general level of safety within the national airspace system, and the individual reports are often useful in identifying ATC problems in controlled airspace as well as the hazards involved with VFR operations.

The findings of its study of the United States ATC system 7/ and this special investigation cause the Safety Board to be concerned that the operational error, pilot deviation, and NMAC report data are not complete and are difficult to use effectively. The Board is particularly concerned about the FAA's evaluation of runway incursion problems, since the reporting requirements for runway incursions are less definitive than for airborne incidents. Runway incursions often involve both controller and pilot

7/ Special Investigation Report--"Followup Study of the United States Air Traffic Control System" (NTSB/SIR-83/01, issued May 12, 1983).

performance deficiencies. Although operational error, pilot deviation, or NMAC reports may be used to describe such incidents, the FAA currently does not have a common runway incursion data base or an effective means to correlate the data in the individual data bases.

The Safety Board's investigation of ATC system safety indicators also evaluated the reporting and depth of investigation of runway incursion incidents. The Board's examination of FAA operational error records related to runway incursions revealed that human performance issues were not investigated, and thus underlying causes for controller misjudgments, poor coordination, noncompliance with procedures, and forgetfulness were not identified. Similarly, the Board found that pilot deviations resulting in runway incursions were not always investigated; rather, they were frequently handled informally, perhaps to eliminate a reporting requirement. Pertinent FAA rules do not permit informal counseling in lieu of investigating and reporting pilot deviations. While informal counseling may seem appropriate in some incidents, the practice results in incomplete reporting of runway incursions to data base managers and may hinder effective accident prevention efforts.

Reporting of Operational Errors

The FAA defines an "operational error" as an occurrence that results in less than applicable separation between two aircraft, or between an aircraft and obstacles or obstructions, as required by the FAA Air Traffic Controllers Handbook (FAA Handbook 7110.65D). Obstacles and obstructions include a closed runway and vehicles/equipment/personnel on an active runway.

According to the FAA, 420 operational errors were reported at airport ATC towers in 1985. The FAA further classified 104 (25 percent) of these operational errors as "surface errors" 8/ (controller-induced runway incursions), an increase of 35 percent over the number of surface errors reported in 1984. There were 25 surface errors reported in the first 3 months of 1986, representing a continuing upward trend and a 19-percent increase over the number of surface errors occurring in the same 3-month period in 1985. Of the 104 surface errors reported in 1985, the FAA attributed 87 to the local controller and 17 to the ground controller. The FAA did not attribute any of the incidents to the actions of more than one controller.

A runway incursion, when caused by an inappropriate ATC clearance given by a controller, is very likely to be noted by at least one of the pilots involved, and since the pilot is aware of the event, the controller is more likely to initiate an operational error report. Still, the responsibility for initiating the report often rests solely with the controller who erred; thus, the system is, in fact, an "honor system" which relies on controllers to report themselves or, in some cases, to report a fellow controller. With the possibility of disciplinary action being administered for causing an error, a controller understandably may be reluctant to report it.

During its study of the United States ATC system, the Safety Board discovered several incidents in which controllers did not report operational errors. During this special investigation, Board investigators again discovered operational errors that were not reported to FAA facility management as required. For example, during its investigation of the operational error that led to the Minneapolis incident on March 31,

8/ FAA personnel interviewed for this special investigation used "surface error" and "ground operational error" interchangeably in describing controller errors that led to runway incursions.

1985, the Board learned of another previously unreported operational error that had occurred earlier the same day when two airplanes were on a runway at the same time; one airplane, having aborted its takeoff, was attempting to stop, while the other airplane, having landed, also was attempting to stop (see case No. 2). The controller who was responsible for the error reported the operational error to the tower supervisor. However, the supervisor decided not to record the incident in the facility log (FAA Form 7230-4) as required by FAA Handbook 7210.3, nor did he report the incident to facility management even though the incident was the third operational error by the same controller in a 90-day period. The operational error was brought to the attention of the facility air traffic manager on April 3, 1985, by Board investigators who learned about it during controller interviews. Had the operational error gone unreported, there would have been no formal investigation nor would there have been any corrective action. As a result of the subsequent investigation, the controllers involved received remedial training.

In another incident, the FAA learned of an operational error from news media personnel 2 days after the incident. (See case No. 14.) The local controller responsible for the operational error stated that he did not report it because he did not believe it was serious enough to warrant a report. There was no supervisor in the tower cab at the time of the incident.

In another incident the tower supervisor was preoccupied with other duties and did not witness the incursion, which involved an operational error by the local controller. (See case No. 22.) The incident was brought to the attention of facility management the next day when flight operations personnel from the involved airline telephoned to discuss it. The incident was the third operational error by the same controller in the last year.

The voluntary system for reporting operational errors would be more effective if first-level supervisors were more vigilant. When a supervisor fails to report an error, especially a repeated error by the same controller, the level of safety within the ATC system is diminished. The Safety Board is concerned that a supervisor would fail to report and to initiate an investigation into the performance of a controller who made three operational errors in a 90-day period. The Board believes that, since the FAA usually attributes operational errors to controller performance, a controller-initiated operational error should be an indication to first-line supervisors and facility management that remedial actions are necessary to improve the controller's performance. The Board concludes that controllers, supervisors, and facility managers must recognize the importance of reporting all operational errors, despite any stigma that may be attached to their personal involvement in the incidents. Additionally, FAA management at every level must recognize that the training provided at the ATC Academy and at the ATC facility, the local procedures used by the ATC facility, the airport layout, or equipment design may all be causal or contributing factors in operational errors.

In their review of operational error reports, the FAA simply cited the appropriate paragraph in FAA Handbook 7110.65D to explain why the error occurred. There was no in-depth analysis to determine underlying causal or contributing factors or to determine whether training, procedures, or other factors were involved. This is a "reactive" rather than a "preventive" approach to ATC system safety. The Board believes that an effective quality assurance program should evaluate trends and should conduct comprehensive analyses of human performance, procedural, and other underlying causes of the errors.

The Safety Board found that the FAA has no standard retraining procedures applicable to controllers involved in repeated operational errors. The Board is concerned that this deficiency might allow some controllers to return to duty without sufficient retraining and reevaluation to provide a high level of confidence that the controller will not cause future errors.

When the Safety Board began its special investigation, the FAA had no data base of operational error data, nor did it have any definitive process or system to periodically review the reports to identify trends or recommend corrective actions. Generally, individual operational error reports in isolation do not reveal a need for FAA followup action. It is only when reports are examined collectively that such actions become apparent. Since the Board has begun examining the reports, the FAA has developed a data system so that operational error data, including runway incursions caused by operational errors, might be examined from a systemwide perspective.

Reporting of Pilot Deviations

The FAA defines a "pilot deviation" as pilot noncompliance with Federal Air Regulations, including any ATC rule, procedure, or instruction. Controllers who observe a pilot deviation are responsible for reporting the occurrence to their supervisor who, in turn, submits a formal report to the appropriate Flight Standards office for further investigation. Current FAA regulations require that the investigation and report be completed within 90 days of the occurrence.

The Safety Board found that the investigation of pilot deviation reports is primarily intended to develop violation and enforcement actions against the pilot involved, with little emphasis on the use of the report for ATC system safety analysis. In fact, before August 1985, there was no automated data base or other effective means to access the pilot deviation reports for such analysis. Although an automated data base has now been established (beginning with 1985 incidents), its capability for data retrieval remains limited due to the small data base and limited analytical capability.

The Safety Board also found that, just as with operational errors by controllers, many pilot deviations are not formally reported by controllers or tower supervisors, but are resolved informally at the tower facility level. Thus, the data on these pilot errors are not included in FAA statistics. Furthermore, errors handled informally are not investigated to the extent needed to determine systemic problems and corrective measures.

The Safety Board suspects that the FAA's failure to investigate some tower-reported pilot deviations may be a factor in the nonreporting of incidents by tower personnel. The Board recognizes the benefits of informal resolutions of minor incidents and misunderstandings between controllers and pilots in a limited number of cases; however, the benefits of reporting and investigating such incidents for accident prevention purposes may be lost by such actions. Without adequate reporting, investigation, analysis, and resolution of all incidents, it is difficult to improve the quality and safety of the ATC system. For example, had many unreported pilot deviations at one airport been investigated, it would have been evident that the runway incursions might have been prevented by the installation of relatively inexpensive signs delineating taxiway/runway intersections. (See case No. 10.)

The FAA should act to ensure proper reporting and investigation of pilot deviations. Although the responsibility rests with the first-level supervisor to ensure timely reporting of pilot deviations, FAA ATC facility, regional management, and Flight Standards offices should adopt and enforce procedures and directives to promote the complete reporting of these important system safety indicators.

Reporting of Near-Midair Collisions

The FAA defines a near-midair collision (NMAC) as "an incident associated with the operation of an aircraft in which a possibility of collision occurs as a result of proximity of less than 500 feet to another aircraft, or a report is received from a pilot or flight crew member stating that a collision hazard existed between two or more aircraft." In the event of a near-collision of aircraft, the flightcrews involved may choose to file an NMAC report with the FAA whether the aircraft involved were airborne or on the ground. However, there is evidence that many pilots, Flight Standards inspectors, and Air Traffic personnel do not consider that the NMAC reporting program includes near-collisions that occur during taxi, takeoff, or landing operations, and thus pilots are not likely to voluntarily file NMAC reports describing these incidents.

The current NMAC reporting system requires one of the involved flightcrew members to initiate the report, either by immediately notifying the ATC facility or by notifying a Flight Standards District Office (FSDO). When an NMAC report is received by an ATC facility, the controller receiving the report is required to inform the tower supervisor of the report and obtain the data specified in FAA Form 3556 (Near Midair Collision Preliminary Report). Information from the form is then forwarded to the appropriate FSDO when it involves any of the following:

a. Civil aircraft where reported horizontal or vertical separation is less than 100 feet.

b. Injuries to personnel or structural damage to the aircraft. (An NMAC involving substantial damage, a serious injury, or fatality is also classed as an aircraft accident and therefore, is reported as both an aircraft accident and an NMAC.)

c. A notable person is involved.

d. The incident has or is expected to received press coverage.

e. A civil turbojet aircraft is involved.

Upon receipt of an NMAC report from a flightcrew, Flight Standards personnel contact the involved ATC facility, and the facility transmits the initial NMAC report to the appropriate FAA regional office and FAA headquarters. After the initial report has been filed by the ATC facility, the investigation is handled by Flight Standards personnel. Current FAA regulations require that the investigating FSDO complete the NMAC investigation report within 90 days of the incident. Data from these investigations are transmitted to FAA Headquarters where they are compiled and analyzed and where safety programs and recommendations are developed.

The FAA stated that the primary purpose of the NMAC reporting program was to provide information to enhance the safety and efficiency of the national airspace system. Information obtained from NMAC reports reportedly is used by the FAA to improve the quality of FAA services and to develop programs, policies, and procedures aimed at the reduction of near-collisions.

During its special investigation, the Safety Board asked the FAA for data on NMAC reports involving aircraft that were landing, taking off, or on the ground. The FAA was unable to retrieve NMAC reports by phase of operation.

Of the 26 runway incursion incidents investigated by the Safety Board for this special investigation, 4 incidents (case Nos. 9, 19, 20, and 22) met the published criteria for an NMAC report. One incident involved a near-collision of an airplane that was landing and another airplane that was on takeoff from a runway that intersected the runway used by the landing airplane. (See case No. 19.) When one of the pilots questioned the controller about the runway incursion, the controller acknowledged the conflict. Despite this acknowledgment, the tower did not notify the local FSDO of the incident. When other persons alerted the FSDO and the FSDO asked the tower to provide information about the incident, the tower initially denied the FSDO request. Even after the FSDO obtained written statements from pilots aboard the airplanes that a collision was avoided by 200 feet or less and that one of the pilots took evasive action he believed was necessary to avoid a collision, the tower still was unwilling to label the incident an NMAC. The tower continued to investigate the incident as an operational error, without the further involvement of Flight Standards personnel. Tower personnel advised Board investigators that they considered the incident an Air Traffic problem and they saw no reason for Flight Standards involvement. As of April 1, 1986, the incident had not been classified as an NMAC, despite having met the applicable FAA criteria.

Another incident that met the reporting criteria occurred when the pilot of an airplane that was cleared for takeoff delayed his takeoff rotation until another airplane had crossed his path. (See case No. 22.) The pilot of the departing airplane considered the occurrence a near-collision and forwarded a statement regarding the incident to the FAA. On April 2, 1986, the FAA still was not investigating the incident as an NMAC. A Flight Standards inspector who received the report said he did not investigate the incident as an NMAC because one airplane remained on the ground and because he considered it an Air Traffic matter.

The FAA rules pertaining to NMAC reporting do not eliminate the requirement to conduct an NMAC investigation if the incident also is being investigated as an operational error. However, the Safety Board found in both of these cited incidents that although the pilots submitted statements indicating they had been involved in near-collisions, the FAA never classified or investigated the incidents as near-collisions. The FAA's failure to report and investigate all near-collisions, despite the stated intent of the NMAC program, results in incomplete statistics. If the NMAC program is to function effectively to prevent accidents, its importance must be stressed to Air Traffic and Flight Standards personnel. Further, since there is no "near ground collision" reporting system, the Board believes that the NMAC reporting system should include a category for incidents that occur on or near the airport surface to ensure that they are included in the NMAC data base.

Aviation Safety Reporting System

The Aviation Safety Reporting System (ASRS) of the National Aeronautics and Space Administration (NASA) provides another indication of system safety. Since its inception in 1976, the ASRS has collected reports submitted voluntarily by pilots, controllers, and other users of the national airspace system. These reports depict incidents and situations which, in the opinions of those submitting reports, compromise air safety. The FAA makes frequent use of the ASRS, and has requested reports on aviation safety issues based on ASRS data in the past. In 1978 and 1984, NASA conducted analytical studies of reports by pilots and controllers of runway transgressions. The ASRS defines "runway transgressions" as "any erroneous occupation of a runway at a controlled airport by an aircraft or other controlled vehicle." The second study, which was requested

by the FAA, was published in 1985. 9/ The study analyzed 403 of a sample of 1,210 reports of runway transgressions reported to the ASRS between May 1978 and January 1984. These reports referenced a total of 396 different runway transgressions.

Since ASRS reports are submitted voluntarily, they describe only the occurrences that the reporters consider to be important safety problems. Because knowledge of the ASRS is not universal, the writers of the 1985 analysis of ASRS runway transgression reports believe that the ASRS data underrepresent the problems encountered by users of the national airspace system. Trained professional analysts, experienced in both piloting and ATC, code the reports and label causal factors, sometimes contacting the reporters through a call-back system, which enables the reporters to remain anonymous while still allowing clarification and expansion of reported information.

The analysis of ASRS data in the 1985 report differed from the analysis of factors in this special investigation, because Safety Board investigators, in most cases, were able to interview all controllers, supervisors, and pilots directly or indirectly involved in the incidents. The ASRS analysis, however, could analyze data only from the individual reporter. Board investigators were able to investigate environmental, staffing, and workload issues without having to rely on an individual reporter's description of the incident. On the other hand, since the ASRS reports were submitted voluntarily, the content of the ASRS incident reports may have been more candid than the information offered by pilots and controllers during interviews with Board and FAA representatives present.

Despite the difference in methodology and depth of investigation, the ASRS data in the 1985 report provided important insights into the problem of runway incursions, and the conclusions of the 1985 report paralleled many of the findings of the Safety Board's special investigation. The 1985 report concluded that controller-enabled departure transgressions yielded the highest risk level (greatest likelihood of causing an accident). However, pilot-enabled incidents represented the majority of the reports received; the ratio of pilot-enabled incident reports to controller-enabled incident reports was about 2 1/2 to 1. (The ratio may be due, in part, to the nature of the ASRS system, which gives pilots limited immunity from FAA certificate action when they voluntarily report their violations to ASRS).

In the 1985 report, pilot-enabled transgressions were reported as difficulties with clearances, communications, orientation, and preoccupation. Controller-enabled transgressions were reported as failures in traffic separation, traffic sighting, and intratower coordination. Restricted visibility and intersecting runway operations regularly appeared as factors in both pilot- and controller-enabled runway transgressions.

In the 1985 report, the most frequently cited factor in controller-enabled departure transgressions was "controller failure to visually locate traffic." Controller-enabled taxi and arrival transgressions were found to be largely due to misjudgment of traffic spacing. Intratower coordination deficiencies showed a slight correlation to training in progress, distractions in the tower cab, and restricted visibility incidents. A factor frequently associated with controller-enabled departure transgressions was "multiple intersecting runways." Although factors equivalent to controller forgetfulness were precoded items for the study, these factors were not cited as often as controller failure to visually locate traffic. Lack of controller supervision and allocation of available staff were not discussed in the report, presumably because those issues were not suggested by the reports submitted.

9/ Tarrel, Richard J., Non Airborne Conflicts: The Causes and Effects of Runway Transgressions, NASA Contractor Report 177372, September 1985.

PILOT FACTORS IN RUNWAY INCURSIONS

The Safety Board acknowledges that the exact number of runway incursions that occur each year is unknown, due in part to pilots and controllers not reporting them. However, operational error, pilot deviation, and ASRS data indicate that the majority of these incidents were precipitated by pilot actions. In nearly all incursions, even those that occurred during periods of limited visibility, pilots had the last opportunity to observe the developing conflict and to take evasive action to avoid collisions. In several of the incursions examined for this special investigation, it was, in fact, the pilot's final alertness and evasive actions that prevented a collision.

Thus, although the FAA categorizes runway incursions either as operational errors or as pilot deviations, the Safety Board investigation revealed that these are not mutually exclusive categories. Runway incursions investigated by the Board frequently were caused by combinations of controller and pilot factors. Frequently, those incursions classified as operational errors were precipitated by pilot actions. Contrary to the FAA categorization of certain runway incursions as operational errors, the Safety Board believes that most of them could have been prevented by proper pilot actions. The following discussion will evaluate some of the factors the Safety Board believes should be addressed in runway incursion prevention programs for pilots.

Those runway incursions attributed solely to pilot factors usually involved either communication problems, such as misunderstanding clearances or inadvertent entry of a runway because of disorientation.

Some of the incursions might have been averted if pilots (and controllers) had been more attentive to radio communications, had used proper radio phraseology, had read back clearances, or had scanned more effectively before entering an active runway. For example, in one incident, an airplane taxied onto an active runway without clearance while another airplane was taking off from that runway. (See case No. 8.) The pilot of the taxiing airplane had been instructed to taxi to the runway, but to hold short. The pilot acknowledged the instruction with "okay," but after the incident reported that he did not understand that he was to have held short of the runway. His acknowledgement phraseology was improper and incomplete (as he did not give his call sign) and misled the controller, who assumed the pilot would comply with the instruction. In this instance, both the pilot and the controller erred. The pilot used improper phraseology, and the controller accepted an improper acknowledgement.

Another incident involving a communications problem occurred when two aircraft initiated takeoff after only one had been cleared for takeoff. (See case No. 9.) The pilot who had not been cleared for takeoff had requested to take off from an intersection to expedite his departure. He assumed the clearance for the other airplane was for him. Apparently the pilot was so intent on expediting his departure that he also failed to acknowledge the clearance, thus denying the controller a signal that the two aircraft were about to conflict. Although the FAA attributed this incursion to pilot factors, the Safety Board believes that clearing the pilots of two aircraft into position to hold on intersecting runways should be avoided when traffic volume permits.

In another incident, a pilot taxied his aircraft onto a runway and commenced takeoff when the controller cleared another aircraft with a similar call sign for takeoff. (See case No. 10.) The pilot attempted to expedite the departure because the takeoff instruction included the phraseology "without delay." On the next day at the same

airport, an aircraft preparing for departure was cleared to taxi to the departure runway but to hold short of another active runway. (See case No. 10.) The captain taxied the aircraft across the active runway while operating the radio and while the copilot was attending to other duties. Neither recalled hearing the hold short instruction although the captain had acknowledged it.

All of the incidents that involved misunderstood radio communications might have been prevented by pilots if they had alertly monitored radio transmissions. Several communication problems were compounded when pilots acknowledged transmissions they later said they had misunderstood or did not hear clearly. Federal Aviation Regulations and the Airman's Information Manual state that a pilot who is uncertain of a clearance should ask the controller to clarify the confusing or misunderstood communications.

Miscommunication occurred in various ways in both pilot-induced and in controller-induced incidents. In one of the incidents classified by the FAA as an operational error, the pilot initiated the incident by failing to communicate to either the ground controller or local controller that he intended to depart from a runway intersection rather than the departure end of the runway. (See case No. 17.) According to tower personnel, the procedure had been used many times before by pilots who were employed by the same air taxi cargo operator, usually without explicitly requesting tower approval. The local controller did not see the airplane or determine its position when the pilot called for takeoff instructions. The local controller assumed that the pilot had taxied to the departure end of the runway. After a landing airplane overflew the runway threshold, the pilot of the departing airplane was cleared to "position and hold" on the runway. The pilot taxied onto the runway into the path of the landing airplane and then, after being alerted by the pilot of the landing airplane, taxied clear just in time to avoid a collision. The local controller could have prevented the incident by verifying the position of the departing airplane before authorizing the pilot to enter the runway. The pilot contributed to the operational error by failing to communicate his intentions to make an intersection takeoff to the tower; then he failed to prevent the incident by not scanning the runway effectively before taxiing into position.

Several runway incursions that the FAA classified as operational errors occurred, in part, because of pilot delays in reporting information to controllers. In one of the incidents a pilot who had been cleared to taxi his airplane across an active runway encountered a delay as he waited for another pilot to taxi clear of the runway. (See case No. 1.) Had the pilot of the crossing aircraft notified the controller of the delay, the controller would have been reminded that the crossing had not yet been completed. A similar incursion involved the crossing of an active runway by two aircraft, the second of which was not near the runway when cleared to cross and, furthermore, was being taxied slowly. (See case No. 3.) The Safety Board believes that under such circumstances it is not a safe practice for pilots to accept, and for controllers to issue, a runway crossing clearance.

The Safety Board believes these incidents could be prevented through reinforcement of sound communication practices in pilot training programs. Accordingly, the Board believes that the FAA could be instrumental in eliminating many runway incursions if it emphasized in operational bulletins, the Airman's Information Manual, general aviation seminars, and pilot training programs the importance of: reading back taxi, hold-short, runway crossing, and takeoff clearances in proper phraseology; the importance of reporting when unable to promptly cross, take off from, or clear a runway when so cleared; and the need to scan properly before entering or crossing a runway.

In another incursion, the pilot was monitoring a company radio frequency while awaiting takeoff clearance. (See case No. 9.) He initiated a takeoff in response to a takeoff clearance that was issued to another aircraft, precipitating a near-collision. The Safety Board believes that the chatter the pilot heard over the company radio frequency may have distracted him and that listening to frequencies other than the local or ground control frequencies during taxi is a poor practice, particularly for pilots of single-piloted airplanes.

One accident that the FAA classified as an operational error might have been prevented by timely communications from the pilot. (See case No. 5.) The pilot was cleared to taxi his airplane into position to hold for an intersection departure, and the airplane was later struck by a landing airplane. The most perplexing aspect of the accident was that while the departing airplane was on the runway awaiting a takeoff clearance for nearly 6 minutes, the pilot did not contact the controller to determine the reason for the delay. The Safety Board believes that a prudent pilot would expect the takeoff clearance to follow momentarily after a "position and hold" clearance and would question an apparently unwarranted delay. Although the pilot had no obligation to radio the controller, the Board believes that the accident probably would not have occurred if the pilot had reminded the local controller that he was still in position awaiting a takeoff clearance. Such a radio transmission would have alerted the controller to the location of the airplane, which she later acknowledged to have forgotten.

Runway and taxiway markings on airport surfaces can contribute to pilots becoming disoriented. This issue has been addressed previously in Safety Board reports, including the report of the Korean Airlines DC-10 accident in Anchorage on December 23, 1983. (See discussion on pages 3 and 4.) As a result of that accident, the Board issued Safety Recommendation A-84-98 on August 23, 1984, to the FAA about the need for more stringent signing and marking standards in 14 CFR Part 139. Inadequate signing was involved in the near-collision in Houston on October 8, 1984, when a pilot inadvertently taxied his airplane onto an active runway. (See discussion on page 4.) The incident occurred, in part, because the pilot's taxi route lacked signs to identify a critical taxiway and the active runway.

During this special investigation the Safety Board observed similar signing problems at an airport. (See case No. 10.) Investigators discovered that only two runway/taxiway intersections at the airport were plainly and prominently marked. Board investigators met with airport management personnel regarding the lack of signs and made suggestions which resulted in the installation of unlighted reflective signs at locations considered most critical. A measure of the effectiveness of the new signs was the reduction of runway incursion incidents which followed. In the first 7 months after the signs were installed, there were five incidents. There had been 16 incidents in the 11 weeks preceding the sign installation. The Board believes that many of the previous runway incursions would not have occurred if the signs had been in place earlier.

The Safety Board believes that these incidents reinforce the argument that 14 CFR Part 139 should require airports certificated for air carrier operations to install signs at all runway and taxiway entrances, exits, and intersections indicating the identity of the runway or taxiway. The Board reiterates Safety Recommendation A-84-98 and urges the FAA to expedite the implementation of proposed revisions to 14 CFR Part 139. (See discussion of Safety Recommendation A-84-98 on page 38.)

CONTROLLER FACTORS IN RUNWAY INCURSIONS

General

The Safety Board found in the special investigation that runway incursions which involved operational errors involved controllers from all levels of experience. Controllers who had extensive experience were usually supervisors who were working a control position. In each case where the supervisor was working a control position, the Board found that there was no other supervisor or controller-in-charge appointed to monitor or to assist other controllers. In several cases, supervisors were not present because they were performing required duties outside the tower cab. Although a controller-in-charge usually was designated when the supervisor was not present, in each incident the controller-in-charge was also working a tower control position. In one incident the controller-in-charge was working a tower radar coordinator position which he could not leave to perform supervisory duties.

Traffic was light or moderate at the time of most of the incursions investigated for the special investigation. Heavy traffic and poor visibility were infrequently involved. In some of the incidents, controllers were working as few as two aircraft. In one of those incidents, an aircraft landed on the runway closest to the tower cab and turned off the runway onto the only high-speed taxiway on the airport, almost directly in front of the tower cab. (See case No. 11.) The pilot radioed that he was clear of the runway and on the high-speed taxiway. However, the ground controller did not see the airplane, mistakenly assumed he was talking to another airplane that was under tow on the other side of the airport, and issued an incorrect clearance to the pilot. The supervisor was not present in the tower cab; he had just signed out on break because the traffic was light.

In another incident, the supervisor appointed the cab coordinator as the controller-in-charge in his absence. (See case No. 17.) However, because traffic was light, the controller-in-charge, who was not yet qualified on radar positions, took the opportunity to study a radar chart rather than monitor the tower operation. The controller missed an opportunity to prevent the incident because she was not monitoring traffic.

Another problem that appeared in several runway incursions involved coordination of runway crossings by ground and local controllers. Facilities used a variety of coordination procedures—verbal and nonverbal, communicating directly or indirectly (through another controller), using interphones, and using flight progress strips. In those facilities where there was inadequate coordination, there frequently was no specified or standard procedure for coordination between controllers. In one facility the established standard coordination procedures were not followed.

The primary controller-related factors identified in the runway incursion special investigation were forgetting aircraft and lack of or incomplete coordination between controllers.

Forgetfulness

In one of the runway incursions, the controller issued a clearance involving a runway that the controller had forgotten was closed. (See case No. 16.) In six of the runway incursions, the controllers involved said that they forgot about an aircraft or vehicle to which they had given either a direction to hold or a clearance to take off or to cross a runway. Controllers also reported forgetting to follow what they admitted were standard or commonly practiced procedures.

For example, in one incident the local controller said that he had forgotten his previous clearance for two aircraft to cross the active runway when he cleared an aircraft to take off on the runway after only the first of the two aircraft had crossed the runway. (See case No. 3.) In another incident, two airplanes collided after the local controller cleared one airplane to land while the other airplane was holding in position for takeoff from an intersection on the same runway. (See case No. 5.) The local controller forgot that she had cleared the departing airplane to "position and hold" and that she had never provided the pilot a clearance to take off. She stated that she forgot about the airplane on the runway until after the collision.

Other incidents precipitated by a controller who forgot an airplane or coordination occurred at Minneapolis; Austin, Texas; Chicago; and Sarasota, Florida. In the Minneapolis incident, the local controller initiated coordination with the ground controller, instructing him to clear an airplane across a runway from which less than a minute before the local controller had cleared another airplane to take off. The local controller stated that he forgot about the airplane to which he had given takeoff clearance. (See case No. 4.) In the Austin incident, two airplanes almost collided after the local controller cleared the two airplanes to land on intersecting runways and then forgot about one of the airplanes. (See case No. 6.) In the Chicago incident, the ground controller cleared an airplane to taxi to a remote active runway but did not advise the pilot to hold short of a closer active runway that he would cross en route. The ground controller said he forgot about the airplane until the crew called him after their airplane was overflown by another airplane taking off from the closer active runway. (See case No. 7.) In the Sarasota incident, the ground controller coordinated with the local controller to allow an airplane to cross a runway. The local controller approved the request but about 8 seconds later issued a takeoff clearance on the same runway to another airplane. (See case No. 12.)

Human memory has been a topic of much research, and the Safety Board examined these incidents in relationship to psychological research about the functions of human memory. 10/ Memory is a complex process, and there are many psychological theories about the way a person collects and stores information in memory. 11/ Most theories on memory assert a two- or three-level memory structure, with increasingly complex requirements for information to enter and remain in the higher levels. One method of categorizing memory--learning and forgetting--which is supported by research, classifies human memory as sensory, short-term, and long-term.

When a person first senses information through seeing or hearing, for example, it is filtered through a system that scans, selects, analyzes, and either accepts or rejects the information. This system is referred to as the sensory, or immediate, memory unit. Accurate information can only be passed to the remaining short-term and long-term units if it is selected and correctly recognized by the sensory memory unit. The sensory unit operates in milliseconds and is very sensitive to the human physical and psychological state. If the person is fatigued, unduly stressed, inattentive, or under the influence of drugs or alcohol, information can be missed or misperceived and rejected at this memory level.

10/ Puff, C. Richard, Handbook of Research Methods in Human Memory and Cognition, Academic Press, 1982.
11/ Gregory, Richard L., Mind in Science, Cambridge University Press, 1981.

If information passes through the sensory memory unit, it can be transferred to the short-term memory unit. Research indicates that only small amounts of information (about five to nine items) 12/ can be normally handled or retained by short-term memory, although this amount of information can be increased by using learned techniques of information coding. Information begins to decay immediately in short-term memory and may be forgotten in as few as 15 seconds. It is theorized that information must be first processed or stored in short-term memory before entering long-term memory storage, where it does not decay further. A person keeps information in short-term memory by rehearsal or repetition or by using external aids that allow the information to be continually recycled into short-term memory. Stress, distraction, or memory overload (more information than can be held in short-term memory) causes the information in short-term memory to be lost even more quickly. With effective rehearsal and repetition techniques, information can be stored in short-term memory for as long as 20 minutes.

Long-term memory is the depository of information that is retained from minutes to years. Ease of recall of information in long-term storage is dependent on the techniques the person uses to code and organize the information. Some persons have more efficient ways of coding and organizing information than others. Learning theorists and education professionals have effectively used different techniques for information coding and organization, and good designers of training programs attempt to teach students efficient methods of information organization and retrieval.

Air traffic controllers and pilots rely largely on the sensory and short-term memory stores. Controllers make decisions on landing, takeoff, and crossing clearances based on information on the status of airplanes in the immediate airspace and on the airport, which resides in their short-term memory store. They make these decisions with reference to information on the general layout of the airport, flight characteristics of airplanes, Federal regulations, and ATC rules and procedures that they have stored in long-term memory.

The number of items of information that a controller can keep in short-term memory is dependent on the controller's memory capacity. The length of time the information remains in short-term memory depends on competing information as well as human factors such as stress, fatigue, and boredom. Other competing items of information could be individual aircraft call signs, characteristics of the aircraft, location of the aircraft, and expected arrival and departure times.

Vigilance and Boredom

In many of the runway incursion incidents investigated by the Safety Board, controller workload was found to be relatively light. It is reasonable to question why controllers might forget an aircraft on a runway given light workload and fewer aircraft to remember and control. Such errors can be understood by looking at characteristics of controller tasks. In general, controller tasks require a great deal of vigilance, which is the ability to sustain attention over long periods of time while processing aircraft movements that may be intermittent and variable in frequency. When stimuli, such as arriving and departing aircraft, are variable in frequency, there is less continuous information to attend to, which can result in inattentiveness. The characteristics of ATC tasks are such that, regardless of workload levels, attentiveness and vigilance are constantly required. However, given human behavior limitations, when the frequency of

12/ Miller, George A., "The Magical Number Seven, Plus or Minus Two: Some limits on our capacity for processing information," Psychological Review, Vol. 63, March 1956.

events is slow, attentiveness tends to decrease. Corresponding to a loss in attentiveness are potential increases in boredom, fatigue, restlessness, daydreaming, as well as an overall decline in physiological arousal or responsivity. 13/ When viewed in this way, runway incursions related to a controller's forgetting during relatively light workload conditions are more understandable: the light workload environment with few arriving or departing aircraft leads to a sense of boredom, complacency, and/or a loss in vigilance, and forgetting occurs at the expense of a potential aviation accident.

A report prepared for the FAA describes boredom and monotony as "undesirable side effects of repetitious work," particularly with regard to increasing levels of automation, where the operator or controller is required to be vigilant for long periods of time. 14/ Boredom is also discussed in a review of research studies on its occurrence and on personality types who are prone toward boredom. 15/ The review describes several coping strategies workers use to overcome the effects of boredom, including daydreaming, response variability, and inattentiveness. In contrast, individuals who remain alert and who are not bored are highly motivated to perform and to achieve.

One important technique for improving worker performance is to enhance motivation levels by providing feedback to individual workers. This technique applies to almost every working environment, including that of ATC. When managers and supervisors are present to provide positive feedback on good performance, operators tend to work harder and exhibit higher levels of motivation. This technique is not only effective in preventing a loss in vigilance and an increase in boredom, it can also result in overall improvements in performance.

Memory aids can be effective tools to improve controller memory and to enhance vigilant performance. In addition to memory aids, signal enhancement may be effective in providing redundancy gain to an operator and result in improved vigilance. 16/ This concept is consistent with Safety Recommendation A-85-15 that the Safety Board issued on February 22, 1985, asking the FAA to develop a mechanical/aural/visual (or combination thereof) alert device for controllers to coordinate their activities when a vehicle has been cleared to operate on an active runway for an extended period such as in snow removal operations. (See discussion on pages 38 and 39.) Essentially, information is provided to operators or controllers in a redundant manner (e.g., both visually and aurally) to alert them to attend to or to remember a given aircraft.

Vigilance also can be improved by training. 17/ Through effective instruction, controllers can learn to repeatedly perform routine and standard procedures, such as runway scanning, regardless of workload conditions. Thus, they learn to check for aircraft as an automatic process, and to reduce the risk of runway incursions. Interestingly, the referenced research literature indicates that such training can improve performance by making fewer demands on short-term memory. That is, controllers who scan as part of an automatic process are less encumbered with the task of remembering aircraft on runways since the process of scanning itself will help them to remember.

13/ Smith, R. P., "Boredom: A Review, "Human Factors, 23 (3), 329-340, 1981.
14/ Thackray, R. A., Boredom and Monotony as a Consequence of Automation: A Consideration of the Evidence Relating Boredom and Monotomy to Stress (FAA-AM-80-1) 1980.
15/ Smith, op. cit.
16/ Wickens, C. D., Engineering Psychology and Human Performance. Columbus, Ohio: Bell & Howell Company, 1984.
17/ Colquhoun, W. P., "Evaluation of Auditory, Visual, and Dual-mode Displays for Prolonged Sonar Monitoring in Repeated Sessions," Human Factors, 17, 425-437, 1975.

In summary, controller tasks demand high levels of attention and vigilance regardless of workload. When workload is light or intermittent, sustained attention becomes more and more difficult, with a tendency toward boredom, fatigue, inattentiveness, and consequent forgetting. Some possible techniques to improve vigilance include providing feedback on performance to increase motivation, developing effective memory aids, and providing improved instruction and training in standard procedures and safe work habits.

The Safety Board acknowledges that these brief descriptions of human memory, vigilance, and boredom cannot necessarily be generalized from laboratory research to the specific demands of the air traffic controller. Also, the Board is not aware of any research on the information-processing demands on the air traffic controller (i.e., how many items of information must a controller accept and process during a specified period of time on a given position?). However, the principles of learning and memory and of operator behavior can be applied to help explain the incidences of controller error investigated and to suggest procedures, training, or aids to compensate for known human limitations.

Scanning

In the seven incidents in which the controllers involved forgot something, there were additional factors that the Safety Board believes contributed to the incidents. For example, in four of the seven incidents, the Safety Board determined that inadequate scanning of the runways and/or the BRITE 18/ displays probably contributed to the error.

In one incident, the local controller instructed the ground controller to clear an airplane to cross an active runway. (See case No. 4.) If the ground controller had scanned the area, he would have seen another airplane on takeoff roll on the same runway. In another incident, the local controller did not refer to the BRITE display, where he would have seen the radar returns of two airplanes that were both cleared to land. Scanning the BRITE display probably would have reminded the local controller of the airplane he had forgotten. (See case No. 6.)

In a third incident, a ground controller forgot about a taxiing airplane. The ground controller probably would have seen the airplane well before it crossed the active runway in front of a departing airplane if he had scanned the airport runways and taxiways. (See case No. 7.) In another incident, the local controller forgot coordination that he had accomplished 8 seconds earlier when he became preoccupied with two other aircraft on his radio frequency. (See case No. 12.) In psychological terms, the two other aircraft competed for his attention with the coordination procedure; consequently, memory of the coordination decayed. If the local controller had scanned the runway before issuing a takeoff clearance, he would have seen the airplane approaching the active runway on an intersecting taxiway and probably would have been reminded of the prior coordination with the ground controller for the airplane to cross the runway.

Scanning serves as a memory aid; it is a method to compensate for the natural decay of information in memory. The concept of scanning is briefly addressed at the ATC Academy, has been stressed in General Notices (GENOTs) published by the FAA, and has been added to FAA Handbook 7110.65D (paragraph 3-12). However, the Safety Board believes, in the light of these incidents, that FAA trainers and supervisors are not effectively teaching the importance of scanning as a memory aid, nor are they reinforcing this behavior through effective recurrent training, evaluation, and supervision.

18/ Bright Radar Indicator Tower Equipment is a "slaved" radar indicator placed in the tower cab for use in sequencing traffic. The system displays primary and secondary radar data detected by the servicing radar site.

Use of Memory Aids

Safety Board investigators attempted to find what types of memory cues or aids controllers use to remember aircraft, runway status, and other pertinent information. Interviews with controllers involved in runway incursions revealed factors that they believed contributed to, or would have helped prevent, the incidents.

In one incident, the local controller described a personal technique that he believed contributed to his forgetting an aircraft. (See case No. 4.) The local controller stated that he had developed a personal technique of "dropping" the flight progress strip (holder) "down the tube," which would deposit it at the appropriate departure control position as soon as he issued takeoff clearance, but before the actual departure of an aircraft. The local controller suggested that this was a "bad (personal) procedure" because, as long as he retained the flight progress strip, it would offer a reminder that he was still responsible for the flight. Conversely, passing the strip "down the tube" made it easier for the local controller to forget the flight.

In another incident, the local controller used a scratch pad to keep track of aircraft for which she did not have flight progress strips. (See case No. 5.) She used symbols to indicate the level of service requested and drew lines through the call sign of the aircraft when she was no longer providing services to the aircraft. This procedure could have been an effective memory aid. However, in this instance the local controller drew a line through the call sign of an airplane she cleared into position to hold. She subsequently forgot to issue a takeoff clearance to the airplane and cleared another airplane to land on the same runway. This accident illustrates that memory aids, if used, must be used consistently and correctly.

The Safety Board found that the memory aids used by controllers in these incidents were inadequate. Memory aids such as those mentioned above were developed by individual controllers without FAA research or standards. The Board concludes that the FAA should research effective memory aids and provide ATC tower facilities and controllers with standards for such aids. The development of such aids should be accomplished by persons knowledgeable in both ATC and human performance factors. Methods for use of such aids should be incorporated into the ATC Academy and facility training programs.

Supervisory Factors

In the seven incidents in which the controllers involved forgot something, the assigned tower cab supervisor or, in the absence of the supervisor, the assigned controller-in-charge either was working an active position or was in another part of the tower. A supervisor was not able in any of these cases to serve as a monitor or "extra pair of eyes" to evaluate controller performance continuously and perhaps to catch a controller's oversight before a runway incursion.

The Safety Board is aware that the tower cab supervisors are responsible for administrative duties, many of which do not allow them to dedicate time exclusively to watching and listening to controllers and their traffic, and it acknowledges that the supervisors necessarily must perform other duties away from the tower cab. The Board also recognizes that the supervisors must maintain currency on all ATC tower positions by occasionally working active positions. However, the Board believes that the runway incursions examined for this special investigation illustrate the need for increased first-hand supervision of controllers to reinforce good working habits and to act as a safeguard in preventing mishaps. The supervisor or controller-in-charge working a control position cannot effectively monitor controller performance and control traffic simultaneously.

In one incident, the supervisor, who was working the combined local control/cab coordinator positions, cleared two airplanes to land on intersecting runways. No one was available to act as a monitor or as a "supervisor" to detect the situation as it developed. (See case No. 6.) In another incident, it was the area supervisor (with 26 years of experience) working the local control position who forgot he had cleared an airplane to take off, and who shortly thereafter instructed the ground controller to clear a taxiing aircraft to cross the runway. Again, there was no oversight of his actions. (See case No. 4.) The latter incident had a further complication in this regard, since it was the ground controller's supervisor who directed him to provide the crossing clearance. The Safety Board learned that it was not standard practice at the tower for the local controller to direct the ground controller to clear aircraft to cross active runways. As was the case in all facilities visited by Board investigators during this special investigation, the standard procedure at this facility was for the ground controller to request permission from the local controller to clear an aircraft to cross a runway. However, the supervisor attempted to expedite traffic movement by telling the ground controller, a developmental controller, to provide the crossing clearance, instead of waiting for the ground controller to ask for the clearance. The Board believes that the supervisor's position of authority could have influenced the ground controller to follow the local controller's instruction without scanning, which he otherwise might have done. In this incident, not only was the supervisor not able to see the situation developing, but he probably contributed to the outcome by virtue of his position of supervisor/controller.

In addition to providing an extra pair of eyes and ears, the supervisor or another controller, if given the full-time responsibility of monitoring controller performance in the tower cab, could better reinforce adherence to standard operating procedures, could enhance motivation by providing positive feedback to individual controllers, and could be in a better position to determine the controller's ability to handle the particular traffic situations. Currently, although supervisors are responsible for monitoring controller proficiency on positions, they are not able to monitor controller performance on a day-to-day or even hour-to-hour basis because of other duties or because of the need to work active control positions themselves.

Currently, supervisors are required to conduct a semi-annual tape-talk and over-the-shoulder proficiency check of each controller on a tower cab position. 19/ The Safety Board believes that the supervisor cannot sufficiently monitor controller performance on the basis of these checks alone. Moreover, the Board found during its special investigation that in some facilities, even the semi-annual proficiency and training checks were not performed within the prescribed interval. The errors discussed in the following section on coordination further illustrate the need for increased monitoring of controller performance.

Coordination

Lack of or incomplete coordination between local and ground controllers was a significant factor in nine of the incidents investigated. In some incidents, no coordination was effected because the facility had established local procedures that facility managers believed precluded the need for coordination. In some incidents, coordination was not accomplished because one controller did not perceive the situation correctly, and did not believe coordination was necessary. In other incidents, one controller believed coordination was effected, but another controller misunderstood, and coordination was not complete.

19/ Tape-talk is a session between a controller and the first-line supervisor in which the supervisor critiques a period of controlling activities recorded on audio tape. An over-the-shoulder proficiency check is conducted during actual controlling activities.

In one incident, the local controller approved the coordination with the ground controller to allow three aircraft to cross the active runway. (See case No. 13.) He later rescinded the crossing clearance to allow a departure from the runway, but he did not obtain an acknowledgment from the ground controller. As a result, the second coordination was incomplete and led to the incursion.

In two incidents, coordination between the local controller and ground controller was effected to cross more than one aircraft across the runway. (See case Nos. 1 and 3.) The coordination to clear the last aircraft in the group was effected well in advance of the actual execution of the crossing. The Safety Board believes that in both of these cases, the controllers used incomplete coordination procedures. Although coordination was accomplished, complete information about the status of the runway was not available to the local controller when he cleared another aircraft for takeoff. The Board believes that coordination would have been more effective in these cases if the ground controller had coordinated the clearance of only the airplanes at or approaching the hold line.

In another incident, the ATC tower facility procedure did not require coordination between two local controllers who were controlling different runways with intersecting arrival/departure flight paths. (See case No. 22.) Coordination was not required because it was "assumed" that the approach intervals between arrivals on one runway were sufficient to permit the controller to effect takeoffs from the intersecting departure runway. However, the local controller who was providing departure clearances did not notice an airplane approaching the conflicting runway and cleared another airplane to take off, which nearly caused a midair collision.

In another incident, a helicopter controller did not coordinate the departure of a helicopter from a helipad with the local controller controlling airplane departures because the helicopter controller assumed that the helicopter would not cross any runways controlled by the local controller. (See case No. 20.) In another incident, the ground controller did not coordinate the crossing of a runway by a taxiing airplane with the local controller because the ground controller did not make a mental note of the position of the airplane on its arrival or when the pilot reported his position, and the ground controller had not determined the taxiing airplane's location. He assumed that the taxiing airplane was in a location that would not conflict with active runways. (See case No. 11.)

Some facilities at which the incursions occurred had written procedures for coordination between the local controller and ground controller to provide clearance to cross runways. For example, the tower facility at Philadelphia International Airport had a written procedure for coordination that required the ground controller to advise the local controller when a runway crossing was complete. The Houston-Hobby Airport tower facility required the ground controller and local controller to accomplish all coordination over the interphone (through headsets) to ensure that their communications were more likely to be heard and understood; their communications also were recorded on a tower tape channel for future verification of coordination. Other facilities had no written procedures and simply used FAA Handbook 7110.65D as a guide. The handbook requires coordination between the ground controller and local controller before the ground controller can authorize any aircraft or vehicle to cross or use any portion of an active runway. The handbook states that this coordination may be accomplished verbally, by flight progress strips, by other written information, or by computer displays. However, it does not specify procedures, responsibilities, or appropriate phraseology for verbal coordination between local and ground controllers regarding requests for crossing clearances, approval of the requests, or postcrossing actions. The Safety Board believes that if specific coordination procedures had been required and followed, many of the incidents examined in this special investigation would have been prevented

CONTROLLER TRAINING AND PROFICIENCY

General

The near-midair collision of a helicopter and an airplane at Washington National Airport on September 24, 1985, illustrated serious deficiencies in controller training. (See case No. 20.) Investigators found during postincident interviews that the controllers present during the incident had differing views on facility procedures for helicopter departures. The helicopter controller, who had not yet reached full performance level at the tower, was overdue for her over-the-shoulder proficiency check and tape-talk. Yet the helicopter controller was considered qualified to give on-the-job training to other developmental controllers, and did so regularly. Since the controllers interviewed did not agree on helicopter clearance procedures, the Safety Board concluded that the procedures for helicopter operations were not effectively covered either in classroom training, in on-the-job training (OJT), or through reinforcement by day-to-day monitoring of controllers by the controllers' supervisors at the airport. The Board addressed these issues in Safety Recommendations A-86-10 through -12 issued to the FAA on January 15, 1986. (See discussion on pages 39 through 41.)

In another incident, the local controller gave permission to the ground controller to clear an airplane to cross a runway and then revoked the permission. (See case No. 13.) The ground controller did not respond to the local controller's revocation. The fact that the local controller felt confident in changing a clearance, assuming that the ground controller would follow his direction, suggested a deficiency in training.

In another incident, the ground controller could not remember the manner in which he requested permission to cross the runway. (See case No. 1.) The local controller could not remember the phraseology used by the ground controller. However, both the ground controller and local controller stated that coordination procedures at their facility required statements of "how many" were crossing "what runway" at "what taxiway," and that they always used this procedure. The Safety Board believes that these procedures are, in fact, not always followed. They were not followed in this incident, and the local controller did not ask the ground controller for clarification. The incomplete coordination found in this incident suggested that training and enforcement of standard operating procedures was not sufficient at this facility.

The FAA advised the Safety Board that ATC candidates hired by the FAA for entry into control tower training first report to their assigned facility for processing and then attend training at the ATC Academy. Upon completion of the training, the student ATC employees return to their assigned facility to begin OJT in various positions of operation in the tower cab. Usually, new employees are first assigned to the flight data/clearance delivery position. Typically, upon completion of OJT on that position, the employees are assigned to the ground control position for OJT and then to the local control position. In a tower-only facility, employees progress to the cab coordinator position if the facility is staffed with that position. In a facility with tower and radar approach control functions, after qualifying in all tower cab positions, employees begin training in the radar room. Employees attain the full performance level when they are certified on all positions of operation within the facility.

ATC Academy

According to ATC Academy managers, the primary mission of the ATC Academy is "to screen (ATC students) for potential (to become controllers), not to teach air traffic control." Comprehensive controller training is not conducted at the ATC Academy but is taught through OJT at the assigned facility after the student completes the ATC Academy curriculum.

Student ATC employees attend classes 40 hours per week for 14 weeks at the ATC Academy. A tower controller training class has an average of 18 students, and multiple classes may start simultaneously. Tower controller training at the ATC Academy is conducted in four phases—indoctrination, fundamentals of ATC, control tower operations, and nonradar ATC. After graduation, the students receive further training at their assigned facility, leading to eventual certification on positions within the facility. The course of instruction at the ATC Academy provides student controllers with classroom training relevant to the flight data/clearance delivery, ground control, and local control positions. Practical or hands-on laboratory experience is provided in the areas of flight data/clearance delivery and in nonradar control; this laboratory exposure is introductory and used as a part of the screening process.

ATC Academy personnel stated that the course materials are based on procedures contained in FAA Handbook 7110.65D. A quality assurance staff, assigned to the training center, monitors training to ensure that it is consistent with the current handbook. They said that instruction related to coordination between the local and ground control positions at an ATC tower is covered in a classroom environment only and that the subject matter taught is based on a single paragraph in the handbook. The subject represents about 20 minutes in the 14-week training program. Training involving actual coordination between local and ground control positions is not accomplished at the ATC Academy, but is introduced through OJT at the student employee's assigned facility.

The ATC Academy does not teach standardized methods of dealing with ATC problems in a dynamic tower cab environment. The terminal branch manager at the ATC Academy said that he was familiar with the VFR tower simulator used by the U.S. Air Force at its training facility. He said there were no plans to acquire a similar simulator for use at the ATC Academy. ATC Academy management personnel, when asked to comment on why the academy devotes a 4-week block in the training syllabus to nonradar procedures even though only a few FAA tower facilities use those procedures, reported that over the years it had been found that "students who performed well in the non-radar syllabus became better air traffic controllers."

U.S. Air Force ATC Training

Safety Board investigators visited the U.S. Air Force (USAF) Training Center (ATC School) at Keesler Air Force Base, Mississippi, to compare USAF controller training methods to those of the FAA. Students attend the USAF ATC classes 40 hours per week for 16 weeks. The instruction provides students with both classroom (academic) and practical (laboratory) or hands-on experience through the use of a VFR tower simulator. USAF ATC School personnel stated that an average class is made up of between 13 and 17 students; during fiscal year 1984, 875 students were enrolled in the school and 754 students completed the course.

Despite the distinctly different mission requirements, the USAF ATC School bases its training on the procedures contained in FAA Handbook 7110.65D and an Air Force Regulation, similar to FAA Handbook 7210.3, establishing recordkeeping requirements and ATC facility administration procedures. Course material for the USAF ATC School is approved by the FAA through the ATC Academy to ensure that it does not deviate from or conflict with national airspace system standards.

The USAF ATC School provides two blocks of instruction that are related directly to coordination between the local and ground control positions. Block III of the course, about 90 hours, is conducted in a classroom environment and covers procedures. Block IV of the course, about 120 hours, is dedicated to practical experience in a laboratory environment.

The laboratory portion is conducted in two phases; the first phase, 80 hours, is dedicated to a static environment where students, acting out the roles of aircraft, vehicles, or tower controllers, put into practice the procedures learned in the previous block of instruction. This training is conducted in a large room around the layout of a generic airport with an elevated tower cab overlooking the airport. The second portion of the Block IV training, about 40 hours, is conducted in a VFR tower cab simulator. This simulator consists of a full-size tower cab with all operating positions (local controller, ground controller, flight data/clearance delivery, and cab coordinator positions) and a 60-foot projection screen. Students in this phase of the training spend 6 hours per day for 5 days in the simulator. The remaining 2 hours of each training day are dedicated to debriefing the simulator training sessions.

The USAF ATC School has used the tower cab simulator since 1979. The simulator displays a 190° color scene of the generic airport. It can be programmed to depict seven different light or surface conditions. The simulator visually displays both fixed- and rotary-wing aircraft in virtually all flight regimes in a real-time presentation. Through the use of the simulator, a nearly unlimited number of traffic situations can be presented to the student from basic, problem-free situations to the most complex situations that a controller might expect to encounter. USAF ATC School personnel stated that the single most important benefit derived from training conducted in the static lab and the simulator was that it exposed the student controller to realistic traffic as the student rotated through all operating positions within the tower cab. As a result, USAF student controllers complete the 16 weeks of training better prepared than FAA student controllers to assume tower controller responsibilities. Furthermore, upon successful completion of a test at the end of the training course, USAF student controllers are issued a control tower operator (CTO) certificate without rating. When the FAA student controllers complete the FAA Academy, they are not yet prepared to be tested for issuance of a CTO certificate.

In contrast to USAF ATC School training, the current ATC Academy training method prepares the newly hired controller only for the flight data/clearance delivery position--a position staffed at many facilities by noncontroller air traffic assistants. When the newly employed academy-trained controller is initially assigned to ground or local control positions, it is literally the first time (sometimes months after completion of ATC Academy training) that the new controller receives training on those positions. The new controller is trained on the positions by an OJT instructor, who may be a full performance level (FPL) controller (checked out on all tower positions) or a developmental controller (checked out on one or more, but not all, positions). The capability of the new developmental controller to acquire the necessary skills to perform the job safely and efficiently is highly dependent on the skill, motivation, and technique of the persons conducting the OJT. OJT instructors are required to complete OJT instructor training and to have at least 30 hours experience in the position on which they are providing the training.

On-the-Job Training

According to a General Accounting Office report to the U.S. Department of Transportation, in 1981 79 percent of the total ATC workforce, including at terminals and centers, were FPL controllers. 20/ However, the report states that in 1985, only 51 percent of the total ATC workforce were certified FPL controllers. At tower facilities, the percentage of FPL controllers was slightly higher, but still lower than what the FAA considered essential for appropriate controller staffing.

20/ U.S. General Accounting Office, "Serious Problems Concerning the Air Traffic Control Workforce" (GAO/RCED-86-121).

Reduced FPL controller staffing in terminal facilities determines the ability and time available for OJT of tower controllers. When there are few controllers certified in the more complex controller positions, there are also fewer qualified controllers to train developmental controllers on those positions. This situation is worsened by the fact that the few controllers certified at the more complex positions must actually work those positions for larger percentages of their working hours, which leaves even less time for giving OJT. The lower percentage of FPL controllers at tower facilities also means that there are fewer qualified controllers available to serve as monitors.

The FAA can certify controllers who have taken the FAA OJT training course to give OJT on any position for which they are certified. Developmental controllers may give OJT to other developmental controllers. For example, the controller who misunderstood helicopter clearance procedures in one incident was a developmental controller, who just hours before the incident was giving OJT to another developmental controller. (See case No. 20.) Furthermore, this controller was overdue for a proficiency check. As a result of its investigation of the incident, the Safety Board issued Safety Recommendation A-86-12 which suggested that the FAA require that OJT on a specified position only be given by controllers with current performance evaluations on that position and who have demonstrated ability to give OJT. (See discussion on pages 39 through 41.)

MANAGEMENT AND SUPERVISION OF THE ATC SYSTEM

Tower Supervision and Staffing

An FAA air traffic control tower is managed by an air traffic manager. Area supervisors are assigned to supervise air traffic controllers in each area of operation. Area supervisors must be qualified on all positions in the area they supervise. In order to maintain proficiency, area supervisors are required to work a control position at least 16 hours per month--8 hours per month in tower cab control positions and 8 hours per month on radar positions (if applicable). The responsibilities of the area supervisors are outlined in FAA Order 7210.3G. The order states that in addition to supervisory responsibilities, area supervisors assist the "specialist" (controller). The order advises that it is particularly important that area supervisors carefully monitor current and anticipated sector activity to ensure that staffing is adequate and deployed at optimal efficiency. The order is not specific about how area supervisors should supervise or to what extent they should monitor, train, or assist controllers.

FAA Order 7210.3G acknowledges that area supervisors have nonoperational duties requiring the area supervisors to leave the tower cab. Those duties might involve tape-talks (review of air traffic controller performance), assessment of operational errors, accident investigations, or other administrative responsibilities. Air traffic managers are responsible for ensuring that nonoperational area supervisor duties are not scheduled during periods of heavy traffic so that area supervisors are available in the tower cab if needed.

During this special investigation, Safety Board investigators found that area supervisors were frequently working either a single control position or combined control positions when the incursions happened. The controller responsibilities made it difficult, if not impossible, for the supervisor to supervise, monitor, or assist other controllers. In one incident, the supervisor also was providing OJT to a controller. In 8 of the 17 runway incursions classified by the FAA as operational errors, the supervisor was absent from the tower cab at the time of the error. Usually a controller-in-charge was appointed to assume responsibility for the tower cab operation in the absence of the supervisor;

however, in one incident the supervisor was not present and a controller-in-charge was not appointed. In only two incidents was the supervisor present and unencumbered by the responsibilities of working one or more control positions; however, in both cases, the supervisor was occupied with other duties and did not see the incident.

The FAA Air Traffic Service requires that a controller-in-charge be appointed to assume a leadership role when the area supervisor is not present in the tower cab. In all incidents investigated by the Safety Board, when there was a controller-in-charge, the controller-in-charge was also responsible for at least one combined working position. In one incident, an area supervisor was not available when he could not get to work because of a snowstorm. (See case No. 1.) The local controller was appointed controller-in-charge in the absence of his supervisor. Additionally, because the local controller had previously been detailed as a supervisor, he was asked to assume the responsibilities of the area supervisor. The tower used a cab coordinator position to coordinate for the ground controller and local controller. The local controller had assumed that position as well. As a result, when the incident occurred, there was no supervisor, cab coordinator, or controller-in-charge to assist the local controller; the ground controller was also quite busy. A supervisor was needed to assist in having a critical taxiway cleared, to arrange for position relief, and to assume the cab coordinator position. The Board believes that in this incident, the supervisor or another controller was needed to assist the local and ground controllers and that facility management was deficient in permitting a staffing situation to develop during a period of heavy traffic and adverse weather with several key control positions combined.

The Safety Board found that most of the runway incursion incidents examined in this special investigation occurred in nearly ideal weather conditions and with light traffic. Although it might seem that control positions could be combined in light traffic, the incidents suggest that a degree of redundancy is needed during light traffic as well as heavy traffic.

Many tower facilities use a cab coordinator position to assist with coordination between the tower and other facilities and between the ground controller and local controller. When the cab coordinator position is used, typical staffing includes a ground controller, a local controller, flight data/clearance delivery (which is usually combined and frequently staffed by a noncontroller air traffic assistant), the cab coordinator, and an area supervisor. The specific duties of the cab coordinator vary from facility to facility. There is no FAA-wide standard position description for the cab coordinator position or for other tower controller positions. One cab coordinator stated that he considered it part of his responsibility to be an extra set of eyes (monitor) in the tower. He reported, however, that although he could sometimes devote 80 to 90 percent of his time to scanning the operating area and to assisting the local controller and ground controller, at other times, because of other duties, he was unable to devote any time to monitoring. Apparently, cab coordinators can assist the local controller and ground controller in this respect far better during slow traffic than they can during heavy or complex traffic situations. For that reason, the Safety Board believes that the primary responsibility for monitoring in the tower should rest with the area supervisor or be assigned to another controller who is free of control responsibilities.

During this special investigation the Safety Board investigators advised the FAA informally that another controller was needed in control towers to reduce the rate of runway incursions. The FAA studied the idea and implemented it in GENOT 7110.956, which was issued to Air Traffic Facilities on January 31, 1986, and in GENOT 7110.961, issued on February 14, 1986. The GENOTs acknowledged that (surface error) runway incursions were occurring because of improper controller procedures, but directed that

During moderate to heavy traffic periods, as manpower resources allow, provide a specialist for the tower to act as another pair of eyes and assist with the coordination for runway crossings and runway usage between local and ground control.

The Safety Board believes that in virtually all of the runway incursions cited in this report and classified as operational errors, the redundancy needed in the tower to prevent the incident was not present. Area supervisors were ineffective in averting the incursions because they were usually involved either in nonoperational duties or they were occupied by working one or more control positions. In several incursions, it was the supervisor who made the error that precipitated the incident. The area supervisor and controller-in-charge in almost all incidents were not able to monitor traffic or to assist the controllers who were involved in the operational error. The cab coordinator probably could perform this function during periods of light to moderate traffic. However, during periods of moderate to heavy traffic, the cab coordinator might not be able to monitor controller activities because of other duties. The Board believes that this is a staffing problem that should be addressed further by FAA management, and that a monitor should be required during all levels of traffic rather than just during "moderate to heavy traffic as manpower resources will allow" as stated in the GENOT. The Board believes that the FAA should attempt to free the supervisor or controller-in-charge of other duties, including extensive controlling duties, whenever possible so that they might be available to monitor control positions. The Board recommended this action in Safety Recommendation A-83-38 issued to the FAA on May 12, 1983. The findings of the special investigation show that the FAA has not yet complied with the intent of Safety Recommendation A-83-38. (See discussion on pages 37 and 38.)

The Safety Board noted that in many cases, the supervisor or controller-in-charge was not available, even on a limited basis, to supervise or to assist other controllers. The Board is concerned that the requirement stated in FAA Order 7210.3G is not sufficiently specific in the description of the area supervisor's duties. The Board also believes that the order should state that, in the absence of the area supervisor, the controller-in-charge who replaces the area supervisor, should be responsible for the same duties, including monitoring and assisting other controllers.

Following one incident where the area supervisor was working the local control position, the Safety Board advised the FAA "that a supervisor who is busy working a control position cannot effectively and safely monitor controllers." On January 15, 1986, the Board reiterated the provisions of Safety Recommendation A-83-38 to the FAA.

Traffic Management

Of the 17 controller-induced runway incursion incidents investigated by the Safety Board, controller personnel involved in the incidents described traffic volume as "light" in 12 of the incidents, "light to moderate" in 2 of the incidents, and "moderate" in 1 incident. Two incidents were described as having occurred in "heavy" traffic. National FAA flow control or traffic management measures had little bearing on the problems, which were involved in both of the heavy traffic incidents, and no bearing in any of the other incidents that were part of the special investigation. However, traffic management at certain facilities and by certain individual controllers was identified as a problem that contributed to several runway incursions.

The Safety Board considers management of a controller's workload, by either the controller or a supervisor, extremely important in preventing transient overloads. In a runway incursion at Minneapolis (see case No. 1), neither the controller nor a supervisor

exercised appropriate individual workload/traffic management. The Board believes that national and facility flow control measures must prevent excessive peaks in traffic volume by realistic metering of flow, but most importantly, individual controller workload or short-term flow control must be achieved by direct and reasonable individual controller oversight by a supervisor.

In another incident at Minneapolis involving an airplane that landed on a runway still occupied by an airplane that had rejected takeoff, the local controller cleared the departing airplane for takeoff when the landing airplane was on final approach, about 2 miles from the airport. (See case No. 2.) The Safety Board believes that the local controller may have been self-motivated to expedite arrivals and departures.

In another incident at Minneapolis, both the local controller and ground controller stated in postincident interviews that they had been concerned with the approach of an arriving airplane when they incompletely coordinated the crossing of an active runway by an airplane while another airplane was taking off from the runway. (See case No. 4.) In their effort to expedite traffic, they did not follow procedures.

In an incident at Houston, the ground controller stated that he was concerned about crossing three airplanes ahead of an airplane on final approach for landing on a runway. (See case No. 13.) The Safety Board believes that the arriving aircraft distracted the ground controller and contributed to his not hearing the local controller's instruction to wait until another airplane had taken off.

The Safety Board believes that the controllers in these three incidents which resulted in runway incursions were personally motivated to expedite traffic to accept approaching aircraft without delay. The Board could not determine whether these pressures were reinforced by supervisors. However, the Board believes that this pressure, whether real or perceived, was a factor in the cause of the runway incursions.

Of the two incidents where heavy traffic was involved, the heaviest traffic occurred in the March 31, 1985, incident at Minneapolis involving the DC-10's. (See case No. 1.) The controller-in-charge, who was acting as local controller and cab coordinator, through his actions and inactions allowed the traffic to build until the limits of the airport were exceeded and the ground controller was also overloaded. The Safety Board believes that if an area supervisor had been available in the tower cab during the heavy traffic period, the workload of both the local controller and the ground controller could have been reduced and the incident might not have occurred.

The capability of controllers to control traffic effectively and safely is influenced by the amount of workload they can accommodate. Studies of controller workload have established that a "macho" or "I can handle it" attitude can develop in controllers to the point that they may exceed their own capabilities. Such a condition could occur during "light to moderate" traffic as well as during "heavy" traffic if a controller attempts to expedite traffic by compressing aircraft spacing during takeoff and landing operations. The Safety Board believes that workload or "flow control" with respect to individual controllers must be achieved by direct and reasonable oversight by a supervisor and by training controllers to recognize their limitations. Also, the Board believes that the FAA should remind supervisors and controllers of the dangers of attempting to expedite traffic departures or crossing runways in order to accommodate arrival and departure traffic.

FAA RUNWAY INCURSION PREVENTION PROGRAMS

During the special investigation, Safety Board investigators received both verbal and written status reports of FAA actions relevent to the runway incursion problem and information about several ongoing programs that address the problem. For example, recognizing that the problem involves several operational areas, in mid-1985 the FAA formed an interdisciplinary working group tasked with the responsibility of developing a comprehensive action plan regarding runway incursions. The group is comprised of personnel from the FAA's Airports, Air Traffic, Flight Standards, and Safety Services. The following are actions that have resulted from these efforts:

A Notice of Proposed Rulemaking (NPRM) to revise the requirements in 14 CFR Part 139 concerning airfield marking and signing and vehicle access to airfields was published in the Federal Register in October 1985. If adopted as proposed, the rule would contain several provisions that are related to runway incursions. The FAA received more than 200 letters in response to the NPRM. Because of the large number of comments received, the FAA does not expect to issue the final rule until late 1986.

Revised procedures emphasize the inclusion of holding position markings, including signs, in all appropriate Airport Improvement Program (AIP) projects. An FAA program guidance letter (86-1) issued on November 11, 1985, instructed FAA airport divisions to make a special effort to encourage sponsors to include taxiing hold lines and signs in any subsequent AIP projects.

The FAA issued an Airport Safety Alert in December 1985 to identify conditions on airports that might cause runway incursions. It provided general information on proper marking and signing of taxiways at their intersections with runways.

The FAA is producing a videotape on ground vehicle operations on airports. The videotape will be directed to airport management, staff, and other users of airports who may have a need to operate a ground vehicle on the airport. To complement the videotape, the FAA also is developing a publication that will identify actions that airport management can take in regard to ground vehicle operations. The FAA proposes to describe or discuss good vehicle operator practices, including proper communication with the control tower, in part of this publication or perhaps in a separate publication.

The FAA also has addressed the runway incursion problem by the following ATC actions, some of which are proposed but not yet implemented:

- Issued on February 17, 1986, GENOT 7110.961, which addresses runway incursions and prescribes five actions that tower managers must take.

- Issued on March 17, 1986, an order on airport operating practices that requires tower managers to implement airport operating practices at their facilities.

- Developing operational position standards (OPS) to standardize, to the extent possible, how controllers carry out control functions. OPS is currently being operationally confirmed at selected facilities. Confirmation is tentatively scheduled for completion in July 1986. Implementation will be dependent upon funding availability to brief supervisors, OPS coordinators, and other ATC personnel on OPS.

- o VFR tower cab laboratory training (static laboratory) will be provided during initial training at the FAA Academy. Scheduled for Fiscal year 1987.

- o A videocassette reenacting vivid runway incursions or animating some past incidents/accidents will be developed for use as a mandatory training tool for all tower controllers. Schedule is dependent upon funding availability.

The FAA's Office of Aviation Medicine has an ongoing program studying controller errors, including runway incursions. A working group is analyzing the controller error problem and will recommend remedial actions. This program is attempting to isolate variables that can be dealt with through modified selection and training methods or through appropriate procedural changes. This is a long-term project expected to extend into 1987.

Some control towers have local programs to reduce runway incursions. These programs are not part of a national program, but were undertaken due to the initiative of management personnel at the involved facilities. For example, the air traffic manager at the Philadelphia International Airport implemented a procedure whereby, in addition to coordinating prior to a runway crossing, the ground controller also coordinates further with the local controller after the crossing to assure the local controller that the crossing is complete and that it is safe to continue operations on that runway. Because of concern about the inadequacy of verbal coordination after one or more incidents, the air traffic manager at Houston-Hobby Airport elected to have the ground controller and local controller both wear headsets and to accomplish all coordination of crossings verbally over a recorded interphone channel. The procedure was intended to lead to more completely understood coordination communication and a reduction in ground operational errors. The Houston-Hobby air traffic manager also requires controllers who make ground operational errors to brief management and their peers at the facility on the details of the errors. The intent of the procedure is to further educate all controllers at the facility and to eliminate additional errors by the involved controllers.

The air traffic manager at Hartsfield International Airport in Atlanta established a runway crossing committee in 1975. At that time the passenger terminal was on the north side of the airport and there were many crossings of the closest parallel runway by taxiing aircraft that were assigned to take off or land on the more remote runways. These crossings caused an unacceptable number of vehicle operator and pilot-induced runway incursions. The runway crossing committee involved tower management, airport management, airlines, and other users of the airport. A systematic and continuing effort has kept runway incursions at a low level in subsequent years. Now with four parallel runways and a midfield terminal, the operations at the airport far exceed those of the late 1970's and the potential for runway incursions has increased. However, the runway crossing committee has persisted in keeping the crossing problem under control. Some of the measures taken include:

1. Posting of lighted signs at each main runway crossing point advising pilots to "hold for clearance" before crossing.

2. Making an Automated Terminal Information Service announcement reminding pilots that all runway holding clearances must be read back, including aircraft call sign.

3. Reminding controllers to get a positive confirmation from pilots regarding crossing instructions and holding clearances.

4. Circulating operations bulletins to airlines and fixed-base operators reminding pilots to read back clearances, including call signs.

5. Placing posters concerning runway crossings in pilot lounges and other areas.

6. Circulating letters concerning runway crossings periodically to all organizations that operate vehicles on the airport.

7. Distributing leaflets describing the runway crossing problem to pilots and vehicle operators.

8. Conducting training sessions by tower personnel to continually educate vehicle operators on the airport.

9. Moving hold-short lines 150 feet from the runways and widening lines to improve their conspicuity.

10. Closing a high-speed taxiway that is difficult to view from the tower during low visibility conditions.

11. Holding runway crossing committee meetings as needed to discuss continuing incidents and the need for corrective action.

The Safety Board is encouraged by the efforts of the individual facility managers who implemented these ideas and believes that many more such ideas are being implemented elsewhere. However, the Board believes that the FAA should deal with the runway incursion problem on a national basis. Facility managers should be polled to find out what ideas are being suggested and implemented so that they might be evaluated for possible implementation on a national scale.

A memorandum dated March 7, 1986, from the FAA's Associate Administrator for Air Traffic to all air traffic managers acknowledges that the runway incursion problem requires further action. The memorandum reports that although operational errors decreased significantly overall in 1985, surface operational errors in 1985 were up 32.5 percent over 1984 and the growth of terminal errors "continued to climb in 1986." The memorandum stated that 86 of 102 surface operational errors reported in 1985 were attributed to the local controller. Most instances reportedly involved situations where the local controller forgot what had previously been coordinated. In January 1986, local controllers were held responsible for eight of the nine errors reported. The memorandum expressed the view that the key to the problem of surface operational errors is to devise methods that will aid the local controller in remembering traffic and to stress the importance of teamwork and coordination.

The Safety Board believes that the FAA actions cited above will lead to a reduction in runway incursions. However, many of the projects are incomplete and the potential effectiveness of them is questionable unless some of the basic ATC problems involving adequacy of controller training, coordination in the tower, and supervision are resolved. Until these problems are adequately addressed, controllers will continue to forget aircraft, there will be continued breakdowns in coordination in the tower, and supervisors will not be free to monitor performance or assist controllers.

SUMMARY

The Safety Board special investigation revealed that the magnitude of the runway incursion problem could not be measured because of both incomplete reporting and followup investigations by the FAA. Since the cause of most runway incursions could be understood by examining the human performance aspects of the incidents, the Board believes that all runway incursions should be investigated for both pilot and controller factors and for the determination of underlying causes. The result of such investigations should be analysed by means of a combined data base. Complete incident reporting and analysis also could generate timely and complete accident prevention programs.

The special investigation revealed a lack of controller supervision and redundancy in the tower cabs when runway incursions occurred. In the majority of the controller-induced runway incursions, the Safety Board found that even though facility staffing was sufficient to provide coverage for all operating positions, supervisors often were not available in the tower cabs and controllers-in-charge were not always assigned or available. When a controller-in-charge was assigned, the duties usually were combined with another position, preventing the controller-in-charge from effectively monitoring or providing assistance to other controllers. The Board believes that supervision and position staffing are short-term problems that could be corrected by more effective facility management. However, the Board is concerned that a lack of supervision in the tower cab contributes to the runway incursion problem when no supervisor is available to monitor and assist controllers. As several incidents summarized in the report of the special investigation demonstrated, another controller or a supervisor dedicated to monitoring the activities of controllers, particularly at the local control position, should have discovered and corrected the controller's error in time to eliminate a risk of collision.

The special investigation also revealed deficiencies in the FAA's tower controller training program. These deficiencies are long-term and will require a dedicated effort on the part of the FAA to correct. The Safety Board believes that FAA controllers have not been afforded the best available training to prepare them for their tower duties. The Board finds that insufficient training is given in the coordination between control positions. Also, the Board believes that if the FAA would introduce "hands-on" dynamic tower cab simulation for use by the "tower option" student controllers at the ATC Academy, controllers would receive better training. Other benefits might include greater standardization of control techniques, the teaching of teamwork in a controlled environment, and the opportunity to present unusual but critical situations to which the controller might never be exposed during on-the-job training at the facility where controller training is eventually completed. The Board is convinced that if the training program included the practical application of ATC procedures through the use of tower cab simulation, new controllers would have better work habits, would have a better understanding of proper coordination and scanning techniques, and would transition more quickly to tower control positions.

Although the Safety Board believes that part of the long-term solution to the runway incursion problem involves the restructuring of the ATC Academy curriculum, the short-term solution involves improved supervision in the tower, broader use of cab coordinators, freeing supervisors and controllers-in-charge of control positions, and stressing standardized and complete coordination between control positions. The FAA should reexamine the on-the-job training controllers receive and review the qualifications of the instructor to ensure that on-the-job training is given, whenever possible, by experienced and motivated full performance level controllers rather than by developmental controllers or full performance level controllers who, while highly qualified, may not have had many hours of experience at a certain position.

Controllers should scan runways and taxiways at all levels of traffic and should be assisting each other by observing all traffic. In this special investigation most incidents occurred in low traffic and under conditions of excellent visibility. The Safety Board believes that inadequate scanning on the part of the ground controller contributes to some errors, but complacency or lack of vigilance during periods of low workload is involved also. Under those circumstances, there is a breakdown in communications and/or inadequate scanning by pilots as well as controllers.

Some runway incursions were found to be the result of a combination of pilot and controller errors. Incidents could be prevented if controllers and pilots used proper phraseology and if pilots acknowledged all ATC clearances, including taxi clearances. When acknowledging clearances, pilots should provide their aircraft call sign to assure tower personnel that the clearance was understood. When a clearance is not understood, pilots should ask for clarification.

To avoid runway incursions, pilots must be mentally alert when taxiing, taking off, or landing. Pilots also could reduce the risk of runway incursions by scanning the runway more effectively before taxiing onto active runways, by reducing taxi speed while approaching and preparing to cross any runway, and by delaying a request for clearance to cross until ready to cross the runway. The Safety Board also believes that runway and taxiway signing are effective runway incursion prevention tools whose use should be mandated by 14 CFR Part 139.

CONCLUSIONS

1. There is a lack of total reporting and investigation of runway incursions caused by operational errors and pilot deviations.

2. Operational error and pilot deviation information were not entered into an automated FAA data system until August 1985. The FAA still does not have a runway incursion data base or data system.

3. The FAA has no systematic method to analyze pilot deviations or operational errors for systematic underlying causal factors.

4. Most FAA operational error investigation reports document controller violation by citing a pertinent paragraph from FAA Handbook 7110.65D, but do not document underlying causes.

5. Pilot deviation reports are primarily enforcement-oriented.

6. More effective scanning of the runway by pilots and controllers would have prevented many of the runway incursions that the Safety Board investigated.

7. Many runway incursions classified as operational errors (i.e., controller-induced) could have been prevented by proper action by the pilots involved.

8. Runway and taxiway signs are effective in preventing pilot disorientation and inadvertent runway incursions when taxiing.

9. Agressive runway incursion prevention educational programs, stressing readback of crossing clearances, and the importance of holding for clearance before crossing active runways would be effective in reducing the number of runway incursions.

10. In the controller-induced runway incursions investigated by the Safety Board, errors were made by controllers with a wide range of experience. The controllers with the most experience were in supervisory or controller-in-charge roles and/or were usually working active control positions simultaneously.

11. Insufficient scanning of the airport and BRITE displays by local and ground controllers was a factor in many incursions, and the use of nonstandard phraseology by pilots and controllers was a factor in some.

12. Several of the runway incursions classified as operational errors could have been prevented if there had been more complete communication and coordination between the ground and local controllers.

13. FAA Handbook 7110.65D does not specify how coordination between ground and local controllers should be accomplished, and the FAA has no national policy on the procedures by which coordination of the movement of aircraft and vehicles across active runways is accomplished.

14. Although some facilities had locally developed procedures for face-to-face coordination between local and ground controllers, these procedures were not strictly observed and they were designed without consideration for known human memory limitations.

15. In almost all runway incursions classified as operational errors, the supervisor either was not in the tower cab or was working at least one control position.

16. When the area supervisor is not in the tower cab, a controller-in-charge is generally designated to assume the responsibilities of the supervisor; however, there is no requirement that precludes a supervisor or controller-in-charge from simultaneously performing the duties of one or more controller positions.

17. Area supervisors cannot effectively monitor controller performance regularly because of other duties and because of the need to work active control positions periodically to maintain proficiency.

18. A lack of controller and/or supervisory redundancy in the tower cab is a factor common to many controller-induced runway incursions.

19. Ground and local control techniques and coordination methods for which there is no specified or standard national procedures are taught on-the-job at each FAA tower facility.

20. The FAA has no standard evaluation and retraining procedures for controllers who are involved in operational errors.

21. Over-the-shoulder proficiency checks and tape-talks (the only standard methods of measuring controller proficiency after a controller is certified on a position) were not conducted at the required intervals at some facilities.

22. The ATC Academy currently does not teach ground and local controller techniques or give practical instruction in ground and local control coordination techniques.

23. The use of practical "hands on" tower training at the ATC Academy using dynamic laboratory or simulation techniques would provide student controllers with a better understanding of practical tower control methods than does the classroom training now received at the ATC Academy.

24. Inadequate national flow control measures were not involved in any of the runway incursions investigated by the Safety Board. However, high traffic volume and complexity coupled with poor individual controller traffic management was involved in two incursions.

RECOMMENDATIONS

As a result of its investigation of the accident at O'Hare International Airport on December 20, 1972, the Safety Board issued the following safety recommendations to the FAA:

> Establish and publish taxi routes for arriving and departing aircraft to be used during periods of restricted visibility on the order of 1/2 mile. (A-73-25) (issued May 17, 1973)
>
> Require pilots to obtain the controller's approval before crossing a lighted runway during periods of restricted visibility on the order of 1/2 mile. (A-73-26) (issued May 17, 1973)
>
> Require flight crews to report their aircraft position on the airport when establishing radio communications with controllers, and require the controllers to read back the reported aircraft position when it cannot be verified either visually or by means of radar. (A-73-54) (issued August 10, 1973)
>
> Require flightcrews to read back taxi clearances when operating in visibility of less than one-half mile. (A-73-55) (issued August 10, 1973)

The FAA did not take the recommended action in the first two recommendations, stating that the ever-changing traffic situation precluded use of a chart (A-73-25) and that a continuing controller requirement to approve each specific crossing of lighted runways would result in an intolerable communication problem and increase in controller workload (A-73-26). With regard to Safety Recommendation A-73-55, the FAA stated that sufficient instructions for communications between the controller and the pilot were in practice and that no further modification to communications procedures was necessary. The Safety Board classified Safety Recommendations A-73-25, A-73-26, and A-73-55 as "Closed--Unacceptable Action."

The FAA did conduct an in-depth study of aircraft position reporting during periods of reduced visibility, which resulted in General Notice 7110.322, issued November 29, 1983. This notice addressed "position verification" and required controllers to repeat an aircraft's reported position before issuing a taxi or takeoff clearance. The Safety Board classified Safety Recommendation A-73-54 as "Closed--Acceptable Action."

Following investigation of three runway incursion accident/incidents that occurred in 1978, the Safety Board issued the following safety recommendations on June 8, 1979, to the FAA :

> Conduct a directed safety study, on a priority basis, to examine the runway incursion problem and to formulate recommended remedial action to reduce the likelihood of such hazardous conflicts. (A-79-42)
>
> Alert all controller/pilot personnel that runway incursion mishaps represent a serious safety problem which requires their immediate attention. Special emphasis should be placed on the need for both groups to maintain greater visual surveillance in those taxi operations involving any runway crossing. (A-79-43)

In response to Safety Recommendation A-79-42, the FAA commissioned the Transportation Systems Center in Cambridge, Massachusetts, to conduct a study. The study was completed in April 1981 with a report titled "An Analysis of Runway-Taxiway Transgressions at Controlled Airports" (report No. FAA-EM-81-5). The study concluded that there "does not appear to be any pattern to the causes . . . other than human errors on the part of both air traffic controllers and pilots." The study also concluded that "more uniform communication and verification of messages between pilots and controllers could serve to reduce the chance of ambiguous or erroneous commands/actions." The report raised the question as to whether system reliability might be improved by increasing the reliability of the human element or by adding redundant elements. The study did not evaluate controller training or human performance issues. The study did suggest that incident reporting might be a part of the problem, since there were indications that all of the incidents were not reported, which precluded appropriate corrective measures. The report did not propose any corrective measures.

While the FAA did conduct the study on the runway incursion problem, the study did not result in developing remedial action to reduce or alleviate the problem. Because the FAA did not comply with the intent of the recommendation, and based upon the recommendations that resulted from this special investigation, the Safety Board classified Safety Recommendation A-79-42 as "Closed—Unacceptable Action/Superseded."

The FAA issued Advisory Circular (AC) 90-48C, Pilots' Role In Collision Avoidance on March 18, 1983, in response to Safety Recommendation A-79-43. This AC was published to alert all pilots to the potential hazards of midair collisions and near-midair collisions and to emphasize basic problem areas related to the human causal factors where improvement in pilot education, operating practices, procedures, and improved scanning techniques are needed to reduce conflicts. Paragraph 4.c, Clearing Procedures, of the AC emphasizes the importance of pilot scanning of runways before taxiing onto runways. The Safety Board classified Safety Recommendation A-79-43 as "Closed—Acceptable Action."

As a result of its study of the ATC system in 1983, the Safety Board issued Safety Recommendation A-83-38 on May 19, 1983, which recommended that the FAA:

> Institute air traffic control directives and procedures to require, when the assigned first-line supervisor is occupied working a control position, that there is appropriate and adequate direct supervision to ensure the detection and reporting of all controller errors or deviations, the detection and monitoring of fatigue and/or stress, and the control of each controller's workload.

On July 3, 1985, the FAA issued Change 5 to the Facility Operation and Administration Manual (7210.3G). This change required facility managers, to the extent possible, to avoid scheduling area supervisors for nonoperational duties during periods of known heavy traffic. Because the Safety Board's special investigation found that most runway incursion occurrences happen during relatively light traffic, the Board has requested that the FAA ensure that there is appropriate and adequate direct supervision at all times. The Board classified Safety Recommendation A-83-38 as "Open--Acceptable Action."

Following its investigation of the accident at Anchorage on December 23, 1983, the Safety Board issued Safety Recommendation A-84-98 on August 23, 1984, which recommended that the FAA:

> Require that airports certificated for air carrier operations install signs at all runway and taxiway entrances, exits and intersections that indicate the identity of the runway or taxiway.

In its letter of November 30, 1984, the FAA stated that it concurred with this recommendation and was developing a Notice of Proposed Rulemaking (NPRM) which would address the proper identification of runways and taxiways. The NPRM, which proposes to revise 14 CFR Part 139 was published in the Federal Register in October 1985. If adopted as proposed, the rule would contain several provisions that are related to runway incursions. These include:

(1) airfield marking and signing, including holding position markings;

(2) limiting access to the airfield to those ground vehicles necessary for air operations;

(3) requiring that vehicle operators be familiar with the airport's rules; and

(4) requiring the airport certificate holder to make available records of vehicle accidents.

The FAA does not expect to issue the final rule until late in 1986. Pending the FAA's final action on this rulemaking effort, the Safety Board has classified Safety Recommendation A-84-98 as "Open—Acceptable Action."

As a result of two accidents and one incident involving ground vehicle operations on active runways, the Safety Board issued the following safety recommendations on February 22, 1985, to the FAA:

> Develop a mechanical/aural/visual (or combination thereof) alert device and require its use by local and ground controllers to coordinate their activities when a vehicle has been cleared to operate on the active duty runway for an extended period such as in snow removal operations. (A-85-15)

> Periodically emphasize in the training of air traffic control personnel providing airport advisory services the proper application of runway usage procedures stressing positive coordination between control positions. (A-85-16)

> Periodically emphasize in the training of air traffic controller personnel the requirements contained in the Air Traffic Control Handbook 7110.65D, March 1984, for restricting vehicle and aircraft operations in the ILS critical areas when the ILS is being used for approach/landing guidance and the reported ceiling, visibility or runway visual range are below the specified levels. (A-85-17)

In response to Safety Recommendation A-85-15, the FAA developed and issued an order directing facility managers to develop and use an aural and/or visual display method to indicate when vehicles are operating on a runway. This order was distributed on March 7, 1986. The Safety Board requests that the FAA provide additional information on the types of devices developed by the facility tower managers, controller reactions to the use of these devices, any measurable improvement in controller coordination, and the facilities in which these devices have been installed. Pending its review of this information, the Board has classified Safety Recommendation A-85-15 as "Open--Acceptable Action."

In response to Safety Recommendations A-85-16 and -17, the FAA stated that current training practices and procedures sufficiently addressed runway usage and proper communication/coordination between local and ground controllers. This response is counter to the findings of the Safety Board's special investigation. The Board has classified Safety Recommendations A-85-16 and -17 as "Open--Unacceptable Action."

As a result of its investigation of the near-collision of the two Northwest Airlines DC-10's at Minneapolis on March 31, 1985, the Safety Board made the following safety recommendations on April 19, 1985, to the FAA:

> Issue a General Notice (GENOT) directing the management of all terminal air traffic control facilities to immediately brief all traffic controllers on the importance of complete and accurate coordination between local and ground controllers before taxiing airplanes on or across an active runway. (A-85-32)

> Develop and implement, on a priority basis, specific procedures and standards, and specify responsibilities to be used during direct face-to-face and/or interphone coordination between local and ground controllers regarding requests and approvals to clear airplanes to taxi across an active runway. (A-85-33)

In its letter of July 12, 1985, the FAA advised the Safety Board that it had issued a GENOT which emphasized the importance of complete and accurate coordination between local and ground controllers. Additionally, the FAA issued a letter to tower facility managers which directed them to conduct an analysis of local procedures which address runway crossings and local and ground controller coordination. Several other initiatives to improve traffic awareness and local and ground controller coordination were also proposed. The Board has classified Safety Recommendations A-85-32 and -33 as "Closed--Acceptable Action" and "Open--Acceptable Action," respectively.

As a result of a runway incursion incident at Washington National Airport on September 24, 1985, the Safety Board issued the following safety recommendations on January 15, 1986, to the FAA:

> Establish standardized departure/arrival routes for helicopter traffic arriving and departing Washington National Airport. (A-86-7)

Design, publish, and require the use of a chart depicting visual flight rules helicopter routes for civilian and military helicopter operations throughout the Washington, D.C. metropolitan area, which would include the standardized departure and arrival routes to and from Washington National Airport. The chart should include graphic and narrative descriptions of the selected routes. (A-86-8)

Study the feasibility of establishing standard visual flight rules helicopter routes and arrival and departure procedures at major airports throughout the National Airspace System. (A-86-9)

Require the inclusion of visual flight rules helicopter control procedures, in using standard routes, in both classroom and on-the-job training of local controllers. (A-86-10)

Examine the administration of the Technical Appraisal Program at Washington National Airport tower to confirm compliance with all directives pertaining to Air Traffic Control Specialist Proficiency Requirements. (A-86-11)

Require that on-the-job training at specified control positions be given only by controllers who are qualified instructors and who have current (in the last 6 months) performance evaluations of on-the-job training ability and current (in the last 6 months) performance evaluations at the specified control position. (A-86-12)

The FAA responded to these recommendations in its letter of April 10, 1985. The FAA informed the Safety Board that it had published a new chart for helicopter traffic arriving and departing Washington National Airport, which depicts the Washington, D.C. area as well as Washington National Airport, and provides helicopter routes to be used. The Board has classified Safety Recommendations A-86-7 and -8 as "Closed--Acceptable Action."

In response to Safety Recommendation A-86-9, the FAA informed the Safety Board that it has begun a study of the feasibility of establishing standard visual flight rules helicopter routes and arrival and departure procedures at major airports. Pending its review of the results of this study and subsequent FAA action, the Board has classified Safety Recommendation A-86-9 as "Open—Acceptable Action."

With regard to Safety Recommendation A-86-10, the FAA stated that the ATC Academy was revising the classroom portion of the training program to include simulation of airport ground and local control situations involving helicopter operations, and that the on-the-job training portion requires the demonstration of the use of standard arrival and departure route procedures prior to position certification. Pending further information from the FAA on the status of revising the tower controller training program, the Safety Board has classified Safety Recommendation A-86-10 as "Open—Acceptable Action."

In response to Safety Recommendation A-86-11, the FAA stated that an evaluation had found Washington National Airport to be in full compliance with the Technical Performance Appraisal Program and that every effort would be made to ensure that the program is properly administered in the future. However, there was no indication of the actions taken to achieve this result. Therefore, the Safety Board requests that the FAA provide additional information as to the actions taken to correct the discrepancies found during the investigation. The Board has classified Safety Recommendation A-86-11 as "Open—Acceptable Action."

With regard to Safety Recommendation A-86-12, the FAA's letter did not indicate that any action had been taken to correct this situation. The Safety Board has classified Safety Recommendation A-86-12 as "Open—Unacceptable Action" pending further correspondence on this issue.

As a result of its special investigation of runway incursions at controlled airports in the United States, the National Transportation Safety Board reiterates Safety Recommendations A-83-38, A-84-98, A-85-16, and A-85-33. Also, the Safety Board recommends that the Federal Aviation Administration:

> Revise the current tower training curriculum at the ATC Academy to include more emphasis on practical standardized "hands-on" tower training using dynamic laboratory and simulation facilities. (Class II, Priority Action) (A-86-30)
>
> Establish a program for improved supervision of tower controller performance in which scanning, coordination, and use of proper phraseology is emphasized and which includes retraining of controllers who are deficient. (Class II, Priority Action) (A-86-31)
>
> Establish an ad hoc task force, including controller and human performance expertise, to develop effective memory aids that would reduce incidents of air traffic controllers forgetting traffic, and to incorporate a description of these memory aids and how they should be used in the ATC Academy controller training syllabus and in the tower facility training program. (Class II, Priority Action) (A-86-32)
>
> Require controllers to obtain a readback for all hold, takeoff, or crossing clearances and for clearances onto an active runway. (Class II, Priority Action) (A-86-33)
>
> Emphasize in operational bulletins, the Airman's Information Manual, general aviation seminars, and pilot training programs, the importance of reading back taxi, hold-short, runway crossing, and takeoff clearances in proper phraseology; the importance of reporting when unable to promptly cross, take off from, or clear a runway when so cleared; and the need to scan properly before entering or crossing a runway. (Class II, Priority Action) (A-86-34)
>
> Emphasize in operational bulletins, the Airman's Information Manual, and pilot training programs that a good operating practice for pilots of single-pilot airplanes is to monitor only assigned air traffic control communication frequencies after a clearance onto an active runway for departure, until flight from the airport traffic area is completed, or after receipt of clearance for landing, until the landing and taxi across all active runways is completed. (Class II, Priority Action) (A-86-35)
>
> Revise controller phraseology for use when issuing takeoff and landing clearances to include the runway number (for example: "American 75, runway 36, cleared for takeoff"). (Class II, Priority Action) (A-86-36)

Issue a General Notice directing the management of all terminal air traffic control facilities to brief all controllers on the dangers of attempting to expedite traffic departing or crossing runways in order to accommodate arrival and departure traffic. (Class II, Priority Action) (A-86-37)

Issue an Advisory Circular delineating both the pilot and controller roles and responsibilities in the prevention of runway incursion incidents. (Class II, Priority Action) (A-86-38)

Revise the near-midair collision reporting and investigating program to clarify the intent that near-collisions on or near the airport surface constitute an occurrence which must be investigated as a near-midair collision. (Class II, Priority Action) (A-86-39)

Revise and enforce the requirements to report and to investigate operational errors, pilot deviations, and near-midair collisions that involve aircraft on the ground as well as in the air, and develop a combined data base for comprehensive procedural and human performance causal analyses of runway incursion incidents. (Class II, Priority Action) (A-86-40)

Issue an air carrier operations bulletin to require air carrier inspectors to review air carrier training and operations manuals and pilot training programs to ensure that they contain specific standardized information and guidance to pilots concerning their role in the prevention of runway incursions. (Class II, Priority Action) (A-86-41)

Disseminate copies of the Safety Board's Special Investigation Report on Runway Incursions at Controlled Airports in the United States to all terminal control facilities and to the ATC Academy for use in their training programs. (Class II, Priority Action) (A-86-42)

In cooperation with terminal air traffic managers, airport managers, airline representatives, and pilot groups, determine the most effective signs, markings, and procedures, from an operational and human performance perspective, to prevent pilot-induced runway incursions and issue an Advisory Circular to disseminate the information to airport managers and pilot organizations. (Class II, Priority Action) (A-86-43)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ JIM BURNETT
Chairman

/s/ PATRICIA A. GOLDMAN
Vice Chairman

/s/ JOHN K. LAUBER
Member

/s/ JOSEPH T. NALL
Member

May 6, 1986

APPENDIX

SUMMARY REPORTS OF RUNWAY INCURSION INCIDENTS AND ACCIDENTS

Case No.	Date	Location	Aircraft Involved
1.	3/31/85	Minneapolis, Minnesota	Northwest DC-10; Northwest DC-10
2.	3/31/85	Minneapolis, Minnesota	Eastern DC-9; Republic DC-9
3.	5/8/85	Philadelphia, Pennsylvania	Lufthansa DC-10; Republic DC-9
4.	6/12/85	Minneapolis, Minnesota	Lear 24; Bemidji Beech 80
5.	6/20/85	Birmingham, Alabama	Alabama Air National Guard RF-4C; Smithair, Inc. Beech E-18S
6.	6/26/85	Austin, Texas	Southwest B-737; Piper Cherokee
7.	7/3/85	Chicago, Illinois	Midway Express B-737; Midway Airlines DC-9
8.	7/4/85	Boston, Massachusetts	Delta B-727; Provincetown-Boston Cessna 402
9.	7/5/85	West Palm Beach, Florida	Gull Air Cessna 402C; Gates Learjet 35A
10.	7/17/85	White Plains, New York	Piper PA-28
	7/18/85	White Plains, New York	Piper PA-60 Aerostar
	7/19/85	White Plains, New York	Beech 100 Kingair; N43W
	7/20/85	White Plains, New York	Midway Airlines DC-9
	7/20/85	White Plains, New York	Cessna 172
11.	7/31/85	Little Rock Arkansas	Beech 200 Kingair; Piper PA-30
12.	8/2/85	Sarasota, Florida	Delta B-727; Piper PA-34 Seneca
13.	8/2/85	Houston, Texas	Gates Learjet 35; Fort Worth Airlines Nihon YS-11
14.	8/11/85	Syracuse, New York	Gulfstream American G3; runway closed, construction
15.	8/15/85	Tulsa, Oklahoma	Cessna 152; Cessna 421

Case No.	Date	Location	Aircraft Involved
16.	8/21/85	Rochester, New York	Piper PA-28; runway closed
17.	8/29/85	Kansas City, Missouri	Central Airlines Rockwell Commander 500; Southwest B-727
18.	8/29/85	Atlanta, Georgia	Swearingen SA-26AT Merlin; Delta B-737
19.	9/3/85	Nashville, Tennessee	Mitsubishi MU-2; American MD-80
20.	9/24/85	Washington, D.C.	Eastern B-727; Bell 206
21.	1/7/86	Bangor, Maine	Boeing KC-135; partially closed runway
22.	2/25/86	Chicago, Illinois	United DC-8-71; Air Wisconsin Fokker F-27

GLOSSARY

AS	-	area supervisor
ATA	-	air traffic assistant
ATC	-	air traffic control
ATIS	-	automated terminal information service
ATM	-	air traffic manager
BRITE	-	bright radar indicator tower equipment
CC	-	cab coordinator
CD	-	clearance delivery
CDT	-	central daylight time
CFCF	-	central flow control facility
CIC	-	controller-in-charge
CST	-	central standard time
EDT	-	eastern daylight time
FAA	-	Federal Aviation Administration
FD	-	flight data
FPL	-	full performance level
FSO	-	flight safety officer
GC	-	ground controller
GENOT	-	General Notice
GPWS	-	ground proximity warning system
HC	-	helicopter controller
IFR	-	instrument flight rules
ILS	-	instrument landing system
IMC	-	instrument meteorological conditions
KIAS	-	knots indicated airspeed
LC	-	local controller
NOTAM	-	Notice to Airmen
OJT	-	on-the-job training
OTS	-	over-the-shoulder
RVR	-	runway visual range
TRACON	-	terminal radar approach control
VFR	-	visual flight rules
VMC	-	visual meteorological conditions
VOR	-	VHF Omni-Directional Radio Range

1. Minneapolis, Minnesota - 3/31/85

About 2104 (CST) on March 31, 1985, Northwest Airlines flight 51 (NW51), a McDonnell Douglas DC-10, was cleared for takeoff on runway 29L at the Minneapolis-St. Paul International Airport, Minneapolis, Minnesota. About the same time, Northwest Airlines flight 65 (NW65), also a DC-10, was cleared to cross runway 29L at taxiway C, 6,000 feet from the approach end of the runway and 4,500 feet from the ATC tower. The controllers who issued the clearances did not recognize the hazardous situation in time to take preventive action. NW51 was in its takeoff roll when its captain saw NW65 crossing runway 29L. The captain of NW51 averted a collision by rotating to a takeoff attitude at a lower than normal rotation speed, lifting off prematurely, and overflying NW65. The captain of NW51 estimated that his airplane cleared NW65 by 50 to 75 feet vertically. A total of 501 persons were aboard the two airplanes. Thirteen other air carrier airplanes were operating within 500 feet of the intersection of runway 29L and taxiway C at the time of the incident.

The reported weather at the time of the incident was 1,900 feet scattered, 4,500 feet scattered, 20,000 feet thin broken, and visibility 20 miles. A recent snowstorm had passed through the Minneapolis area and left 14 inches of wet snow on the airport. At the time of the incident, runway 29R and several taxiways were closed for snow removal. Runway 4 was being used for departures and runway 29L was being used for arrivals. NW51 had requested the use of runway 29L for takeoff because it was longer than runway 4. Braking action on runway 29L had been reported as "fair" and "fair-to-poor." Braking action on taxiway D had been reported as "nil."

NW65 had contacted the GC at 2050 and was instructed to taxi to runway 4 and to hold short of runway 29L. At 2102, NW65 was holding short of runway 29L on taxiway C, waiting to cross behind Northwest Airlines Flight 755 (NW755) and Republic Airlines Flight 79 (RC79). At 2102:23, the GC cleared NW51 to position and to hold, before takeoff, on runway 29L. The GC cleared NW755 and RC79 to cross runway 29L about 30 seconds before he cleared NW65 to cross the runway. The captain of NW65 delayed crossing an additional 30 seconds while waiting for a landing airplane, Northwest Airlines flight 815 (NW815), to clear the runway. The captain of NW65 did not advise the GC that he had delayed crossing.

At 2103:43, the LC transmitted to NW51, "NW51 heavy, runway 29L, there's traffic crossing downfield, fly the runway heading, cleared for takeoff." NW51 acknowledged the clearance and started its takeoff roll after NW755 and RC79 crossed the runway and about the time NW65 was starting to cross the runway.

The captain of NW65 said he started to cross runway 29L after ensuring that the landing airplane would not slide into his airplane because of the poor braking conditions. The captain said it appeared as he entered the runway that there was an airplane holding in position on runway 29L. The captain attempted to expedite the crossing when the second officer alerted him that the airplane was taking off and was heading straight at NW65.

Safety Board investigators interviewed the controllers and determined that there was incomplete or misunderstood verbal coordination between the GC and the LC involving the clearance of NW65 across runway 29L. The GC said he coordinated the crossing of NW755, RC79, and NW65 with the LC, but he could neither recall the phraseology he used nor whether he said the number of airplanes he wanted to cross.

Since the coordination was conducted face-to-face, the conversation was not recorded. The LC reported that he also did not remember the phraseology used, nor could he recall if the GC requested clearance to taxi a specific number of airplanes across. The LC said he thought that just two airplanes were cleared to cross, but he could not recall any reason why he believed that. The Board found no written procedure in any manual, document, or memorandum specifying a method of coordination between LCs and GCs at the tower. Both controllers said coordination procedures normally used at the tower included a statement by the GC of the runway to be used, the location of the aircraft with reference to a taxiway or intersection, and the number of aircraft to be crossed.

FAA Handbook 7110.65D requires coordination between the GC and LC before the GC can authorize any aircraft or vehicle to cross or use any portion of an active runway. The handbook states that this coordination may be accomplished verbally, by flight progress strips, by other written information, or by automated displays. As a minimum, controllers are required to provide aircraft identification and applicable runway/intersection/taxiway. The handbook is specific about procedures for transferring control of aircraft from one controller to another and for conducting controller position relief briefings. However, it does not specify procedures, standards, or responsibilities during verbal coordination between LCs and GCs regarding requests and subsequent approvals to cross an active runway. Each tower facility may establish local procedures describing how coordination between controllers shall be accomplished.

In this incident, the GC said he coordinated the crossing of runway 29L by NW65 when the airplane was third in line holding short of runway 29L. He said he thought he asked if the airplane could cross "behind the guy rolling out after landing," referring to NW815. The LC said he thought he approved the crossing while NW815 was rolling out after landing, but he thought he told the GC he was going to "roll a heavy" (NW51) as soon as NW815 cleared the runway. The LC said he watched NW815 closely and grew concerned that he might have to cancel the takeoff clearance of NW51 because of how slowly NW815 was exiting the runway. He said he thought that all airplanes he and the GC had coordinated to cross had cleared the runway. He said he did not know either the position of NW65 or that NW65 had been cleared to cross the runway until shortly before the near-collision. He said he first noted NW65 when NW51 was already 1,500 to 2,000 feet down the runway on takeoff roll, when the GC gestured and asked, "Are you rolling?" The GC said he yelled to the other controllers, but no warning transmissions were made to either airplane.

The GC had been employed as a controller in May 1982. He was assigned initially to the tower at Los Angeles International Airport and was transferred to Minneapolis in September 1984. The LC was assigned the combined duties of CC and CIC at the time of the incident. The assigned supervisor was not present in the tower at the time of the incident. He had been assigned additional duties elsewhere in the tower since another supervisor had been unable to get to the tower because of road conditions. Because the LC/CIC recently had been detailed as a supervisor, he was assigned the responsibility of cab supervisor in addition to his other assigned duties on the day of the incident.

Staffing at the tower the night of the incident was adequate to fill the required positions. However, two controllers, in addition to the absent supervisor, usually assigned to the shift were not present due to the road conditions. At the end of the previous tower crew shift, two controllers who had completed their shift volunteered to work 2 hours overtime to provide relief to the working controllers. The LC/CC/CIC was working the

local control position at 2030 when the two controllers were leaving and he decided to close the CC position and combine it with the local control position. He told the two controllers they could go home. At the time of the incident, two controllers who were qualified to work all positions in the tower were in the break room.

The LC described traffic from 1600 up to the time of the incident at 2104 as "steady, heavy and complex." The GC said he was "nearing the peak of what he could do." He said he could have asked for assistance, but the only person available in the cab at the time was a trainee. He said positions could have been rotated in the cab (so he could have taken a less demanding position), but the required position relief briefings would have required too much time for the high demands of the traffic. The LC/CC/CIC said that because he was extremely busy working the local control position, he was unaware that the GC felt he was nearing work overload.

Earlier in the day at the peak of the snowstorm, the airport was closed for snow removal. Thus, the peak traffic period, which usually occurred around 1730, about halfway through the tower crew shift, was delayed, and traffic was steady and heavy in the final hours of the controllers' shift. Because several taxiways still had not been cleared by the time of the incident, landing traffic was slow leaving the runways. Along with controller and supervisory duties, the LC/CC/CIC was responsible for requesting snow removal from taxiways. Airport snow removal personnel said they had not received any requests from the tower for additional snow removal from taxiways adjacent to runway 29L.

Safety Board investigators considered the possibility that the tower personnel were pressured to accept more aircraft than they could handle given the runway conditions. Investigators found that at 1430, the FAA's CFCF told the AS by telephone that traffic was backed up because of weather, and asked the AS how many aircraft he could accept for arrival. The AS answered that based on no departures, one runway, and the braking reports, he could accept 30 arrivals per hour with a 4-mile separation between the aircraft. The AS then discussed this arrival rate with the LC/CC/CIC. The LC/CC/CIC told the AS that he had runway 4 available in addition to runway 29L. The AS then decided to accept 30 arrivals per hour and to maintain departures. At the time this decision was made, visibility was 1/2 mile with constant snowfall.

The Safety Board concluded that the CFCF did not overtly pressure the tower to accept more traffic than it could safely handle. However, the Board believes that the AS and the LC/CIC/supervisor made poor decisions in (1) accepting the high volume of traffic in poor airport conditions, (2) not retaining controllers to help relieve the evening shift controllers during the heavy traffic period, (3) closing out the CC position during heavy traffic, (4) not reevaluating arrival rates and staffing requirements as traffic volume and complexity increased, and (5) failing to request that a critical taxiway be cleared of snow.

This incident demonstrated how coordination between the GC and LC are critical to crossing operations involving active runways. In this incident, it was obvious that the LC/CC/CIC was not able to assist other controllers or to act as an extra set of eyes to prevent incidents. As a result of its investigation, the Safety Board issued Safety Recommendations A-85-32 and -33 on April 19, 1985, which recommended that the FAA develop and implement specific procedures and standards for coordination between GCs and LCs regarding clearances to cross active runways.

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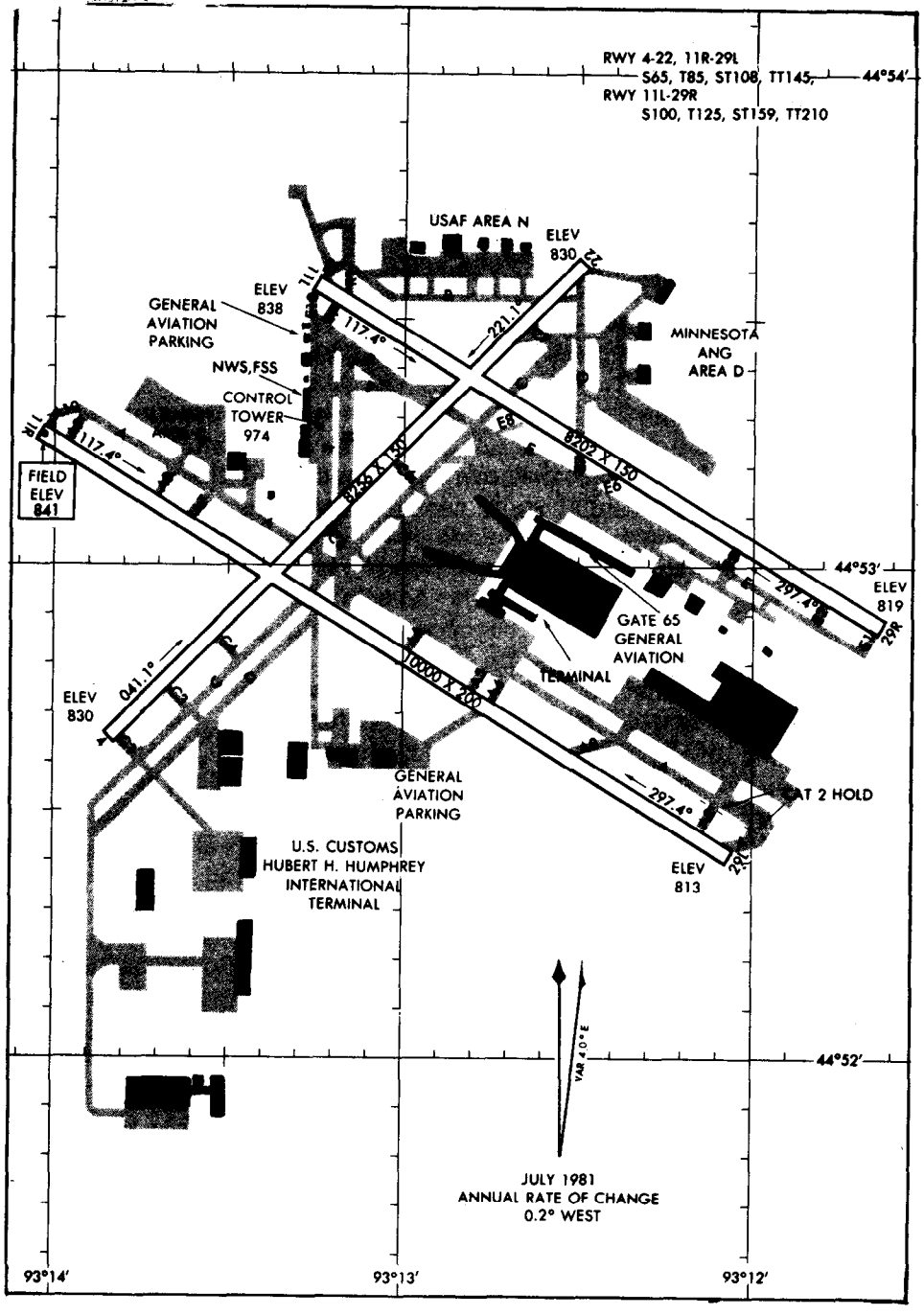
AIRPORT DIAGRAM

MINNEAPOLIS, MINNESOTA

MINNEAPOLIS-ST PAUL INTL (WOLD-CHAMBERLAIN FIELD) (MSP)



2. Minneapolis, Minnesota - 3/31/85

At 1216 (CST) on March 31, 1985, Eastern Airlines flight 799 (EA799), a McDonnell Douglas DC-9, rejected its takeoff due to the failure of the right (No. 2) engine on runway 29L at the Minneapolis-St. Paul International Airport, Minneapolis, Minnesota. The engine was determined to have lost power due to slush ingestion from the contaminated runway. EA799 was rolling out on runway 29L after the rejected takeoff when Republic Airlines flight 167 (RC167), also a DC-9, landed on runway 29L after being cleared to land by the LC. Both airplanes were on the runway at the same time, proceeding in the same direction and attempting to stop. At the time of the incident, neither airplane was aware of the other due, in part, to reduced visibility.

RC167 had reported to the LC at 1212:55 that the flight was approaching the locator outer marker. The LC cleared RC167 to land on runway 29L. The LC advised RC167 that an Eastern Airlines flight was departing from runway 29L before the arrival of RC167. After RC167 landed, the LC asked, "How are you doing?" RC167 responded that it would be turning off shortly. RC167 exited runway 29L via a taxiway about 3,000 feet from the end of runway 29L. The crew of RC167 said they did not see flight EA799 and were not aware that EA799 had rejected its takeoff.

Shortly before the incident, at 1214:24, the LC had instructed EA799 to taxi into position and hold on runway 29L behind a departing Lockheed Jetstar, N1CC. At 1214:50, the LC issued takeoff clearance to N1CC. At 1215:22, the LC issued takeoff clearance to EA799. EA799 initiated the takeoff, but at 1216:15 advised the LC that the flight was aborting the takeoff. EA799 rolled out to the end of runway 29L before exiting the runway.

At the time of the incident, day IMC prevailed with an indefinite 700-foot obscured ceiling and visibility 1/2 mile with snow and blowing snow. The RVR on runway 29L was reported as 4,000 feet. Winds were reported from 360 degrees at 16 knots with gusts to 24 knots. At the time of the incident, braking action on runway 29L reportedly was poor. The runway was contaminated with wet slush and snow. After the incident, runway 29L was closed by airport personnel for snow removal.

The LC said that when he cleared EA799 for takeoff, RC167 was on final approach about 2 miles from the runway threshold. He said EA799 was slow to start its takeoff because of the runway conditions. The LC said RC167 reported the airport in sight when the flight was about a mile from the runway. He advised RC167 at that time that an Eastern DC-9 was on takeoff roll. The LC said RC167 was committed to land at the time EA799 was anticipated to be airborne. He said that when EA799 advised that it was aborting, RC167 was touching down on the runway.

The LC said he did not feel that an operational error had occurred since EA799 aborted at a position on the runway where he expected the airplane to be airborne, because RC167 was committed to land, and because he considered that the separation between the airplanes was safe.

The LC was a developmental controller qualified through all tower positions. This incident was the third ground operational error the controller had been involved in during the previous 90 days. The FAA determined that in two of these incidents his actions were causal and in the other his actions were a contributing factor.

The AS said he was in the radar room and did not observe the incident, but when he was advised that an incident had occurred, he relieved the LC from the position to discuss the incident. The AS reported that FAA Handbook 7110.65D, Par. 3-122, required a minimum distance of 2 miles, with that distance increasing to 3 miles when takeoff clearance was issued. He said separation requirements were not met in the case of EA799 due, in part, to the contaminated runway and the subsequent engine failure/rejected takeoff of EA799. The AS recommended that the LC add an additional 1 to 2 miles separation between aircraft should he encounter this situation in the future.

The AS did not report the incident to facility management, nor did he record it in the appropriate facility log. Safety Board investigators learned of the incident on April 3, 1985, during their investigation of another runway incursion incident that occurred on March 31, 1985. The AS reported the first incident to the tower manager on the evening of April 3, 1985.

The captain of EA799 reported to the Safety Board that as his airplane was approaching V1 speed, the right engine experienced a compressor stall and began to lose power. The captain rejected the takeoff by retarding power on the left engine and placing that engine in reverse thrust. The captain said that only after he had the airplane under full control as a result of the rejected takeoff did he advise the tower that the flight was aborting the takeoff. He said braking action was poor and because of braking it was necessary to roll to the end of runway 29L before clearing the runway. The captain, unaware that RC167 landed while EA799 was still on the runway, did not see RC167 at any time.

The captain of RC167 said he recalled the tower telling him that there was another airplane on departure on runway 29L but he did not see the other airplane during his landing roll. The captain said he was not aware that EA799 had aborted its takeoff and was still on the runway when he landed. He did not hear EA799 state that it was aborting its takeoff. The reason he did not "hear" the radio call may have been due to selective listening involved with other combined duties and because the EA799 announcement occurred at about the time of the RC167 landing.

Many factors present in other incidents investigated by the Safety Board were present in this incident. The supervisor was not in the tower cab at the time of the incident. Even though the controller in the local control position had demonstrated deficiencies in controlling in the previous 90 days (as evidenced by the operational error involvement noted in his records), no supervisor was present to observe his performance. The Board believes the LC made a serious error in judgment by allowing RC167 to land so close to EA799's planned departure. Even if visibility had been better, this separation was less than the minimum allowed; the situation was also compounded by the poor visibility and contaminated runway conditions.

The Safety Board believes that the situation might have become obvious sooner if the captain of EA799 had notified the LC of his aborted takeoff earlier. However, the Board recognizes that communication with ATC must be secondary to dealing with an emergency and maintaining control of the aircraft. The LC's decision to allow RC167 to land with less than minimum separation was much more significant to this incident. An aborted takeoff was a factor the FAA considered in developing the minimum separation requirement for landing. The LC in this case did not plan for that possibility. The Board also believes that the facility supervisor was remiss in not being in the tower at the time of the incident, in the light of the bad weather conditions and the fact that a developmental controller, who had already demonstrated lack of proficiency, was controlling aircraft in poor visibility conditions.

(See airport diagram on page 50.)

3. Philadelphia, Pennsylvania - 5/8/85

At 1927 (EDT) on May 8, 1985, Lufthansa flight 403 (L403), a McDonnell Douglas DC-10, rejected its takeoff from runway 27R at Philadelphia International Airport, Philadelphia, Pennsylvania, when the crew saw Republic Airlines flight 211 (RC211), a McDonnell Douglas DC-9, crossing the runway. L403 had been cleared for takeoff from runway 27R. The GC had cleared RC211 and United Air Lines flight 355 (UA355) to taxi from the terminal to runway 27L and to cross runway 27R at taxiway R, about 4,400 feet from the approach end of runway 27R. UA355 crossed runway 27R ahead of RC211 without incident. RC211 was crossing the runway while L403 was on its takeoff roll. The crew of L403 saw RC211 crossing its path and rejected the takeoff. The LC did not advise L403 of the crossing traffic.

Safety Board investigators interviewed the controllers and determined that the GC coordinated the crossing of the two airplanes with the LC by requesting permission to "cross two" at the intersection of taxiway R and runway 27R. When the GC coordinated the runway crossing, he did not advise the LC that the second airplane, RC211, was some distance away and not immediately prepared to cross the runway. Neither did the GC advise the LC of the identity of the two airplanes he wanted to clear across runway 27R. Traffic was very light when the crossing coordination was accomplished. The traffic complexity and volume at the local control position increased from light to moderate shortly before the incident.

The LC said he forgot that he had approved the runway crossing by two airplanes. He had observed UA355 complete the crossing and did not realize that RC211, which was taxiing slowly, was the second of the two airplanes cleared to cross the runway. The Safety Board believes that the crossing coordination was accomplished prematurely, when RC211 was not prepared to cross runway 27R and that this was a significant factor in this incident. Had the GC continued to monitor the progress of RC211 until it was prepared to cross and then coordinated the crossing, the incident would not have occurred.

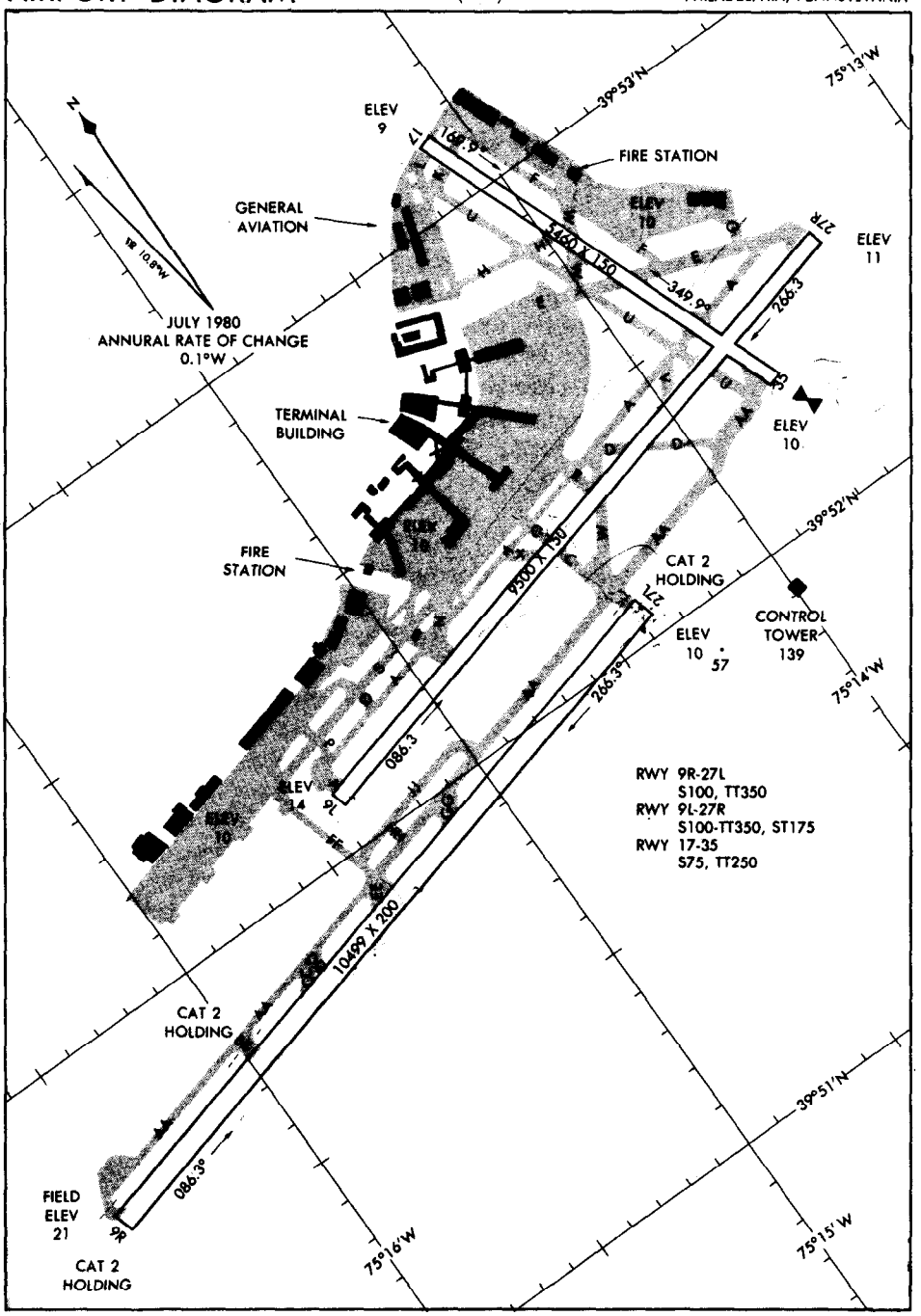
The GC advised RC211 that its departure would be delayed until 5 minutes after UA355 because of traffic separation requirements. This information may have affected the choice of a slow taxi speed by the captain of RC211. Other traffic separation requirements and wake turbulence considerations, involving arriving aircraft to runways 35 and 27R, may have influenced the LC's decision to expedite the departure of L403. These other responsibilities may have increased the LC's mental workload, which could have been a factor in his forgetting about the second crossing airplane.

The supervisor was not in the tower cab at the time of the incident. The CIC said he was in the rear of the cab and was not monitoring traffic because the traffic was light at the time of the incident. There were no apparent distractions and no equipment outages in the tower. The LC attributed his error to a "mental lapse." The LC considered himself proficient in tower operations, although he worked radar positions most of the time and recently had worked tower cab positions only about 4 hours per week.

AIRPORT DIAGRAM

AL-320 (FAA)

PHILADELPHIA INTERNATIONAL (PHL)
PHILADELPHIA, PENNSYLVANIA



4. Minneapolis, Minnesota - 6/12/85

At 2024 (CDT) on June 12, 1985, N86CC, a Lear 24, taxied across runway 29R at taxiway C at Minneapolis-St. Paul International Airport, Minneapolis, Minnesota, while Bemidji Airlines flight 306 (BMJ306), a Beech 80, was on its takeoff roll on the runway.

The GC had instructed N86CC to taxi to runway 22 and to hold short of runway 29R. As N86CC was approaching runway 29R on taxiway C, the LC advised the GC to "cross the Lear." At 2023:22, the GC instructed N86CC to "cross runway 29R, no delay, traffic 1 mile final." The pilot of N86CC acknowledged, "We'll expedite," and rolled onto runway 29R at the intersection with taxiway C. The traffic to which the GC was referring was a DC-9 he had observed on final approach on the BRITE display. The GC was not aware that the LC had cleared BMJ306 for takeoff on runway 29R at 2022:53.

At 2022:40, the LC had instructed BMJ306 to taxi into position and hold on runway 29R and to be prepared for an immediate takeoff. At 2022:53, the LC issued takeoff clearance to BMJ306. At the time this takeoff clearance was issued, a Republic Airlines DC-9 was on a 1-mile final approach for landing on runway 29R. BMJ306 started its takeoff, became airborne, and overflew N86CC at an estimated altitude of 200 feet.

Before the incident, the tower had been using runways 29L and 29R for both arriving and departing traffic. At the time of the incident, tower personnel were in the process of changing the configuration to use runway 22 for departure traffic and runways 29L and 29R for arrival traffic. N86CC was to be the first departure from runway 22 after the change.

At the time of the incident, day VMC prevailed with high scattered clouds and visibility 15 miles. Official sunset was at 2059. Based on these facts and the location of the airplane relative to the tower, the Safety Board determined that visibility from the tower cab was not a factor in this incident.

At the time of the incident, the tower personnel consisted of a FD/CD controller, a GC, an LC, and a CC. The AS, who had 26 years of experience as a controller, was working the local control position. The GC was a developmental controller at the tower and was certified on FD/CD, ground control, and TRACON data. He previously had been an FPL controller at the South Bend, Indiana tower. The CC had been qualified as an FPL controller for about 6 months before the incident. The LC, CC, and GC all had multiengine and instrument pilot ratings.

Safety Board investigators interviewed the controllers and determined that the GC had not asked the LC for permission to cross N86CC. The LC told the GC to cross N86CC because he was concerned with the arriving DC-9. The GC said that when the LC said "cross the Lear" he knew that meant without delay. The GC was also concerned with the DC-9 arrival. He said his concern was magnified because he could detect urgency in the LC's voice. Although the GC admitted reading a GENOT issued by the FAA 3 weeks before this incident that warned controllers to scan all runways, 1/ he could not recall scanning runway 29R to verify that there was not additional traffic on the runway when he received clearance from the LC to cross N86CC. His failure probably was due, in part,

1/ On June 6, 1985, an addition to FAA Handbook 7110.65D, paragraph 3-12, became effective, requiring local control to visually scan runways and ground control to assist to the extent possible. A GENOT regarding causative factors on runway transgressions emphasizing accountability and mental alertness was issued on April 29, 1985.

to his effort to expedite the crossing of N86CC in response to the LC. The GC said he first noticed BMJ306 after it was airborne and silhouetted against the sky at about 200 feet above the runway surface. The GC said he became convinced after the incident of the importance of scanning the runway before clearing an aircraft to cross rather than relying solely on an approval to cross announced by the LC.

The LC said distractions relating to the workload and the expedition of traffic were not the only reasons that he forgot that he had previously issued a clearance to the GC to have traffic cross runway 29R when he cleared BMJ306 for takeoff. The LC said he had developed a personal technique of "dropping" the flight progress strip (holder) "down the tube," which would deposit it at the appropriate departure control position as soon as he issued takeoff clearance, but before the actual departure of an aircraft. The LC suggested that this was a "bad [personal] procedure" because as long as he retained the flight progress strip, it offered a reminder that he was still responsible for the flight. Passing the strip "down the tube" made it easier for the LC to forget the flight.

The CC said he saw his role as "an extra set of eyes in the tower." When asked what percentage of the time the CC could be called "an extra set of eyes," he answered that it depended on the specific demands at the time. He said that on some days, he could devote 80 to 90 percent of his time to scanning; however, on other days, telephone calls and other duties prevented him from looking out the windows or monitoring controller communications. He characterized the amount of time that he was scanning around the time of the incident as 80 percent. He said he knew BMJ306 was cleared for takeoff, heard the LC tell the GC to cross N86CC, and saw BMJ306 airborne. He said he had warned the GC, "Don't forget about the Bemidji," but that he guessed the GC did not hear him. He did not repeat his concerns to the GC. It was not determined whether the GC heard the CC's warning. However, since the crossing of N86CC was expedited, there was insufficient time to make a second announcement if the first was not heard.

(See airport diagram on page 50.)

5. Birmingham, Alabama - 6/20/85

At 2101 (CDT) on June 20, 1985, Dixie 06, a McDonnell Douglas RF-4C, operated by the Alabama Air National Guard, collided with Airborne Express flight 74 (ABX74), a Smithair, Inc., Beech E-18S, on runway 5 adjacent to taxiway B at Birmingham Municipal Airport, Birmingham, Alabama. The collision occurred as Dixie 06 was on landing roll and ABX74 was holding on the runway awaiting takeoff clearance. Both airplanes were destroyed by impact forces and postcrash fires. The pilot of ABX74, the only occupant aboard the airplane, was fatally injured. The two crewmembers aboard Dixie 06 received minor injuries.

Dixie 06 had departed the airport at 1934 on an IFR flight plan for a local training flight. ABX74 was preparing for a commercial cargo flight to Atlanta, Georgia. About 2045, Dixie 06 contacted Birmingham Approach Control and obtained clearance to make a low approach to be followed by a full-stop landing on runway 5. About 2053, Dixie 06 was making the ILS approach and had advised the LC that it was 4 miles out on final and would be making a low approach. At 2054:19, ABX74 reported to the LC that it was ready at the intersection and the LC cleared the airplane to ". . . taxi position and hold five." There were no further communications with ABX74 in the 5 minutes 41 seconds before the collision. ABX74 taxied into position to take off on runway 5. ABX74 was awaiting takeoff instructions when the airplanes collided.

At 2056:30, Dixie 06 was cleared for a visual approach to runway 5. At 2059:40, Dixie 06 advised the LC that it was on a 4-mile final with the gear down for a full stop. The LC said, "Dixie 06 cleared to land hold short of runway three six on your rollout if possible." The pilot said, "zero six wilco." At 2101:00, Dixie 06 transmitted, "On fire zero six is on fire." The LC said, "Say again aircraft calling" and Dixie 06 replied, "Six is on fire." There were no further communications with the airplane.

The pilot of Dixie 06 said that a few seconds before the collision he realized that the strange light pattern that he had seen on the runway during the landing roll was that of another airplane. He attempted to make an evasive maneuver to the left to avoid a collision. He estimated that his rollout speed with the drag chute deployed was 120 to 130 knots.

The control tower is about 1,000 feet to the east of runway 5 and about 7,000 feet from the approach end of the runway. It is 4,400 feet east of the intersection of the runway and taxiway B and is 68 feet in height. The high-intensity runway lights were set at step III and the centerline and touchdown lights were set at step I. Runway 36, which intersects the departure end of runway 5, was also in use at the time of the accident.

The LC on duty at the time said she was busier than normal for a night operation. She was standing while she was working traffic and was generally facing north through east toward runway 36 and away from the traffic landing and taking off from runway 5. She had to turn to the left about 90 degrees in order to have full view of runway 5. She was working nine aircraft at the time of the accident--three in a left-hand traffic pattern making touch and go's on runway 36, three inbound for runway 36, one transiting helicopter, and the accident airplanes on runway 5.

The LC said she did not recall clearing ABX74 into position on the runway. Her only recollection of the airplane was when the GC told her that it was taxiing to runway 5 and that he did not know the pilot's intentions. She said she did not have a strip on the airplane, but was keeping track of airplanes for which she did not have strips by using a scratch pad. The scratch pad showed that she had placed a star symbol by ABX74 and had drawn a line through the call sign. She said the star meant that the airplane was not requesting stage III service. She said she did not remember drawing the line through the call sign, but that it meant that she was no longer controlling the airplane—that it had taken off and had switched radio frequencies. She said she usually scans the runway for other aircraft or ground vehicles before clearing an airplane to land, but did not remember doing this before clearing Dixie 06 to land.

At the time of the accident, the tower was staffed by a developmental controller assigned to the local control position, an FPL controller assigned to the ground control position, and an ATA assigned to the combined positions of FD/CD. The assigned supervisor was absent from the tower cab, conducting an investigation into an operational error that had occurred earlier. The LC said the supervisor had been in the cab before her earlier supper break. The GC said two supervisors were on duty that evening. He said a supervisor usually does not remain in the cab for an entire shift. However, no one was appointed to be in charge when the supervisor left the cab before the incident.

The LC joined the FAA as an ATC specialist at the tower on December 26, 1982. She was a radar developmental controller and was certified on all positions within the tower. The LC received all of her training by OJT on the various operating positions in the facility. The majority of that training had been received under daylight conditions. Her recent OTS evaluation was conducted on the local control position on March 31, 1985. The results showed, "Traffic volume routine, not difficult. No deficiencies were noted." She received two runway incursion briefings, one on May 22, 1984, with reference to FAA notice N7110.897 and one on May 28, 1985, with reference to GENOT 5/58. She received a current medical examination on February 5, 1985, and had no limitations or waivers.

The Safety Board believes that the LC did not know where ABX74 was because she became preoccupied with controlling other traffic, which directed her attention away from runway 5, during a traffic period that exceeded her capabilities. The LC could have acted to prevent the accident by either calling the radar room and requesting additional personnel for duty in the tower or advising the radar room to cease practice approaches to the airport and/or holding their arrival traffic to reduce the local control workload. Additionally, the GC, an FPL with more experience than the LC, could have detected that the LC was at or exceeding her capabilities and should have offered assistance to reduce the LC's workload. Furthermore, the Board believes that the supervisor could have prevented the accident had he been monitoring the overall traffic situation from the cab. Since he had to leave the cab, he should have assigned a CIC to supervise the tower cab in his absence. In addition, the Board noted that the LC did not use the correct terminology when she issued the landing clearance to Dixie 06. She failed to specify the landing runway in her clearance. Mentioning the runway might have alerted the pilot of ABX74. Also, her instruction to ABX74 to ". . . taxi into position and hold five" might have indicated to the pilot to expect to hold on the runway for 5 minutes before getting takeoff clearance.

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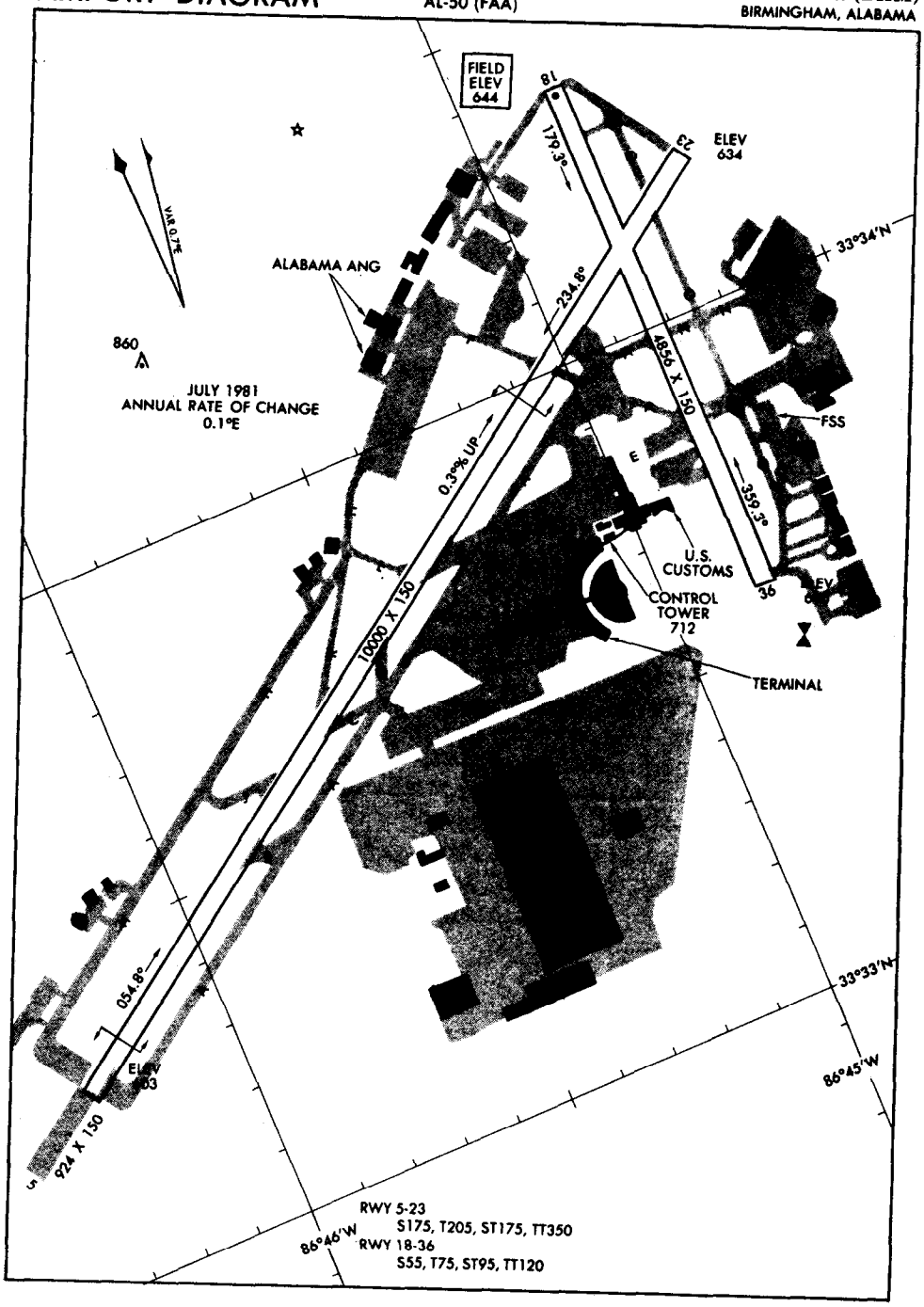
AIRPORT DIAGRAM

AL-50 (FAA)

BIRMINGHAM MUNICIPAL AIRPORT (BHM)

BIRMINGHAM, ALABAMA



6. Austin, Texas - 6/26/85

At 1219 (CDT) on June 26, 1985, at Austin Municipal Airport, Austin, Texas, Southwest Airlines flight 769 (SW769), a Boeing 737, which had made a visual approach to runway 13R, crossed 50 feet in front of N33354, a Piper Cherokee, which had made a VOR approach to runway 17 while passing through the intersection of runways 17 and 13R. Both airplanes had been handed off to the LC, who cleared each airplane to land on their respective runways. As a result, N33354 was rolling out shortly after touchdown on runway 17 when SW769 was landing on runway 13R. The intersection of the runways is 900 feet south of the approach end of runway 17 and 1,200 feet from the approach end of runway 13R.

At the time of the incident, VMC prevailed. The weather observation was: clouds 5,000 scattered, 25,000 scattered, visibility 20 miles, temperature 89° F, dew point 70, wind from 130 degrees at 5 knots, altimeter 29.88 inches.

The local control and CC positions were combined. The local control position was staffed by an AS who had relieved another controller 17 minutes earlier for a lunch break; thus, the AS was working an active position. The LC was an FPL controller. His last OTS check in the tower cab was in October 1984, 8 months before the incident. He received a radar OTS check about 1 hour before the incident. He said he worked "traffic" about 15 percent of the time in the month before the incident; the remaining 85 percent of his time was spent with supervisory duties.

Before SW769 was switched to local control, the crew was advised by approach control that their traffic was a Cherokee on 2-mile final. The crew of SW769 acknowledged the information with a "Roger," but did not acknowledge seeing N33354. The LC cleared N33354 to land at 1716:07. He cleared SW769 to land at 1717:13. The LC said he considered another airplane, Southwest flight 235 (SW235) which was departing from runway 13R, to be SW769's traffic. He planned the approach of SW769 based on the expected departure of SW235, but did not consider that N33354 was also traffic pertinent to the arrival of SW769. Although the LC had cleared N33354 to land on runway 17, he did not make a mental note of the position of N33354 while it was on final approach. He first became aware of the conflict between SW769 and N33354 at the time of the incident when the GC brought the matter to his attention.

The LC acknowledged that moments before he had observed SW769 on the BRITE display on a 7-mile final. He recalled noting that the N33354 data tag indicated that N33354 would land on runway 17. He did not recall monitoring the progress of N33354 visually or on the BRITE display as it approached runway 17. He said he concentrated his efforts on coordinating the arrivals and departures of the other aircraft that were on the local control frequency. He had forgotten about the N33354 landing on runway 17 even though he had cleared it to land a minute before.

Coordination between controllers was not involved in this accident, nor was there any requirement for coordination between the tower cab controllers. Both airplanes were the responsibility of the LC, who had forgotten about N33354, which he cleared to land on runway 17. The LC said no distractions or equipment malfunctions affected his ability to effectively monitor his traffic. There was no apparent controller fatigue factor. At the time of the incident, the LC was working only three aircraft, two arrivals to runway 13R and one arrival to runway 17. Because the supervisor was working the LC position, there was no supervisor or CIC to oversee the LC's actions or to assist with coordination in the tower. The other tower positions staffed at the time of the incident were FD and ground

control and a developmental controller receiving OJT on ground control. The LC acknowledged his error and suggested that his technique was flawed. He said he would modify his technique to be more cautious in the future and to double-check the location of landing aircraft before issuing landing clearances.

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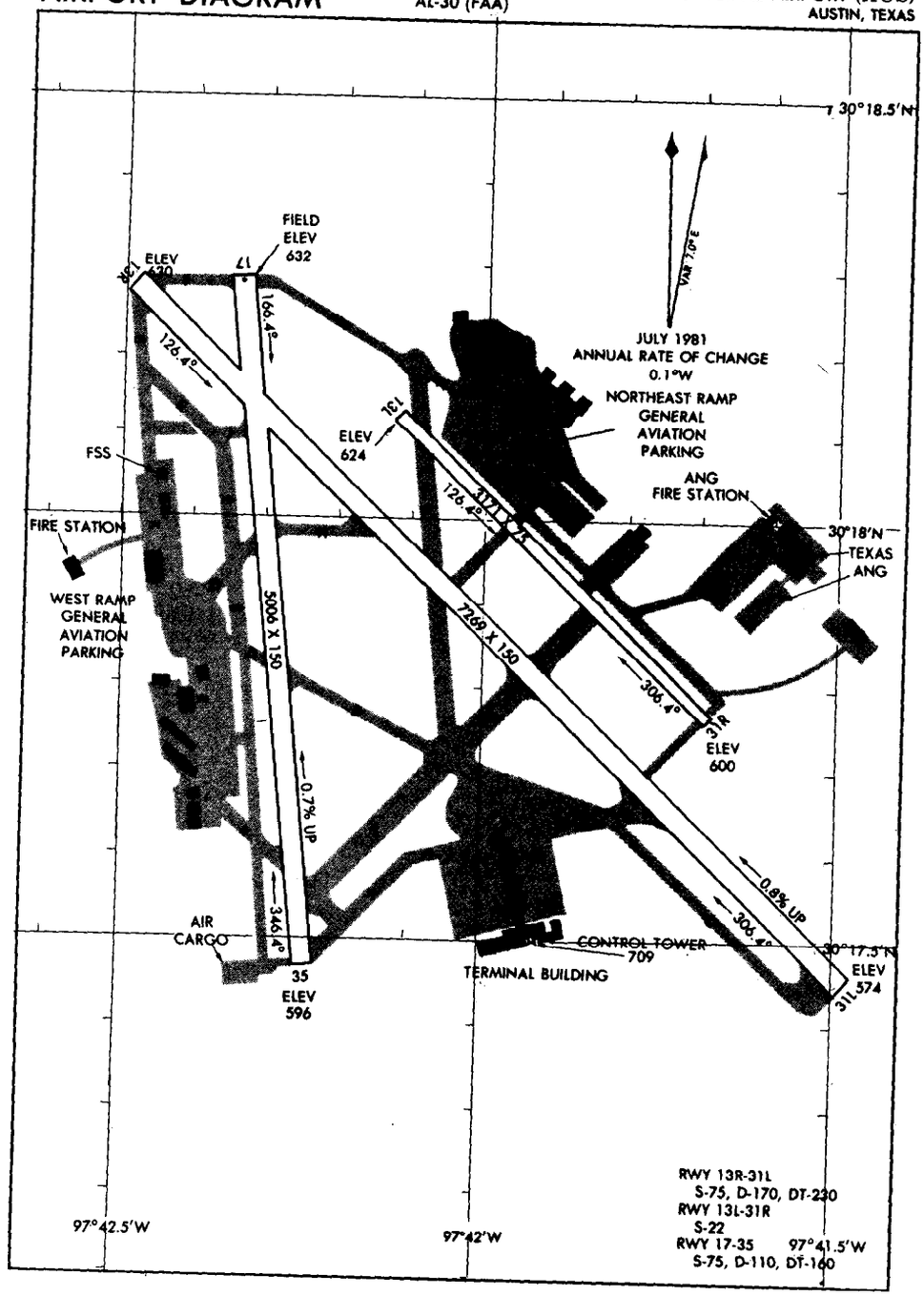
AIRPORT DIAGRAM

AUSTIN/ROBERT MUELLER MUNICIPAL AIRPORT (AUS)
AL-30 (FAA)
AUSTIN, TEXAS



7. Chicago, Illinois - 7/3/85

About 1920 (CDT) on July 3, 1985, Midway Express flight 512 (QH512), a Boeing 737, taxied across the departure end of runway 13R at Midway Airport, Chicago, Illinois, as Midway Airlines flight 379 (MD379), a McDonnell Douglas DC-9, was taking off from the same runway. MD379 overflew QH512 by approximately 200 feet.

At the time of the incident, the current ATIS was reporting that runways 4L and 4R were in use. However, the control tower was permitting occasional operations on runway 13R. There is no requirement to include all of the active runways on the ATIS.

Communications between the GC and both airplanes began when the airplanes were at their gates on the east side of the airport. When MD379 contacted ground control for taxi instructions, it requested runway 13 for departure because of takeoff weight. MD379 was cleared to back-taxi on runway 13L to runway 13R and was later cleared for takeoff. The flightcrew of MD379 reportedly did not observe QH512 on the runway until they were at 110 KIAS, 18 knots below V1. They said a normal rotation for liftoff was made and they cleared QH512 without difficulty.

QH512 had been cleared to taxi via the east ramp to the south ramp to runway 4R, the primary departure runway. The east ramp runs along the east perimeter of the airport meeting the south ramp at its intersection with the departure threshold of runway 13R. During their taxi, the flightcrew of QH512 was following three other transport airplanes proceeding to runway 4R. QH512 was not told that runway 13R was active. QH512 was not told to hold short of runway 13R even though the runway intersected the flight's route to runway 4R. QH512's first officer noticed MD379 departing as QH512 was crossing runway 13R.

The GC properly coordinated MD379's request to use runway 13R with the LC. However, the GC forgot to instruct QH512 to hold short of runway 13R after issuing that instruction to other taxiing airplanes ahead of QH512. He said the instruction to hold short of active runways was a normal procedure. He said he did not recall seeing MD379 taxi into position on runway 13R. He said he forgot about QH512 until the crew of that airplane called after the incident. The LC, having observed that the other airplanes held short of the runway, said he assumed that QH512 would do the same. QH512 would have been out of his field of vision at the time it taxied from the terminal and followed the approved taxi route. Without further coordination, the LC issued a takeoff clearance to MD379 assuming that QH512 would not cross runway 13R.

Just before the incident, the LC was responsible for one airplane on final approach south of the airport and one airplane landing on runway 4R. When he cleared MD379 into position on runway 13R, he would have been looking directly at the airplane if he were facing forward (looking west) in the cab toward the center of the airport. The GC was working four airplanes. If he were facing forward in the cab, traffic on runways 4R, 4L, 13R, and on the north-south taxiway would have been near the center of his field of view. QH512 would have been out of the GC's field of view while it was taxiing south on the east ramp, unless he were actively scanning that area.

At the time of the incident, the control tower was staffed with an LC, a GC, a radar coordinator, and a FD/CD controller. The LC had qualified as an FPL controller 13 months before the incident. The GC was also qualified as an FPL controller. The supervisor was not in the tower cab at time of the incident. He was performing a

supervisory task routinely conducted during periods of relatively light traffic. In his absence, the radar coordinator was designated CIC, responsible for overseeing the tower cab operation. The radar coordinator was required to sit in front of the BRITE display to perform his assigned duties. Because his radar duties did not allow him the opportunity to monitor other positions of operation, he could not see the area where the incident occurred and was not immediately aware of the incident.

The controllers described their workload as light to moderate, and acceptable for the staffing level provided in the cab at the time of the incident. There were no apparent difficulties with communication equipment. The weather was VMC with no restrictions to visibility. Although the sun was setting on the horizon, it posed no problem according to the controllers.

In this incident, the GC forgot about an aircraft he was controlling. Two operational procedures, had they been implemented and followed, might have compensated for the controller's memory limitations, and might have prevented the incident. If the GC had scanned the entire area of his control, which included the east and south ramps, he would have been aware, during his scan, of QH512 taxiing toward and across runway 13R's departure threshold. Additionally, if standardized hold-short procedures had been in effect for all aircraft crossing active runways, a redundancy would have been established in which the pilot would have the responsibility to hold short, even without a specific ATC instruction.

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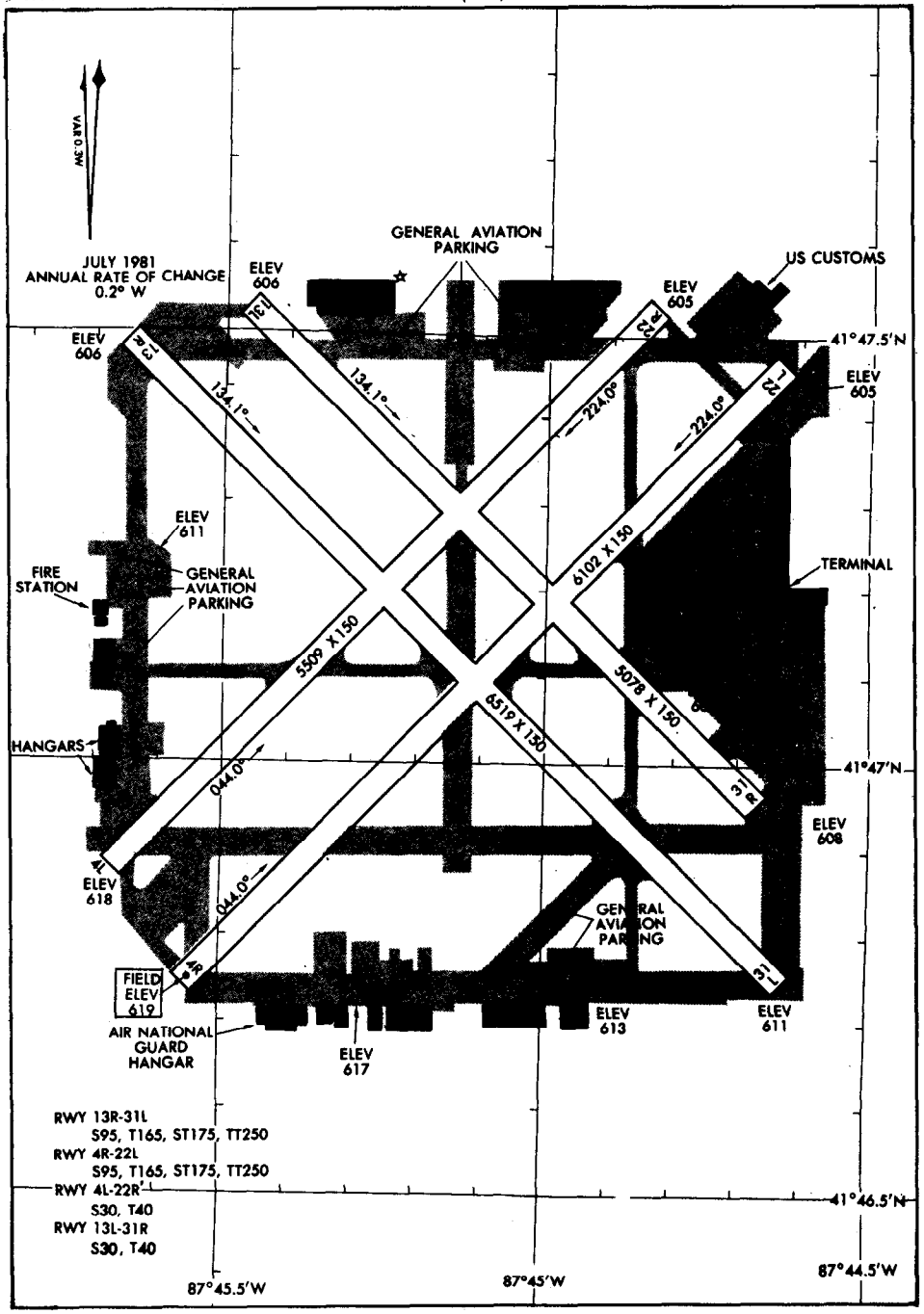
AIRPORT DIAGRAM

AL-81 (FAA)

CHICAGO MIDWAY AIRPORT (MDW)
CHICAGO, ILLINOIS



8. Boston, Massachusetts - 7/4/85

At 0827 (EDT) on July 4, 1985, Delta Air Lines flight 562 (DL562), a Boeing 727 that had landed on runway 33L and was taxiing to the terminal on taxiway Q, entered runway 4L at taxiway Q while Provincetown-Boston Airlines flight 756 (PBA756), a Cessna 402, was taking off from the runway at Boston Logan International Airport, Boston, Massachusetts. The captain of PBA756 took action to avert a collision by rotating to a takeoff attitude at a speed about 8 knots below his programmed liftoff speed. PBA756 overflew DL562 by about 75 feet as DL562 rolled 10 to 15 feet into runway 4L before stopping. The captain of DL562 abruptly stopped his airplane when he saw PBA562 as he entered the intersection.

The LC and GC reported that DL562, on landing roll, appeared to be rolling slowly when the LC instructed DL562, to make a "half left turn at taxiway Quebec, hold short of four left inbound, stay with me." Analysis of the taped conversation revealed that DL562 responded with "okay," a nonstandard, abbreviated reply. Having received that acknowledgment, the LC cleared PBA756 to take off from runway 4L at its intersection with taxiway C. The captain of PBA756 said he heard the acknowledgment of DL562, but monitored the progress of DL562 during the takeoff roll of PBA756. The captain of PBA756 said that as DL562 approached taxiway Q, it became apparent that DL562 might not stop. The captain of PBA756 then rotated his airplane to a takeoff attitude, while above stall speed but below his normal rotation speed, to avoid a collision.

Afterward, the crew of DL562 reported that they did not hear the tower transmission to "hold short" of runway 4L, although they understood that they were to depart runway 33L at taxiway Q and remain on tower frequency. Before turning off the runway, the captain had taken control of the airplane. The first officer handled radio transmissions and conducted the after-landing checklist. After the incident, when DL562 was cleared to cross runway 4L, the first officer responded with "kay." Analysis of this transmission, compared to others on the tape, and the transmission spikes on the flight data recorder foil confirmed that DL562 made this reply. It appeared that the same crewmember who had replied "okay" to the LC during DL562's landing roll made both nonstandard, abbreviated radio calls.

The Safety Board believes that both transmissions from DL562 were intended to be acknowledgments of ATC instructions. The response of "okay" by DL562 following the clearance to taxi via taxiway Q and to hold short of runway 4L provided the LC with assurance that DL562 understood and would comply with the clearance. The assumption by the controller was understandable under the circumstances, but was improper, both on the part of the controller to accept such a reply and on the part of the crew of DL562 to make such a nonstandard reply.

The clearance for DL562 to "hold short" was given when DL562 was on its landing roll. Issuing such a clearance while an airplane is rolling out is considered a poor practice, unless given after the airplane has slowed considerably, because of high cockpit workload and the critical need for crew coordination during touchdown and braking. In this incident DL562 reportedly was provided taxi instructions after it had slowed considerably to approximately taxi speed. Under those circumstances, the Safety Board believes that the crew should have been able to respond properly and to comply with the clearance. In this case, however, it appears that the crew missed part of the clearance, but acknowledged it without asking for a clarification. A pilot is responsible for obtaining clarification of any misunderstood clearance.

The captain of DL562 said that as he approached runway 4L on taxiway Q, he was decelerating but still above taxi speed. He had not been advised that runway 4L was active, but understood that he was to stay in contact with the LC. Under the circumstances, the Safety Board believes the captain maintained too high a speed after entering taxiway Q and should have exercised greater caution as he approached runway 4L, which he did not know to be inactive.

Weather was not considered a factor in this incident. The official weather observation was, in part, broken clouds at 2,000 feet and visibility 15 miles.

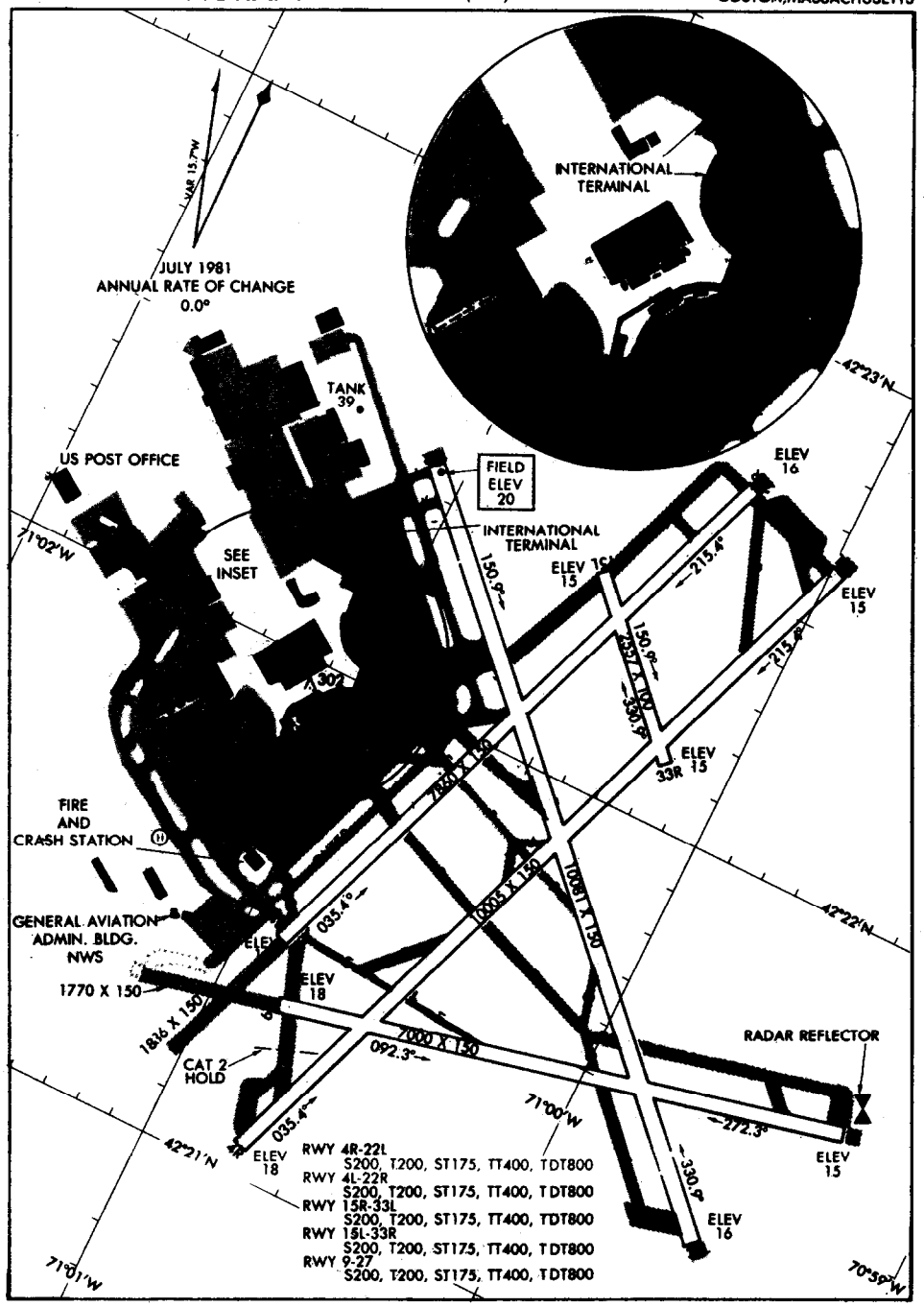
DL562 had 6,100 feet of runway available for its landing roll before reaching taxiway Q. Taxiway Q was 700 feet long between runways 33L and 4L. The captain of PBA756 had 1,500 feet of runway 4L available from the point from which he started his takeoff roll to the intersection with taxiway Q.

The LC, who was working the combined positions LC1 and LC2, said he did not think DL562's speed on landing roll was a factor. He said he would have allowed DL562 to cross runway 4L before clearing PBA756 for takeoff if he thought speed was a problem. He said it appeared that DL562 had slowed to taxi speed before he gave the clearance for DL562 to taxi via taxiway Q. The area supervisor, who was working the ground control position, also did not think that DL562's speed was a factor. However, he monitored DL562's progress and alerted the LC when it looked like DL562 might not stop short of runway 4L.

Although this incident is a pilot deviation, there are operational factors related to ATC that may have contributed to the incident. As in other incidents investigated by the Safety Board, the supervisor was working an active position. In this instance, the supervisor said he alerted the LC when it looked like DL562 might not stop; if he had been overseeing the LC, rather than working a position himself, he might have been more effective in warning and preventing the LC from continuing with the PBA756 takeoff. Additionally, the controllers ignored improper communication procedures, allowing the DL562 crew to answer "Okay," without requesting identification of the airplane making the transmission or full acknowledgment of the instruction to hold short of runway 4L. The DL562 crew's use of nonstandard radio phraseology probably contributed to this incident.

AIRPORT DIAGRAM

BOSTON/GENERAL EDWARD LAWRENCE LOGAN INTL(BOS)
AL-58 (FAA)
BOSTON,MASSACHUSETTS



9. West Palm Beach, Florida - 7/5/85

At 0950 (EDT) on July 5, 1985, Gull Air flight 950 (GA950), a Cessna 402C, and N163A, a Gates Learjet 35A, almost collided as they were taking off simultaneously from intersecting runways at Palm Beach International Airport, West Palm Beach, Florida. The LC earlier had cleared both airplanes to "position and hold." Both airplanes began their takeoff roll when N163A was cleared for takeoff. An urgent communication from the LC and immediate evasive action by the pilots of both airplanes prevented the collision, reportedly by less than 10 feet.

At the time of the incident, day VMC prevailed. The clouds were broken at 2,500 feet and visibility was 10 miles.

The pilot of GA950 said he had asked for an intersection takeoff to expedite his departure. The GC and LC did not say they would expedite his departure, but the pilot perceived that they were attempting to do so. He indicated that this may have influenced his later actions. The pilot of GA950 was monitoring a company radio frequency as well as his assigned frequency while taxiing to the runway. He thought he recalled "chatter" on the company frequency while taxiing but did not think this distracted him.

N163A was cleared to runway 9L for takeoff and GA950 was cleared to runway 13. N163A was cleared to "position and hold" on runway 9L at 0949:18. Thirty seconds later, GA950 was cleared to "position and hold" for an intersection departure from runway 13, at taxiway A. The LC did not issue traffic information to GA950 as required by FAA Handbook 7110.65D to explain why the takeoff clearance could not be issued. At 0949:49, N163A was cleared for takeoff and the pilot read back the takeoff clearance. The pilot of GA950 was not provided any further instructions, but he thought the takeoff clearance he heard on the radio was for him and he started a takeoff roll; he did not acknowledge the clearance. At 0950:20, the LC recognized that a potential collision was imminent and radioed GA950 to "descend now." The pilot of GA950 responded immediately. The pilot of N163A who had observed GA950 at about the same time added power, retracted landing gear, and rotated abruptly to an abnormally steep climb to avoid GA950. N163A was approaching a stall and the right wing reportedly dropped during the maneuver, narrowly missing GA950. Both pilots acknowledged that their evasive maneuvers were necessary to prevent a collision.

In addition to the potential distractions of the company radio chatter cited previously, the description by the pilot of GA950 of his takeoff procedure indicates that he was scanning his instruments and not looking outside, except to refer to the runway centerline, until after he rotated to a takeoff attitude. The pilot did not see N163A approaching until after the tower called him and he responded with forward control forces. He was operating GA950 without the assistance of another pilot.

The pilots of both airplanes held airline transport pilot certificates. The pilot of N163A had about 5,000 hours' flying experience, including 1,500 hours as pilot-in-command in Learjets. The pilot of GA950 had about 6,435 hours flying experience.

The local control position was staffed by a developmental controller, who had been a controller for 3 years. He had been assigned the local control position at the start of his shift, 1 hour 50 minutes before the incident. The ground control position was staffed by a supervisor who had been working the position for 1 hour 50 minutes, since the start of his shift. There were no reported equipment problems or tower distractions involved in this incident.

The incident might have been prevented if the pilot of GA950 had acknowledged the takeoff clearance he thought was intended for his airplane. If the pilot of GA950 had acknowledged the clearance, it might have alerted the LC who could have taken action to reclear GA950 to continue holding in the takeoff position. Also, the incident might have been prevented if the LC had advised GA950 of N163A when clearing GA950 to position and hold. This traffic advisory might have alerted the pilot to the fact that another airplane was also in position to take off from runway 9L.

The Safety Board also believes that the practice of positioning aircraft for takeoff simultaneously on intersecting runways is conducive to errors such as the one illustrated by this incident. The Board is concerned that the continued use of the procedure may result in other runway incursions, when this type of incident could be avoided by delaying the positioning of the second aircraft until the first aircraft has been cleared for takeoff and has started its takeoff roll.

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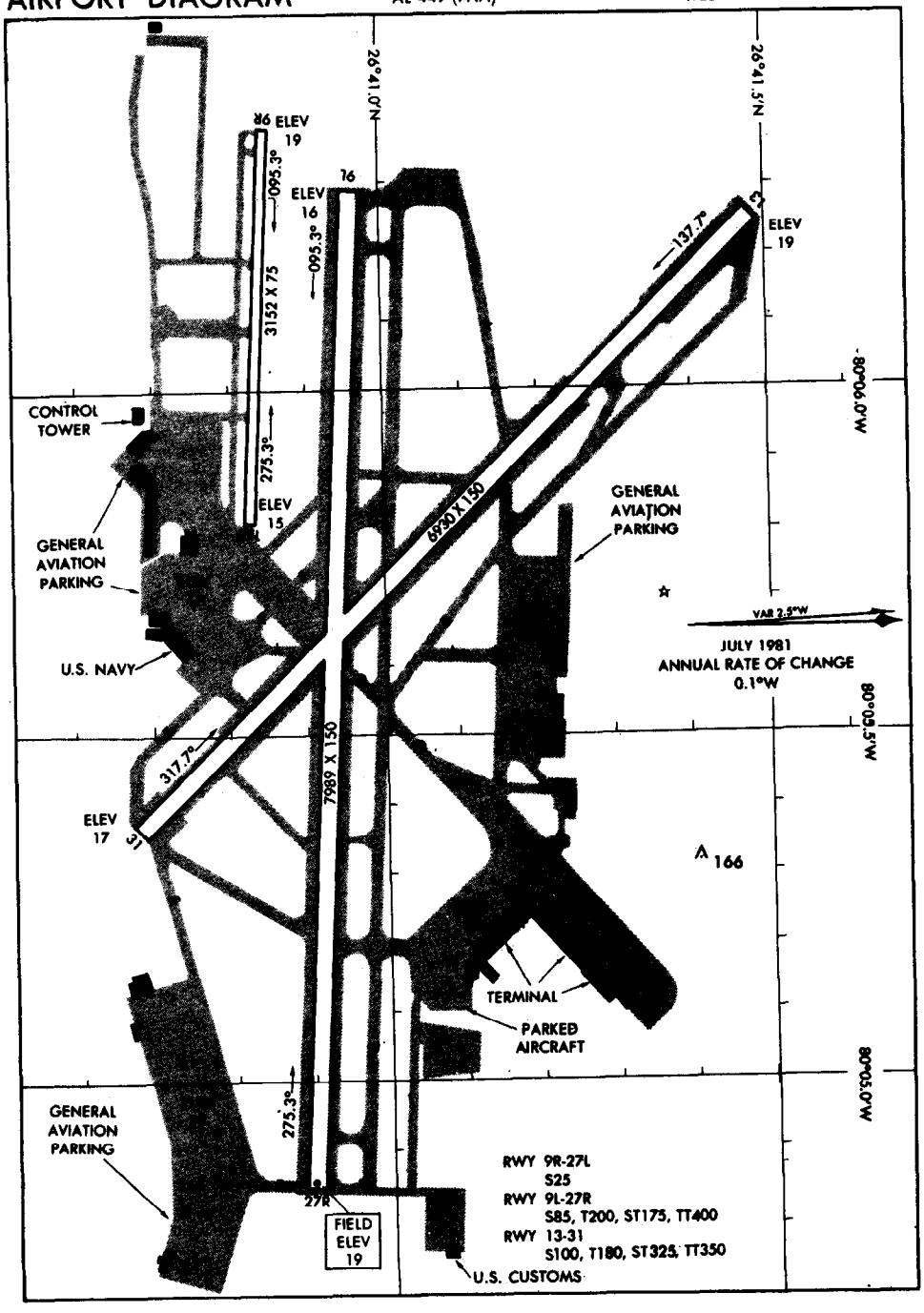
AIRPORT DIAGRAM

WEST PALM BEACH/PALM BEACH INTERNATIONAL (PBI)
AL-449 (FAA)
WEST PALM BEACH, FLORIDA



10. White Plains, New York

Between May 21 and August 5, 1985, 16 runway incursion incidents were reported at the Westchester County Airport, White Plains, New York. The Safety Board investigated five of these incidents that occurred between July 17 and July 20, 1985, and found that they were precipitated by a number of factors, including the lack of signs and markings. Some taxiway markings were deficient and there were few taxiway/runway signs. During the investigation, airport management expressed a willingness to improve the signs and markings on the airport to reduce the number of runway incursion incidents. Through the cooperation of the FAA and the Westchester County Department of Public Works, 16 unlighted, but reflective, signs were installed on the airport during the week of August 5, 1985, at unmarked intersections. The signs complied with size and color guidelines established by the FAA but were not lighted. The signs were manufactured by the Westchester County Department of Public Works and installed by airport maintenenance personnel for about $185 per unit installed.

After the signs were installed, only five runway incursion incidents were reported through March 1986. Locally-based pilots commented favorably about the new signs. Although the absence of signs was not considered a causal factor in the five incidents investigated by the Safety Board, the Board believes that the new signs have been significant in improving pilot orientation and reducing runway incursions at the airport.

The following are summaries of the five incidents investigated by the Safety Board:

7/17/85.--About 1618 (EDT) on July 17, 1985, N8302T, a Piper PA-28, contacted ground control and requested taxi instructions for departure. The GC instructed N8302T to taxi to runway 34 for an intersection departure from taxiway H. The GC instructed N8302T to hold short of runway 29 at the intersection with taxiway T. About 1620, N8302T was seen crossing runway 29 at taxiway T without authorization. As a result of the unauthorized crossing, the LC withheld takeoff clearance to traffic holding in position for departure on runway 29 until N8302T was clear of the runway.

At the time of the incident, day VMC prevailed.

The pilot of N8302T reported that he was not aware that he had crossed a runway when the LC advised him that he had crossed runway 29. There were signs to identify runway 11-29 where the pilot of N8302T entered runway 29 at taxiway T.

7/18/85.--At 2123 (EDT) on July 18, 1985, N91WW, a Piper PA-60 Aerostar, taxied onto runway 16 at the north taxiway while N81Y, a Piper PA-30, was on a short final approach to runway 16. The GC had cleared N91WW to runway 16 from Westair, a fixed-base operator located west of the runway, for an intersection departure. The pilot did not contact the LC until the airplane taxied onto runway 16. The flight was cleared only to taxi to the runway, not to enter the runway. The LC immediately instructed N91WW to clear the runway and issued go-around instructions to N81Y.

At the time of the incident, night VMC prevailed with scattered clouds at 4,000 feet and visibility 12 miles.

The pilot of N91WW was not familiar with the airport. He reported that he had operated out of the airport "occasionally" during the preceding few weeks and still considered the taxiways a maze. The pilot, 52 years of age, held a commercial pilot certificate and had accumulated about 1,700 hours during the previous 27 years. He said the taxi clearance he received was "a little ambiguous" but he did not question it.

However, a review of the tower tapes indicated that the clearance issued by the GC was clear and concise. Although the taxiway was unlighted and there were no signs denoting the intersection of runway 16 and the north taxiway, the pilot reported that he did not feel that their absence was a factor in this incident. The pilot said he understood the phraseology/terms used by the GC; he simply misunderstood what the GC had said when issuing the taxi clearance. The pilot said he understood that he was cleared to taxi to runway 16, but he thought he was to "hold" on the runway. He said he knew he was entering the runway when he crossed the runway lights, but thought he was taxiing in accordance with his clearance. He taxied onto the active runway without scanning the runway to ensure that there was no conflicting traffic.

7/19/85.—About 1643 (EDT) on July 19, 1985, the GC cleared N4475W, a Beech 100 Kingair, to taxi to runway 16. The pilot complied with the instructions and was at the "number 1 position" when another airplane, N43W, located at a downfield intersection was instructed to taxi into position and hold on runway 16. Shortly thereafter, the LC cleared N43W for takeoff "without delay." The pilot of N4475W mistook this transmission as being for his airplane, turned onto runway 16, and started takeoff roll. When the LC saw N4475W turn onto the runway and start its takeoff roll, the LC transmitted "takeoff clearance canceled, hold in position" to convey to the pilot of N4475W that he was not cleared for takeoff and to stop his takeoff. The tower tapes revealed that although the LC was busy and speaking rapidly at the time, his transmissions were clear and concise. When N4475W entered runway 16, Command Airlines flight 263 (CMD263), a Short Brothers SD3-30, was on final approach to runway 16. Due to the situation created by N4475W, the LC instructed CMD263 to abandon its approach and execute a go-around.

At the time of the incident, day VMC prevailed, with thin scattered clouds at 25,000 feet, and visibility 6 miles.

The pilot of N4475W said he visited the airport regularly, sometimes several times a day. He reported that he thought he was cleared for takeoff when he entered the runway. He said he did not recognize that the takeoff clearance he heard was for another airplane. He did not blame the lack of signs at the airport for the incident, although there was no sign identifying runway 16 at the point where he entered the runway. The pilot attributed the incident simply to his mistaking the clearance issued to N43W as one being issued to his airplane. The pilot reported that after applying takeoff power, he recognized that there had been a mistake as he saw the traffic departing downfield. The Safety Board believes that the similar-sounding call signs ending in "W," coupled with the LC's use of "without delay," contributed to the pilot deviation. Although the LC's use of "without delay" was consistent with FAA controller procedures, the Board believes that it contributed to the failure of the pilot of N4475W to verify that the clearance was for him.

7/20/85.—At 0823 (EDT) on July 20, 1985, Midway Airlines flight 183 (MID183), a McDonnell Douglas DC-9, located at the passenger terminal, contacted the GC for taxi instructions. The GC instructed MID183 to taxi to runway 34 and hold short of runway 29. MID183 acknowledged the clearance. When it appeared to the GC that MID183 was not going to hold short of runway 29, the GC again instructed the flight to hold short. However, MID183, upon receiving the second hold-short instruction and having already entered onto the runway, advised the GC that it was too late to stop and continued across the runway. The captain of MID183 later told the GC that he did not hear the hold-short portion of the clearance, although he acknowledged the transmission. The captain said he was taxiing the airplane as well as operating the radios and that the copilot was occupied with other duties in preparation for departure.

At the time of the incident, day VMC prevailed with broken clouds at 15,000 feet and visibility 6 miles.

MID183 taxied from the passenger terminal ramp via taxiway E. There were no signs at the intersection of taxiway E and runway 29, although there were standard yellow hold line markings on the taxiway. Safety Board investigators noted that taxiway E and runway 29 were about the same width and were very similar in appearance under daylight conditions. The captain said he entered the runway before he realized he had been instructed to hold short. The captain had been flying for Midway Airlines for several years and had more than 15,000 hours flying experience. He reported that he had flown into the airport about six times in the previous 6 weeks and about three times per month before that. He considered himself familiar with the airport.

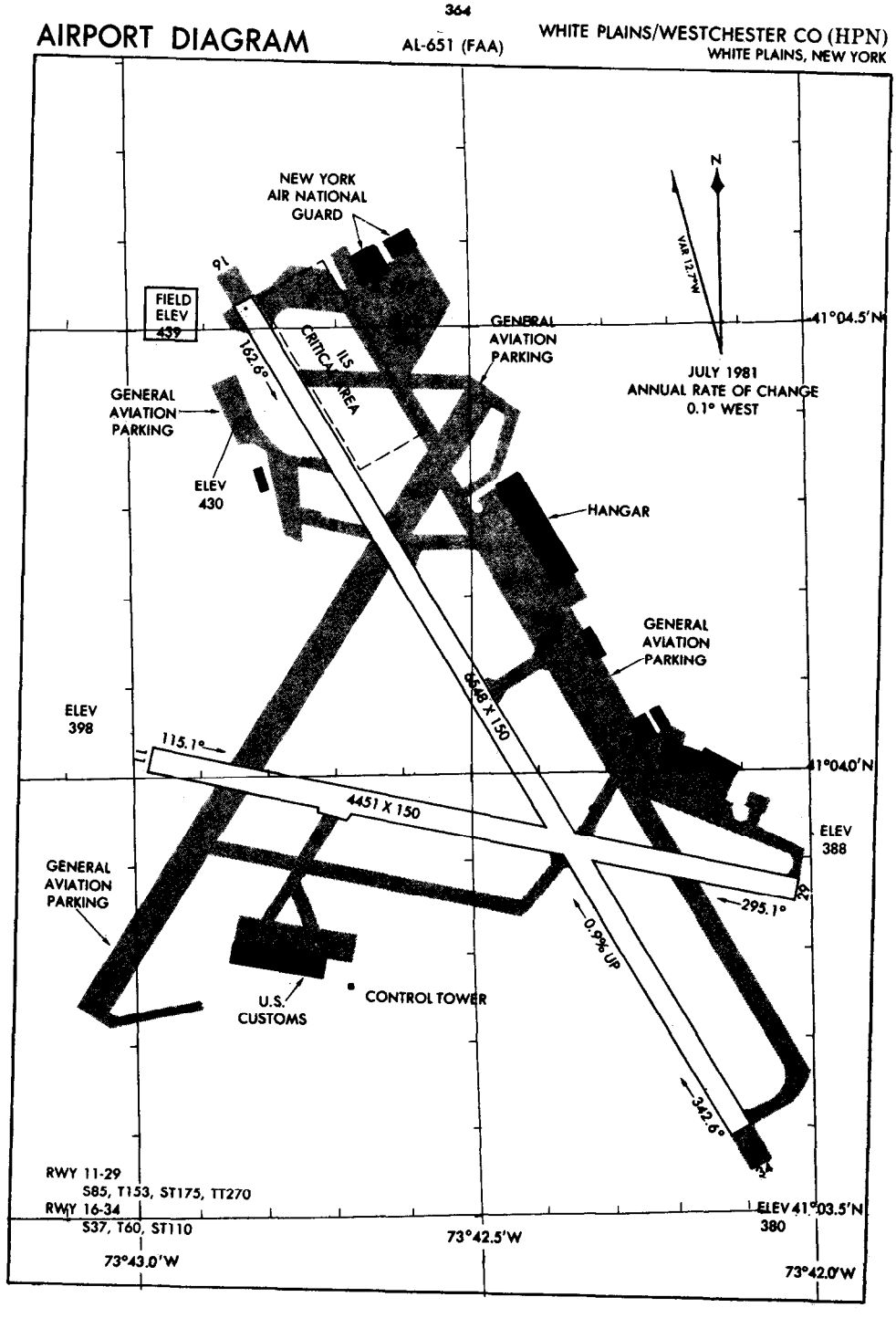
The Safety Board believes that the crew of MID183 was inattentive when they accepted the taxi clearance and while they were taxiing. The absence of a sign at the intersection of taxiway E and runway 29 might have contributed to the incident because it was more difficult for the crew to recognize that they were entering a runway.

7/20/85.--About 1123 (EDT) on July 20, 1985, the GC cleared N20226, a Cessna 172, located at the transient parking area at the passenger terminal, to taxi to runway 29. The GC initially read the clearance instructions rather fast, and the pilot of N20226, a student pilot, asked him to repeat the clearance. The second clearance was clear and concise, and the pilot acknowledged. The airplane taxied via taxiway E and entered runway 29 without a clearance. Taxiways E and F along the normal route to runway 29 were not marked by signs, nor were their intersections with runway 29 marked by signs.

At the time of the incident, day VMC prevailed with scattered clouds at 2,500 feet, broken clouds at 15,000 feet, and visibility 3 miles.

Safety Board investigators interviewed the pilot of N20226 and found that despite the readback of his taxi clearance, he did not fully understand the clearance. The pilot, a 75-hour student on his second cross-country flight, knew he had entered onto "a runway," after the fact, and thought it was runway 29. He said he was not aware that he was on the runway until about the same time the GC informed him that he was.

This incident occurred at the same intersection as the incident involving Midway Airlines flight 183 earlier the same day, although different taxi instructions were issued. The student pilot's inexperience was determined to be a significant factor in this incident, but the lack of any taxiway/runway markings contributed to the incident.


364
AIRPORT DIAGRAM
AL-651 (FAA)
WHITE PLAINS/WESTCHESTER CO (HPN)
WHITE PLAINS, NEW YORK
NEW YORK AIR NATIONAL GUARD
FIELD ELEV 439
GENERAL AVIATION PARKING
ILS CRITICAL AREA
162.8°
GENERAL AVIATION PARKING
ELEV 430
HANGAR
GENERAL AVIATION PARKING
ELEV 398
6548 X 150
115.1°
4451 X 150
ELEV 388
GENERAL AVIATION PARKING
295.1°
0.9% UP
U.S. CUSTOMS
CONTROL TOWER
342.6°
N
VAR 12.7°W
JULY 1981
ANNUAL RATE OF CHANGE
0.1° WEST
41°04.5'N
41°04.0'N
41°03.5'N
ELEV 380
RWY 11-29
S85, T153, ST175, TT270
RWY 16-34
S37, T60, ST110
73°43.0'W
73°42.5'W
73°42.0'W

11. Little Rock, Arkansas - 7/31/85

On July 31, 1985, at Adams Field, Little Rock, Arkansas, the LC cleared N1858E, a Beech 200 Kingair, to land on runway 22 at 1359:28 (CDT), and N7991Y, a Piper PA-30, to land on runway 18 at 1359:55. After landing, the pilot of N1858E was switched from the local control to the ground control frequency at 1401:25. When the pilot of N1858E switched to the ground control frequency, he advised the GC, "1858E's clear, going to Central on the highspeed." The GC acknowledged the transmission and advised, ". . . taxi to parking." The high-speed taxiway from runway 22 toward the parking area is taxiway B, which crosses runway 18 about 2,100 feet from the landing threshold of runway 18. The pilot of N1858E was neither advised to hold short of runway 18 nor advised of traffic on runway 18. N1858E taxied onto runway 18 in front of the landing N7991Y, which reportedly missed N1858E by about 75 feet horizontally.

The pilot of N7991Y said he touched down at 80 mph, about 1,500 feet from the runway 18 threshold. N1858E appeared in front of him shortly after touchdown. The pilot of N1858E did not see N7991Y until it was touching down on runway 18. N1858E was so close to the runway at that time, the pilot elected to add power to expedite his crossing, rather than try to stop abruptly and possibly enter the runway anyway.

Safety Board investigators interviewed the controllers and found that, after rollout, N1858E was switched to ground control without any coordination between the LC and GC. The GC did not visually locate N1858E while he communicated with its pilot but did see another airplane on taxiway A; he did not recognize that the airplane was under tow. He reported that he assumed that the airplane under tow was N1858E, although he had previously provided the towed airplane with a taxi clearance. The GC did not note that the pilot of N1858E said he was on the high-speed taxiway. He said he assumed that N1858E had landed on runway 18 and was back-taxiing on taxiway A. After the incident, when the pilot of N1858E called the GC to confirm that he was, in fact, cleared across runway 18, the GC did not remember that he had previously called.

Traffic was light at the time of the incident. There were only two airplanes on the ground control frequency--the airplane under tow and N1858E. There were reportedly no equipment malfunctions or distractions in the tower, nor was training in progress in the tower. N1858E landed on runway 22 about 1,900 feet northwest of the control tower, which is located on the northeast side of the airport and faces northwest. The incident occurred on the west side of the airport, about 1 mile west of the control tower. The airplane in tow on taxiway A was somewhat farther from the tower and about 700 feet south of the taxiway B/runway 18 intersection at the time of the incident. The point at which N1858E touched down on runway 22 was almost directly in front of the control tower.

At the time of the incident, day VMC prevailed with scattered clouds, at 5,000 feet, high thin scattered clouds, and visibility 6 miles.

The control tower was staffed with an LC/CIC, a GC, and an ATA performing CD duties. At the time of the incident, the GC had been on duty 7 hours 38 minutes; he had been working the ground control position continuously for the preceding 1 hour 29 minutes. The LC was not a regular member of this team; the supervisor was the first-line supervisor for the GC and had not worked regularly with the LC. The supervisor/CC had signed out on break 2 minutes before the incident because of the light traffic and was not in the tower cab. The runway configuration at the time of the incident--landings and departures on runways 18 and 22, with all large aircraft on runway 18--had been consistent all day according to the supervisor.

The GC had been an FAA employee since January 1983. He qualified as an FPL controller at Little Rock on July 23, 1985. He had previously qualified as an FPL controller at the Fort Smith, Arkansas tower. He had no prior ATC experience before entering on duty with the FAA and had no pilot certificates.

The GC said he normally coordinated all runway crossings with local control. He said he did not in this case because he assumed that N1858E was on the west side of runway 18. The GC said his standard procedure was not to inform the LC when an aircraft he was crossing was clear of a runway, since he always told aircraft to hold short of a runway until runway traffic was clear of the taxiway. The LC saw N1858E as it approached runway 18 on taxiway B. He did not communicate his observation to the GC because he assumed the GC had instructed N1858E to "hold short," which was standard procedure. When he realized N1858E was not going to stop, it was too late to alert either airplane.

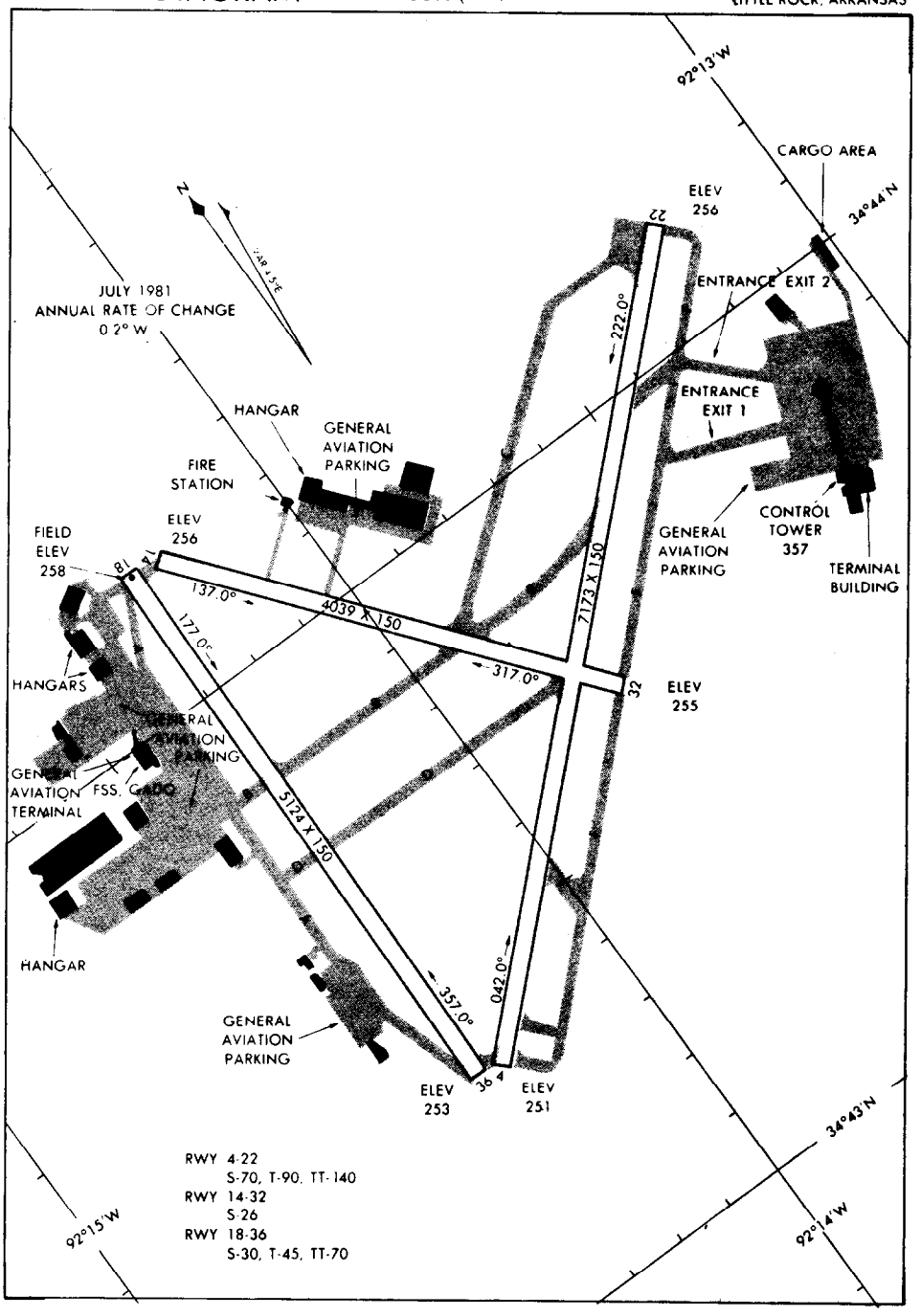
A review of pertinent controller procedures disclosed that the GC was obligated to coordinate all crossings with the LC. However, the LC was not obligated to coordinate with the GC when switching an aircraft to the ground control frequency. The Safety Board believes this incident might have been avoided if the LC had pointed out, or otherwise identified, N1858E when switching it to the ground control frequency or if the GC had positively identified the landing airplane when first effecting communication. High workload was not a factor; neither controller was so busy that he could not have scanned the control area and more effectively coordinated the arrival of N1858E. The GC said he tended to scan more in heavy traffic periods than in periods of light workload.

The Safety Board determined that this incident resulted from the GC's inattentiveness and poor scanning, the lack of coordination between the LC and GC, and the absence of a procedure to ensure coordination of arriving traffic by LCs and GCs. The pilot of N1858E contributed to the incident by not scanning runway 18 before entering the runway, even though he was authorized to cross. This incident illustrates the potential hazard in relaxing adherence to standard operating procedures in times of light workload.

AIRPORT DIAGRAM

182
AL-233 (FAA)

LITTLE ROCK ADAMS FLD (LIT)
LITTLE ROCK, ARKANSAS



12. Sarasota, Florida - 8/2/85

At 1154 (EDT) on August 2, 1985, Delta Air Lines flight 225 (DL225), a Boeing 727, taxied across runway 22 at taxiway B while N3964X, a Piper PA-34 Seneca, was on its takeoff roll on runway 22 at the Sarasota-Bradenton Airport, Sarasota, Florida. Shortly before the incident, the GC recognized the developing situation when he saw N3964X on its takeoff roll and DL225 approaching runway 22. The GC advised the LC of the situation and instructed DL225 to stop. Concurrently with the GC's instruction to DL225, the LC instructed N3964X to reject its takeoff. However, both flights responded that it was too late to stop. N3964X overflew the intersection of runway 22 and taxiway B where DL225 had crossed, at about 200 feet above ground level, reportedly 20 feet horizontally to the rear of DL225.

A few minutes before the incident, DL225 had landed on runway 32. After clearing the runway, DL225 was cleared to taxi toward the terminal but was advised to hold short of runway 22. As DL225 was approaching the intersection of runway 22 on taxiway B, the GC initiated coordination with the LC for approval to cross runway 22. At the time, there was no conflicting traffic and the LC approved the GC's request. About 8 seconds after the coordination was approved, N3964X, located at the approach end of runway 22, called the LC for takeoff and the LC issued the takeoff clearance.

Day VMC prevailed with scattered clouds at 2,500 feet, a 23,000 foot broken ceiling, and visibility 10 miles.

One of the controllers suggested that the relative height of the tower might have been a factor. However, Safety Board investigators found the visibility from the tower cab to be excellent. The distance from the tower cab to the intersection of runway 22 and taxiway B was about 1,400 feet. The distance from the tower cab to the approach end of runway 22 was about 4,300 feet.

The tower was staffed with two control personnel. The AS was working the ground control and CD positions combined. Additionally, he was assigned as the tower supervisor. The other controller was assigned the local control position combined with the CC position. The LC/CC was an FPL controller with 22 years of experience. Tower personnel described traffic before the incident as light, with four aircraft on the local control frequency and four aircraft on the ground control frequency.

The LC said that after he issued takeoff clearance to N3964X, he became occupied with two other aircraft on his frequency. The LC said he forgot he had given the GC clearance for DL225 to cross runway 22 and that he was unable to explain how or why he had forgotten about the DL225 coordination. He said it was a matter of "forgetting" rather than misjudging separation. The LC said equipment and workload were not factors. Additionally, the LC said he was not fatigued.

The GC said he scanned runway 22 before issuing clearance for DL225 to cross. After he cleared DL225 to cross, he attended to flight data duties, but continued to monitor the progress of DL225. The GC said he did not see N3964X initially and that when he did become aware of it he initiated action to prevent a collision.

Under the circumstances of this incident, a supervisor or controller free of other duties probably would have detected the incident developing as soon as the takeoff clearance was issued to N3964X, which should have allowed sufficient time to prevent the

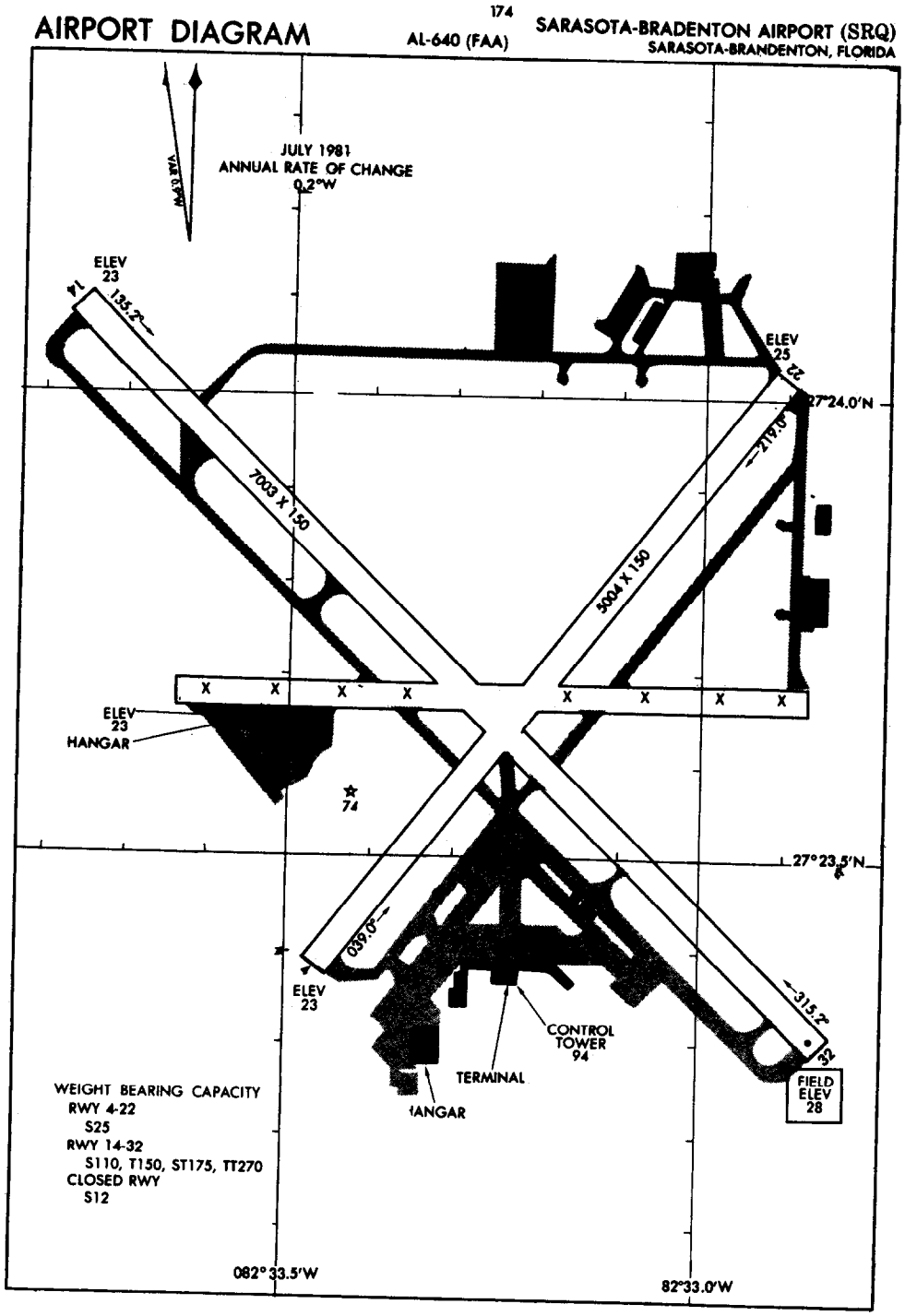
near-collision. However, in this case, the AS was working another position. The Safety Board found that at some facilities, the CC position has been established to provide an "extra set of eyes" to aid in coordinating traffic among CD, ground control, and local control. In this situation, however, the CC was also the LC. The AS could not provide effective coordination between controllers or be an "extra set of eyes" while he was actively working the local control position.

The GC and LC coordinated the DL225 crossing; however, 8 seconds later, the LC forgot about that coordination. Factors affecting the LC may have included:

(1) Inadequate scanning of the control area, thus failing to see DL225;

(2) Dismissing DL225 after it had landed safely, assuming that the airplane was now another controller's responsibility; or

(3) Diminished alertness, perhaps related to boredom or lack of vigilance in working routine light traffic in ideal weather conditions.


AIRPORT DIAGRAM
174
AL-640 (FAA)
SARASOTA-BRADENTON AIRPORT (SRQ)
SARASOTA-BRANDENTON, FLORIDA
JULY 1981
ANNUAL RATE OF CHANGE
0.2°W
VAR 3°W
ELEV
23
135.2°
ELEV
25
22
27°24.0'N
219.0°
7003 X 150
5004 X 150
ELEV
23
HANGAR
74
27°23.5'N
039.0°
315.2°
ELEV
23
CONTROL
TOWER
94
TERMINAL
HANGAR
FIELD
ELEV
28
WEIGHT BEARING CAPACITY
RWY 4-22
S25
RWY 14-32
S110, T150, ST175, TT270
CLOSED RWY
S12
082°33.5'W
82°33.0'W

13. Houston, Texas - 8/2/85

At 1610 (CDT) on August 2, 1985, N26GB, a Gates Learjet 35, taxied across runway 22 at taxiway G while Fort Worth Airlines flight 14 (FTW14), a Nihon YS-11, was on takeoff roll at the William P. Hobby Airport, Houston, Texas.

Shortly before the incident, the GC had asked the LC if he could cross runway 22 at taxiway G with three aircraft behind a departing Southwest Airlines flight and ahead of a Delta Airlines flight that was on final approach for landing. The LC approved the crossing. However, after the Southwest Airlines flight was cleared for takeoff, the LC cleared FTW14 into position for takeoff and called the GC back, using an interphone system, revising the clearance to cross runway 22, until "after Fort Worth." At the time the revised clearance was transmitted by the LC, the GC was communicating with another airplane to determine its location. The GC said afterward that he did not understand what was said, but did not ask for clarification. After observing the Southwest Airlines flight depart, the GC cleared N26GB to cross runway 22 at taxiway G, assuming there had been no change to the crossing approval. The LC issued takeoff clearance to FTW14 at the same time the GC cleared N26GB to cross runway 22. N26GB crossed runway 22 about 4,000 feet ahead of the departing FTW14.

At the time of the incident day VMC prevailed.

The LC said that after the Southwest Airlines flight departed, he instructed FTW14 to taxi into position and hold on runway 22. At this time, due to the position of the Delta Air Lines flight on final, he called the GC and revised the crossing clearance. He said he felt the previous crossing clearance would cause a delay for FTW14 and could have caused the Delta Air Lines flight to be issued a go-around. The LC said that as he issued takeoff clearance to FTW14, he scanned runway 22 to verify that the runway was clear. He then observed N26GB, crossing runway 22. The LC said he immediately asked the GC if he intended to cross any more airplanes and the GC replied, "No." The LC said he allowed FTW14 to continue its takeoff, as he did not consider N26GB, which was clearing the runway, to be a threat to FTW14. He also did not mention N26GB to FTW14. The LC described his workload as "semi-busy." The airport was at the beginning of a peak traffic period.

The GC said N26GB was the first of three airplanes on the south end of the west ramp waiting to cross runway 22. He had been monitoring the LC's traffic continuously to coordinate for crossing when "gaps" appeared between departures and arrivals. When he called for the crossing clearance, he was monitoring the LC's traffic using the BRITE display. After the initial coordination with the LC, the GC cleared N26GB to cross. After he cleared N26GB, the GC became preoccupied with visually locating a taxiing airplane that had called him for a clearance. After locating the airplane, he looked back at the crossing N26GB and noticed the FTW14 shortly after it started its takeoff roll. He did not see a need to alert N26GB, but reported the incident to the supervisor. The GC described his traffic level as moderate with occasionally complex situations. The GC and the LC were both FPL controllers. The supervisor was in the tower cab and was not working a position at the time of the incident. Although he saw the incident as FTW14 was rotating, it was too late to prevent the incident.

At the time of the incident, all operating positions were staffed. A tower directive required that all verbal communication regarding coordination communication between local control and ground control be made via interphone (and thus recorded on official tapes of tower communication). The coordination was accomplished in this case via

interphone. Despite the interphone communication, the GC said he did not understand what the LC said when the crossing clearance was modified. The LC thought he heard a confirmation from the GC when the crossing clearance was modified, but the recording of the interphone channel revealed that there was no verbal confirmation over that circuit.

The Safety Board determined that this incident was caused by the ineffective coordination between the LC and GC, and the failure on the part of the LC to obtain an acknowledgment from the GC before clearing an aircraft for takeoff, when he had previously approved three crossings of the active runway.

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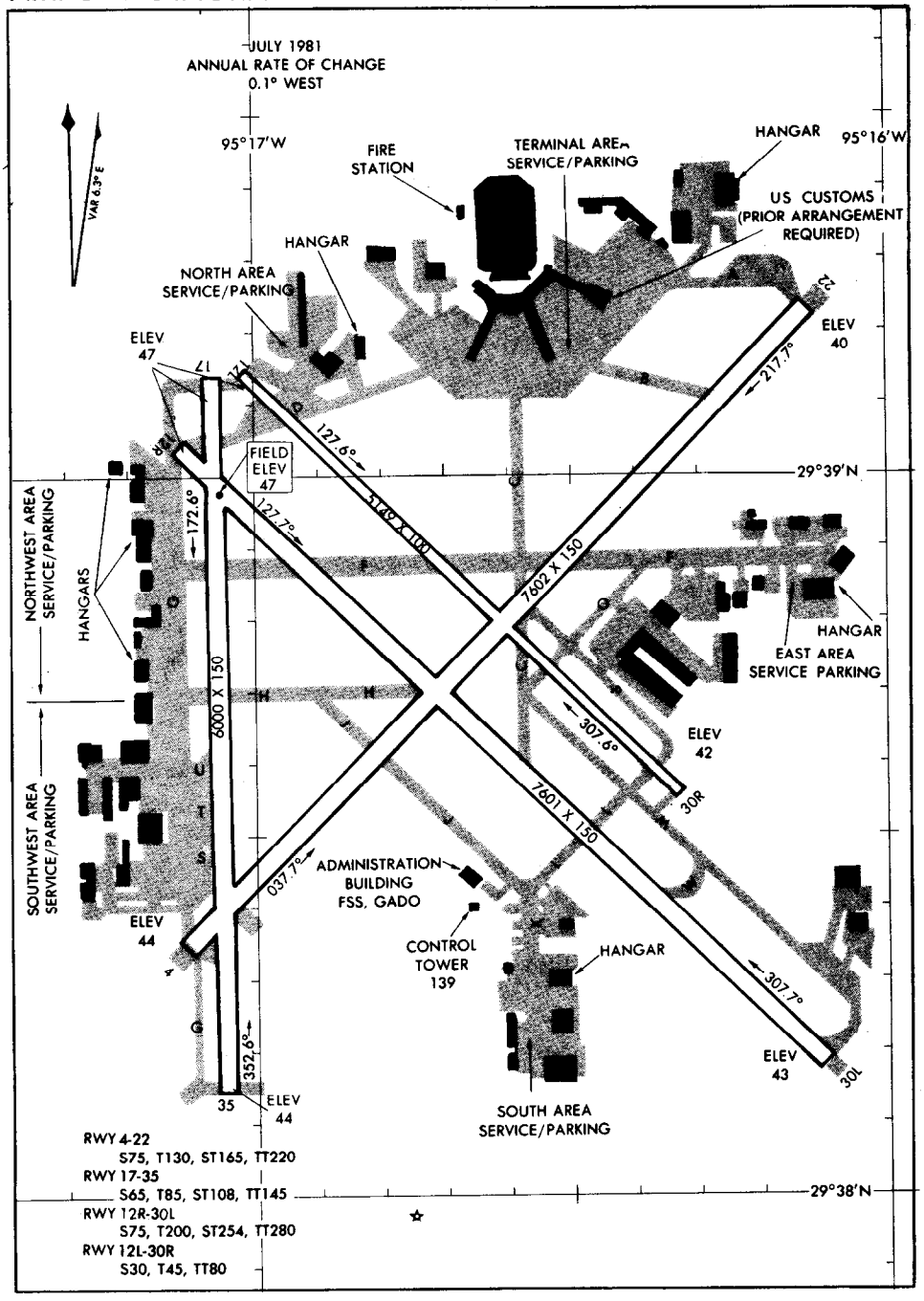
AIRPORT DIAGRAM

AL-198 (FAA)

HOUSTON/WILLIAM P. HOBBY (HOU)
HOUSTON, TEXAS



RWY 4-22
S75, T130, ST165, TT220
RWY 17-35
S65, T85, ST108, TT145
RWY 12R-30L
S75, T200, ST254, TT280
RWY 12L-30R
S30, T45, TT80

14. Syracuse, New York - 8/11/85

About 1425 (EDT) on August 11, 1985, the approach controller at the Syracuse TRACON contacted the LC at Hancock International Airport, Syracuse, New York, and requested approval for N446U, a Gulfstream American G3, to make a low approach to runway 28 and circle for landing on runway 32. The LC approved the request, even though runway 10/28 was closed for resurfacing. N446U soon called the LC and reported a 5-mile final to runway 28. The LC cleared N446U for a low approach to runway 28 and instructed the pilot to report when it began its circling approach to runway 32. N446U continued its approach, descending to about 50 feet above ground level over runway 28 at about 1435. After completing the low pass over runway 28, N446U reported circling for landing on runway 32.

The airport authority had issued a NOTAM closing the runway at 1545 on June 17, 1985, 3 1/2 weeks before the incident. On the day of the incident, no one was working on the runway. However, equipment was on and near the runway, and the surface of the runway reportedly was not suitable for aircraft operations.

Day VMC prevailed with scattered clouds at 3,000 feet and visibility 7 miles.

The controller assigned to the local control position was also assigned the combined duties of GC. The LC said that when the approach controller requested a low approach to runway 28 for N446U, he assumed that the airplane would discontinue its approach before reaching the landing threshold, then circle to land on runway 32. The LC said he saw the airplane on its approach. When it appeared that the airplane was not going to break off before reaching runway 28, he scanned the closed runway for personnel and did not see anyone. The LC said that when he looked back at the airplane, it was already very low. He deemed it unwise to issue any control instructions under those circumstances and therefore issued no instructions at that time.

The pilot of N446U said his airplane was new and was being delivered to his company flight office at the Syracuse Airport on the day of the incident. The pilot requested a low approach to check the GPWS and to check the alignment of the airplane's onboard laser navigation systems. He said the GPWS check required descending to a low altitude. He said the finite navigation points used for the laser navigation system check were the approach and departure ends of runway 28 on the centerline. The pilot requested the low approach to runway 28 even though he knew the runway was closed because he was aware that other runways at the airport were noise sensitive.

The supervisor was not in the tower cab at the time of the incident. The LC did not report the incident to the supervisor, nor did he record the incident in the tower logs. The incident was reported to the FAA's Eastern Region Public Affairs Office by news media personnel on August 13, 1985. The LC said he did not report the incident because there was no one on the runway, and he was not convinced it was a serious enough (operational) error to report.

This incident occurred because the LC assumed that the pilot would break off the approach and circle to land on runway 32 before reaching the closed runway 28. The pilot was not in error to complete the low pass after receiving clearance to do so. However, the LC failed to advise the pilot that the runway was closed or that an unsafe condition existed on the runway as required by FAA Handbook 7110.65D.

The Safety Board is concerned that this incident might not have been reported or investigated by the FAA if the news media had not alerted the FAA.

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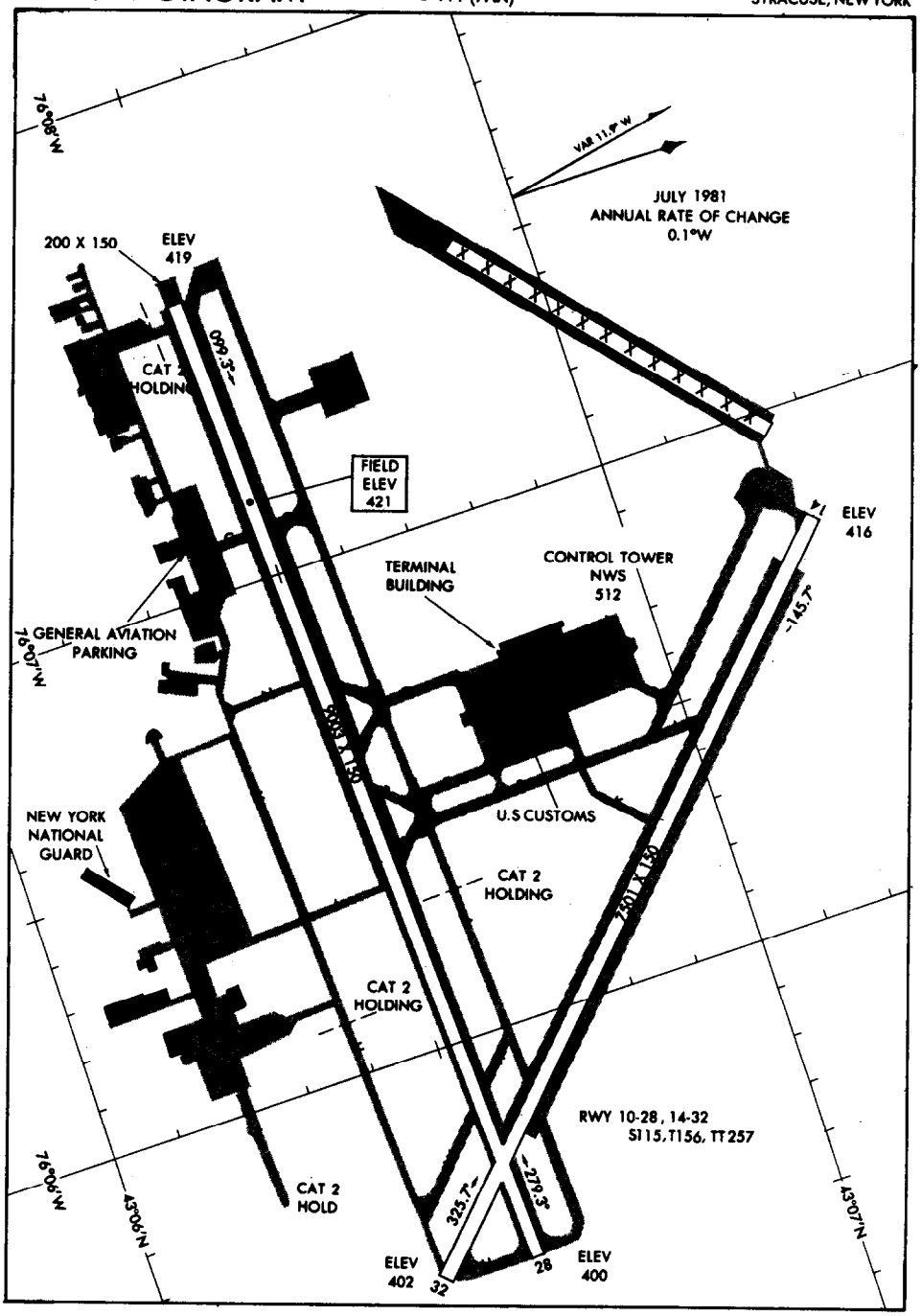
AIRPORT DIAGRAM

AL-411 (FAA)

SYRACUSE HANCOCK INTL (SYR)
SYRACUSE, NEW YORK



15. Tulsa, Oklahoma - 8/15/85

At 1642 (CDT) on August 15, 1985, a student pilot on his second solo flight taxied onto and crossed runway 36L in a Cessna 152 as a Cessna 421 was taking off from the runway at Riverside Airport, Tulsa, Oklahoma. The Cessna 421 had lifted off and was several hundred feet above the ground when it overflew the Cessna 152.

The Cessna 152 had landed on runway 36R a few minutes before the incident and taxied to runway 36L via the inactive runway 30. The student pilot was told to hold short of runway 36L and did so until he heard a communication that he thought was his clearance to cross. He taxied onto runway 36L without acknowledging the clearance. After entering the runway, he heard the LC advise him to "hold" and he stopped briefly. He determined that he was too far out onto the runway to safely remain in that position so he continued to the other side of the runway. During the crossing, he heard but did not respond to calls from the tower because he rationalized that his action in continuing across was the only appropriate response under the circumstances.

At the time of the incident, day VMC prevailed, with scattered clouds at 3,000 feet and visibility 8 miles.

Safety Board investigators determined that runway marking or signs were not a factor in this incident, because the student pilot of the Cessna 152 stopped initially at a point on runway 30 that he considered clear of runway 36L. The airport operator reported that runway 30 was used as the main taxi route between runway 36R and the ramp areas on the west side of the airport when runway 30 was not an active runway. The operator confirmed that there was no sign at the intersection of runways 30 and 36L to identify runway 36L and there was no line on runway 30 to identify the point at which an aircraft was entering runway 36L. It was not clear whether such a line would aid a pilot to determine more accurately where to hold when advised by the tower to do so.

The LC said there were no equipment problems or distractions in the tower. He saw the situation developing but could not get the student pilot to hold his position short of the runway. Traffic was considered average at the time of the incident.

The student pilot had a total of 1.4 hours pilot-in-command (solo) experience. His communications to the tower were clear and his statement to investigators reflected a clear understanding of the tower communications directed to him. The student concluded that he mistakenly thought a communication that was intended for another airplane was his clearance to cross runway 36L.

The Safety Board believes this incident was caused by the inexperience of the student pilot who took the runway when not cleared to do so and failed to acknowledge a clearance that he believed was intended for him. Factors that were present but probably did not contribute to the incident included:

(1) The local control position was staffed by a supervisor. The tower was not staffed sufficiently to allow the supervisor to be free of controller duties so that he could supervise and assist other controllers.

(2) The Cessna 421 was asked to make an "immediate" takeoff to expedite traffic.

(3) When the LC cleared the student pilot to "hold short of 36L," he did not wait for an acknowledgment before communicating with another aircraft. By failing to obtain an acknowledgment, the LC could not be assured that the student understood and would comply with the instruction.

(No airport diagram was available.)

16. Rochester, New York - 8/21/85

About 1320 (EDT) on August 21, 1985, N40776, a Piper PA-28, contacted the LC at Monroe County Airport, Rochester, New York, reported that he was 5 miles west of the airport, and requested landing instructions. The LC instructed N40776 to report 2 miles west of the airport and to plan a landing on runway 7. About 1323, when N40776 reported 2 miles west of the airport, the LC instructed the flight to enter a right base leg for runway 10. About 1324, N40776 advised the LC that the flight was entering a right base for runway 10. The LC acknowledged the transmission and cleared N40776 to land on runway 10. At 1326, N40776 landed on runway 10 while an airport maintenance vehicle with two occupants was on the runway. Runway 10 had been closed at 1300 that day by airport personnel to complete required runway maintenance.

At the time of the incident, day VMC prevailed with scattered clouds at 2,400 feet, broken clouds at 4,000 and 9,000 feet, and visibility 15 miles.

At the time of the incident, three persons were in the tower cab. The LC, who had 19 months of experience and was an FPL controller, was working the combined local control and ground control positions. The person assigned as GC was not actually working the ground control position but was instead observing the LC. The assigned GC was a developmental controller and had been certified on the ground control position for 1 day. Additionally, an ATA was assigned the duties of FD/CD.

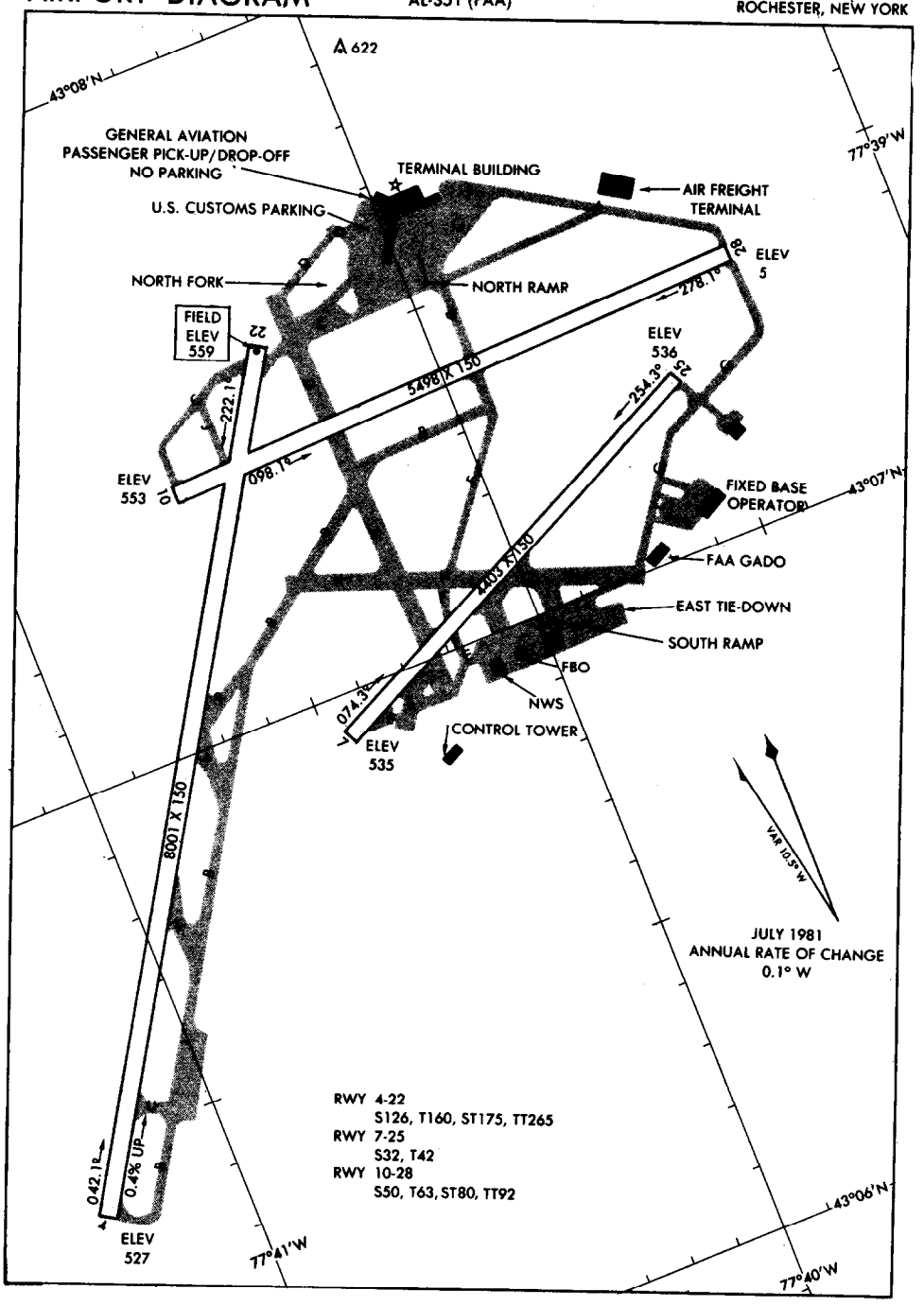
Airport maintenance personnel had contacted the tower about 1235 to confirm that runway 10/28 would be closed at 1300. A NOTAM was issued at 1254 closing runway 10/28 effective at 1300. Upon receipt of this information, tower personnel noted the runway closure information on flight progress strips and posted them at the ground control and local control positions. The LC acknowledged that he had seen the strip and understood that the runway was closed. He said, however, that during the approach and landing of N40776 he forgot the runway was closed. The supervisor was not present in the tower cab at the time of the incident.

The pilot of N40776 said he was not aware that runway 10 was closed when the tower assigned him that runway for landing and cleared him to land. He said he did see a truck, well ahead of him on the runway, when he cleared the runway after landing.

This incident occurred solely because of the improper clearance provided to the pilot by the LC. The runway was closed by a NOTAM 26 minutes before the incident and the LC should have advised the pilot of that closure. The pilot did not learn of the closure of runway 10 because the LC forgot that it was closed and the pilot had no other way to learn about it. Traffic was not a factor. It was unclear why the LC forgot that the runway was closed. Safety Board investigators considered the low experience level of the controllers to be a possible factor in this incident. The absence of the supervisor from the tower cab contributed to the incident since the clearance to land on a closed runway probably would not have gone unchallenged had the supervisor been present.

AIRPORT DIAGRAM

ROCHESTER-MONROE COUNTY AIRPORT (ROC)
AL-351 (FAA)
ROCHESTER, NEW YORK



17. Kansas City, Missouri - 8/29/85

About 2038 (CDT) on August 29, 1985, Central Airlines flight 21 (CTL21), a Rockwell Commander 500, located at terminal A, gate 3, at Kansas City International Airport, Kansas City, Missouri, contacted the GC for taxi instructions. The GC instructed CTL21 to taxi to runway 9. After receiving clearance to runway 9, CTL21 asked the GC if it would be possible to take runway 19. The GC responded with a clearance to taxi to runway 19. There were no further communications between the GC and CTL21. About 2045, CTL21 contacted the LC advising that the flight was "ready to go 19." The LC acknowledged and instructed CTL21 to hold short of the runway. Shortly afterward, the LC transmitted, "CTL21 fly runway heading cleared for takeoff runway niner." CTL21 replied, ". . . we're on one niner sir." At this time, the LC instructed CTL21 to hold short.

At 2051, the LC cleared Southwest Airlines flight 420 (SW420), a Boeing 727, which was on the base leg for landing on runway 19, to land. At 2053, after SW420 had crossed the threshold but before touchdown on runway 19, the LC instructed CTL21 to taxi into position and hold on runway 19. CTL21 acknowledged the instructions and requested the current wind information. The LC issued the wind as "one five zero at seven." As the LC completed this transmission, the pilot of SW420, which had just touched down on runway 19, saw lights ahead on the runway and transmitted, "Who's that pulling out onto 19?" CTL21 transmitted, "Central 21, sir." About 2055, the LC transmitted, "ah understand you're at the intersection, I thought you were at the approach end." CTL21 replied, "ah negative, we're at the intersection." The pilot of CTL21 cleared the runway expeditiously as he saw the lights from SW420 approaching his position.

At the time of the incident, night VMC prevailed with scattered clouds at 12,000 feet and visibility 12 miles.

The GC was working the combined position of GC/FD/CD. The GC/FD/CD said that when he instructed CTL21 to taxi to runway 19, he marked the flight progress strip accordingly. The GC/FD/CD said he saw CTL21 taxi from the terminal and turn north on taxiway A. He did not continue to monitor the taxi progress of CTL21. The GC/FD/CD said he then placed the flight progress strip at the local control position and began to gather data in preparation for updating the ATIS tape. The GC/FD/CD said that while he was making the new ATIS tape, he had difficulty with the machine and had to spend more time than normal with this task. The GC/FD/CD said he knew from personal experience that Central Airlines airplanes requested intersection departures about 75 percent of the time; the remainder of the time, the flights would take an intersection without advising the LC of their intentions when they called for departure.

Safety Board investigators asked the GC/FD/CD, who attended the FAA's ATC Academy before his assignment to the Kansas City tower, about the coordination requirements he had been taught. He said he could not recall whether the subject was addressed at the ATC Academy. The GC/FD/CD said that if he knew an airplane would make an intersection departure, he would mark the flight progress strip accordingly and inform the LC. The GC/FD/CD said that in this case, since traffic was light and he had nothing else that would conflict with CTL21 after the flight turned north on taxiway A, he did not monitor the taxi progress of the flight and did not communicate with the LC. Rather, he turned away from the general area of the GC/FD/CD operating position to update the ATIS tape. The GC/FD/CD said he did not witness the incident because he was occupied with his other duties.

The LC agreed that traffic was light when CTL21 called for takeoff. He noticed that there was a mark in front of the "9" on the flight progress strip, but it was not clear that the departure runway indicated had been changed to 19. He initially cleared CTL21 for takeoff from runway 9 assuming the flight was preparing for departure from that location. When CTL21 replied it was at runway 19, he instructed the flight to hold short. The LC said he scanned taxiway A but did not see CTL21. The flight progress strip did not indicate that the flight was using an intersection, so he assumed that CTL21 was at the end of the runway, even though visibility was good and he did not see an airplane at the end of the runway.

The LC said that when he saw SW420 overfly the end of the runway, he instructed CTL21 to taxi into position and hold on runway 19. He assumed that CTL21 would take the runway at the approach end, following SW420 which had passed that point. He was not aware that anything was wrong until SW420 asked who was on the runway. The LC estimated that the minimum separation between the two airplanes was "about 200 feet" as SW420 came to a stop.

The LC said the taxiway lights were bright. He thought the distance from the tower to the north end of runway 19, about 8,000 feet, might have been a factor also. The distance from the tower to the intersection where the incident occurred was about 4,000 feet. The LC said that in his experience pilots usually request intersection departures when they want one. He said the clearance he issued to CTL21 was clearance to taxi to the approach end of runway 19, not to an intersection. The LC expected the airplane to be at the end of the runway since he was not informed otherwise. The LC was not aware that Central Airlines pilots normally made intersection departures. He had not worked in the tower recently due to training he was receiving elsewhere in the facility.

The LC had attended the ATC Academy before his assignment to the Kansas City tower. The LC thought that coordination between controllers was taught either in phase II or III of training at the ATC Academy, but he did not recall details of the training. The LC said traffic levels at night at the Kansas City facility, where he received his OJT, were normally too light for effective training and he received very little training in the tower during night operations on the ground control or local control positions.

The tower supervisor was not present in the tower cab at the time of the incident. He was elsewhere in the facility conducting an initial investigation into an operational error that had occurred earlier in the shift. The CC had been assigned to the CC position at various times during the shift, and she assumed the designation of CIC, along with her assigned position of CC, about 25 minutes before the incident when the supervisor left the cab. The CIC/CC said that because traffic was light, she seated herself at the supervisor's desk and studied a radar map. She was not viewing the operating area at the time of the incident. The CIC/CC said she noticed the GC/FD/CD making an ATIS tape and noted he was having trouble with the ATIS machine. After the incident she said she directed an unassigned controller to make the ATIS tape so the GC/FD/CD could get back to his position.

The CIC/CC said she would have expected the Central Airlines flight to take an intersection for takeoff, "either to taxi right to it without asking, or to request it." She said persons working the ground control or local control positions should know the locations of all assigned aircraft, and when in doubt, they should contact the aircraft. She pointed out that the GC should advise the LC when an aircraft is at an intersection for

departure and, further, that some controllers write it on the flight progress strip, although it was not a requirement. She recalled that the subject of coordination between the ground control and local control positions was covered briefly during classroom assignments at the ATC Academy "but not well." The CIC/CC served as a controller in the U.S. Navy for 5 years before her employment by the FAA. During her duties in the Navy, she was temporarily assigned to the Los Angeles International Airport tower in 1981 shortly after the controller strike called by the Professional Air Traffic Controllers Organization, and was certified on that facility's ground control position in minimum time. She was appointed as ground control instructor for the duration of her assignment at Los Angeles.

Safety Board investigators questioned the CIC/CC regarding ATC training she received in the military versus the training she received at the ATC Academy. She said her Navy ATC training was superior to the FAA's ATC Academy training and also to the training received at FAA facilities. She said the training she received in military ATC school regarding coordination techniques and procedures was very good.

The Kansas City tower's ATM explained, "The FAA Academy is a screening process, not a training program. Everybody knows that the facility does the real thing." Additionally, the ATM said that as the result of a letter received from the FAA Associate Administrator for Air Traffic dated June 11, 1985, his facility conducted a "self-assessment" including an in-depth review of problems in coordination between the local control and ground control positions and on the duties and responsibilities of the CIC/CC. The self-assessment review did not include GC/LC strip-marking relevant to intersection departures.

All controllers involved in the incident had previously received briefings, required by the FAA, on the subject of runway incursion incident prevention.

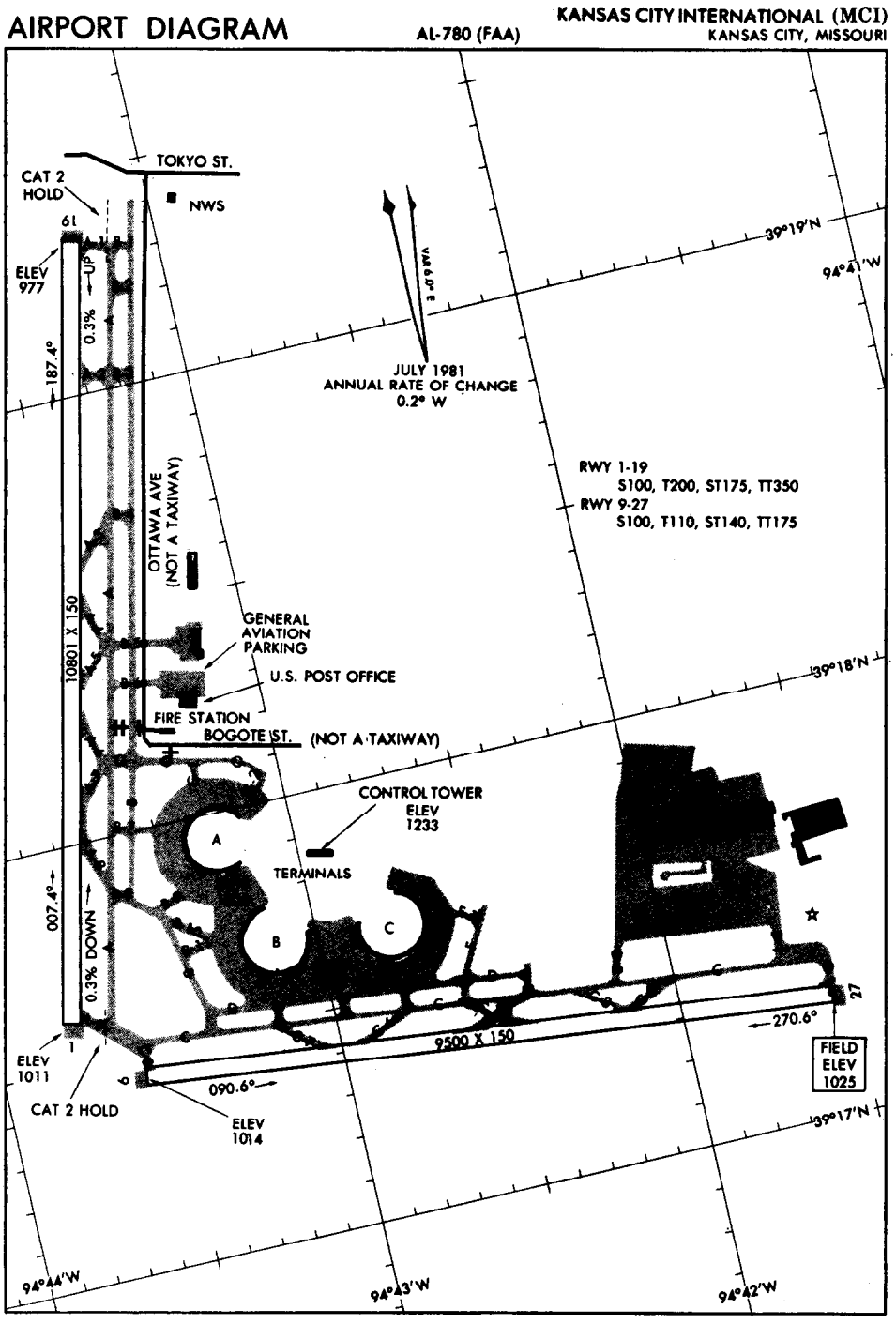
The captain of SW420 said that just after his airplane touched down, he noticed lights moving out onto the runway. Upon seeing the lights, he applied maximum reverse thrust and maximum braking and asked the tower who was on the runway. He said that when he brought his airplane to a stop, it was about abeam the taxiway where the other airplane had cleared the runway. The captain said all available outside lights were in the "on" position on SW420 during final approach and landing.

The pilot of CTL21 said that when he taxied into position on runway 19, he could not see the final approach on the runway because of the angle of the taxiway he was on. After entering the runway, he felt something might be wrong because he noticed a brightness appearing from behind his airplane. The pilot said he responded by expeditiously clearing the runway on his own. As he cleared to the left, he saw SW420, which had just come to a stop where his airplane had been positioned on the runway.

In this incident the three controllers staffing the tower and the pilot of CTL21 might have prevented the incident had they been more alert and professional when performing their respective duties. Fortunately, SW420 alerted CTL21, which recognized the need to clear the runway to avoid the collision.

The pilot of CTL21 set the stage for the incident by entering the runway without advising the LC that he was at an intersection. The LC was the only controller in the tower cab who was not familiar enough with the Central Airlines operation to know to expect an intersection departure, even if it was not requested. The LC cleared CTL21 to position itself on runway 19 without confirming that the airplane was at the approach end of runway 19. The GC/FD/CD could have averted the incident by monitoring CTL21 as it taxied toward the runway. Had he done that and alerted the LC to anticipate an intersection departure, or had he requested confirmation from CTL21 regarding its intentions and marked the flight progress strip accordingly, the LC might have been forewarned. The fact that the GC was also performing FD/CD duties probably contributed to his failure in this regard. The CC/CIC was not performing her assigned function. Had she been alert to the traffic situation and the CTL21 departure, she might have recognized and averted the hazardous situation before SW420 landed.

Clearly, the lack of coordination among the tower controllers in addition to the lack of standard procedures with regard to intersection departures contributed to the LC's error.


AIRPORT DIAGRAM
AL-780 (FAA)
KANSAS CITY INTERNATIONAL (MCI)
KANSAS CITY, MISSOURI
TOKYO ST.
CAT 2 HOLD
NWS
61
ELEV 977
0.3% UP
187.4°
VAR 6.0° E
JULY 1981
ANNUAL RATE OF CHANGE
0.2° W
39°19'N
94°41'W
RWY 1-19
S100, T200, ST175, TT350
RWY 9-27
S100, T110, ST140, TT175
OTTAWA AVE
(NOT A TAXIWAY)
10801 X 150
GENERAL AVIATION PARKING
U.S. POST OFFICE
FIRE STATION
BOGOTE ST. (NOT A TAXIWAY)
39°18'N
CONTROL TOWER
ELEV 1233
TERMINALS
A
B
C
007.4°
0.3% DOWN
1
ELEV 1011
CAT 2 HOLD
090.6°
ELEV 1014
9500 X 150
270.6°
27
FIELD ELEV 1025
39°17'N
94°44'W
94°43'W
94°42'W

18. Atlanta, Georgia - 8/29/85

At 1851 (EDT) on August 26, 1985, N122NK, a Swearingen SA-26AT Merlin, taxied across runway 26L on taxiway Dixie while Delta Air Lines flight 1055 (DL1055), a Boeing 737, was on takeoff roll on runway 26L at the Atlanta Hartsfield International Airport, Atlanta, Georgia. The crew of DL1055 saw N122NK cross the runway quickly, well before they reached taxiway Dixie. DL1055 was able to rotate and lift off about 2,000 feet from the taxiway Dixie intersection. The crew of DL1055 said N122NK was well clear of the runway when they overflew the intersection.

Shortly before the incident, N122NK had been instructed to taxi from Air Center One to runway 27R via taxiway Dixie and to hold short of runway 26R. N122NK acknowledged this clearance. After issuing this clearance, the GC coordinated with the LC and recleared the flight to cross runway 26R and to hold short of runway 26L. N122NK also acknowledged this clearance, responding, "Right, Hold Short of 26L, NK." However, N122NK failed to hold short of runway 26L and taxied onto and across runway 26L while DL1055 was on takeoff roll. The LC confirmed that he coordinated the crossing of runway 26L, but that he advised the GC to cross N122NK after the departure of DL1055.

At the time of the incident, day VMC prevailed with scattered clouds at 1,000 and 3,500 feet, broken clouds at 10,000 feet, and visibility 12 miles.

The pilot of N122NK advised the Safety Board that his copilot was operating the radios but that both pilots were using the cockpit speakers to monitor communications from the tower. The copilot did not repeat ATC instructions to the pilot. The pilot said headsets were not available to the crew and that the cockpit noise level in N122NK was very high. The pilot said he looked both ways before and as he crossed runway 26L and that he did not see DL1055. The pilot said that when he heard "cleared to cross," he thought it was a clearance to cross runway 26L.

The pilot of N122NK said that as a result of this incident, the company owning the airplane provided headsets for its flightcrews operating Swearingen airplanes and that they are now used full-time.

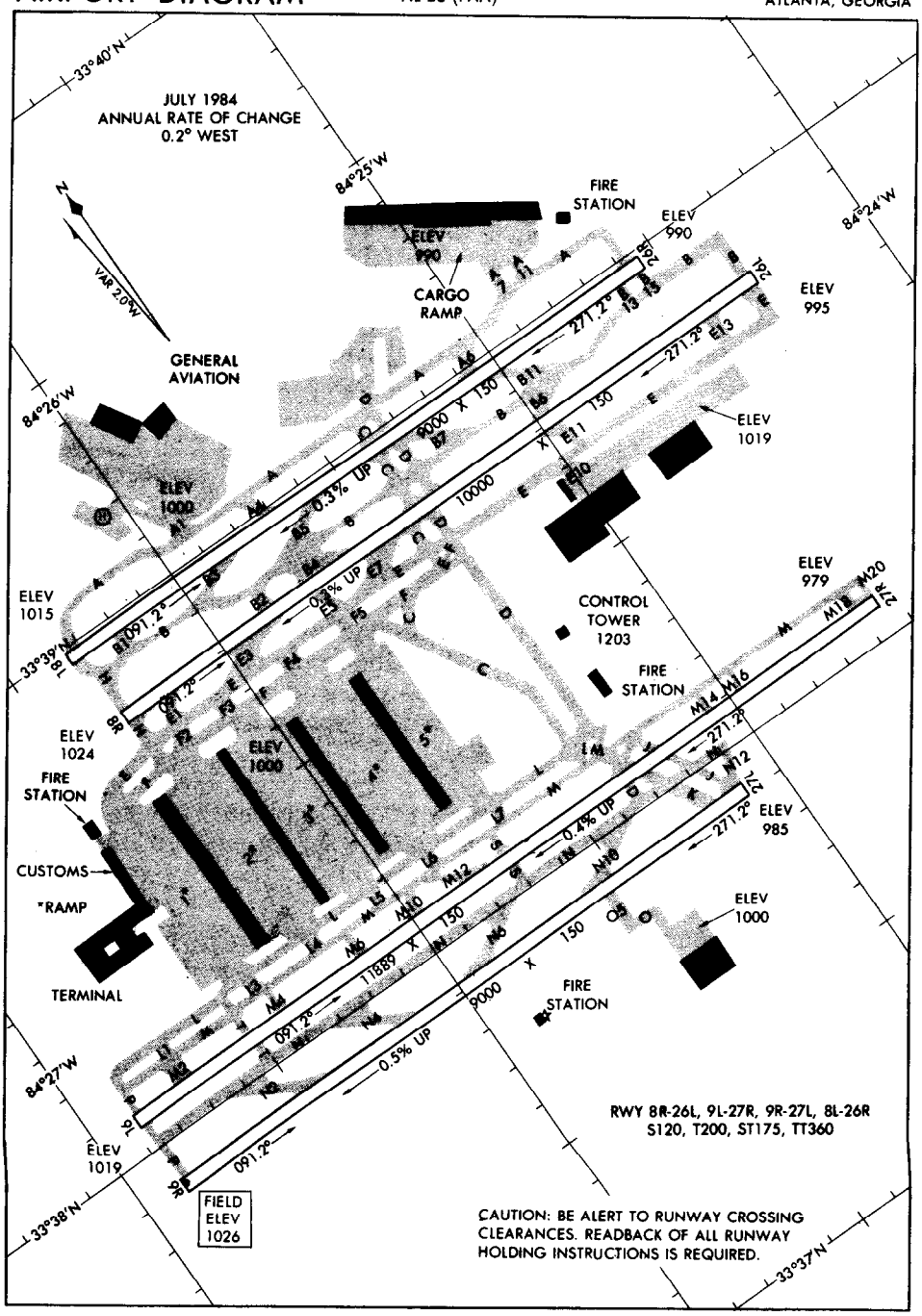
The captain of DL1055 said that when he received takeoff clearance, he applied engine power and started takeoff roll. The captain said he saw N122NK downfield approaching the runway during DL1055's takeoff roll. He assumed initially that N122NK would hold short of the runway. The captain said that as DL1055 approached 70 KIAS, he saw N122NK "dart" across the runway about 3,000 feet ahead. The captain said there was no need to take evasive action.

The Safety Board concludes that this incident occurred because the captain of N122NK was not sufficiently attentive when receiving the taxi clearances and he misunderstood the clearance. Although the copilot heard and correctly repeated the hold short instruction, he did not dedicate the instruction to memory since he assumed that the captain heard the instruction too. Affecting the crew's ability to understand the clearances was their reliance on cockpit speakers, despite the high level of cockpit noise in the airplane. The incident might have been avoided, in any event, if the crew had scanned the runway effectively before crossing. The Board believes that the N122NK crew would have detected DL1055 if they had effectively scanned the runway. The Board found that the coordination between the GC and LC was proper and did not contribute to this incident.

54

AIRPORT DIAGRAM

ATLANTA/THE WILLIAM B. HARTSFIELD ATLANTA INTL (ATL)
AL-26 (FAA)
ATLANTA, GEORGIA



19. Nashville, Tennessee - 9/3/85

At 1331 (EDT) on September 3, 1985, N1727S, a Mitsubishi MU-2, on approach to runway 20L, dove to avoid colliding with American Airlines flight 449 (AA449), a McDonnell Douglas MD-80, which was taking off from runway 13 at the Nashville Metropolitan Airport, Nashville, Tennessee.

Shortly before the incident, N1727S, arriving from the north on IFR and executing a visual approach, received clearance to land on runway 20L. Landing on runway 20L required an overflight of runway 13 at an altitude of about 200 feet above ground level about 6,000 feet from the approach end of runway 13. The LC issued a takeoff clearance to AA449 when N1727S was about 1 mile from the approach end of runway 20L. AA449 rolled onto runway 13, stopped briefly in position, and started its takeoff roll. After rotation, the captain of AA449 saw N1727S approach from his left and pass beneath his airplane. The copilot aboard AA449 estimated that N1727S passed about 200 feet beneath his airplane and that the horizontal separation was about 200 feet. N1727S crossed the path of AA449 from left to right and completed its landing on runway 20L. The pilot of N1727S said that when he saw AA449, he dove his airplane to pass beneath AA449; he estimated the minimum horizontal separation at about 100 feet and the vertical separation at less than 100 feet. Tower personnel said the distance between the two airplanes was "about 1,800 feet." An FAA Alert Bulletin on the incident, dated September 4, 1985, reported the closest proximity of the airplanes to be "Vertical: Zero, Horizontal: 1,600 feet." Recorded radar data obtained from the tower indicated a minimum lateral separation of 0.10 nautical mile (600 feet) at 1330:58.2.

At the time of the incident, day VMC prevailed with scattered clouds at 3,500 feet and visibility 10 miles.

The LC said N1727S called the tower when it was about 2 1/2 miles out on final approach for runway 20L and that she cleared N1727S to land at that time. The LC said that when AA449 called ready for takeoff, she issued takeoff clearance to AA449 for departure on runway 13. The LC said the CIC/CC pointed out that there appeared to be a conflict between AA449 and N1727S if AA449 departed runway 13 at that time. The LC said she saw the situation and instructed AA449 to "hold your position," although takeoff clearance previously had been issued. The LC said AA449 did not acknowledge this transmission but she saw AA449 taxi onto the runway and come to a stop. The LC said she assumed that AA449 was complying with the instruction to hold its position. At this time, the LC said she looked away from AA449 to view flight progress strips of other aircraft and when she looked at AA449 again, it was about 4,000 feet into its takeoff roll. The LC said that when she saw this, it appeared that the airplanes would not collide and that it would create more of a problem if she issued a go-around instruction to N1727S because there would be two airplanes climbing instead of one. Therefore, she said nothing to either airplane.

The CIC/CC said he assumed the combined duties of CIC/CC about 1 minute before the incident. He recognized almost immediately that a potential for a collision existed if AA449 was allowed to continue its takeoff. The CIC/CC said he pointed out the situation to the LC before AA449 started its takeoff roll. He said he heard the LC instruct AA449 to hold its position. However, he could not hear whether the flight replied because the LC was using a headset. The CIC/CC said he also saw AA449 come to what appeared to be a complete stop on the runway and then start its takeoff roll. The CIC/CC said he again called the situation to the attention of the LC, but mentioned to the LC that he felt the airplanes would be clear of each other.

The copilot of AA449 said he was operating the radios and the captain was making the takeoff. The copilot said he received the takeoff clearance from the tower, but neither he nor the captain heard subsequent instructions to hold in position before takeoff.

The LC entered on duty with the FAA at the Nashville tower in October 1980 and had been an FPL controller since May 1984. The CIC/CC entered on duty at the Nashville tower in November 1981 and had been an FPL controller since October 1984.

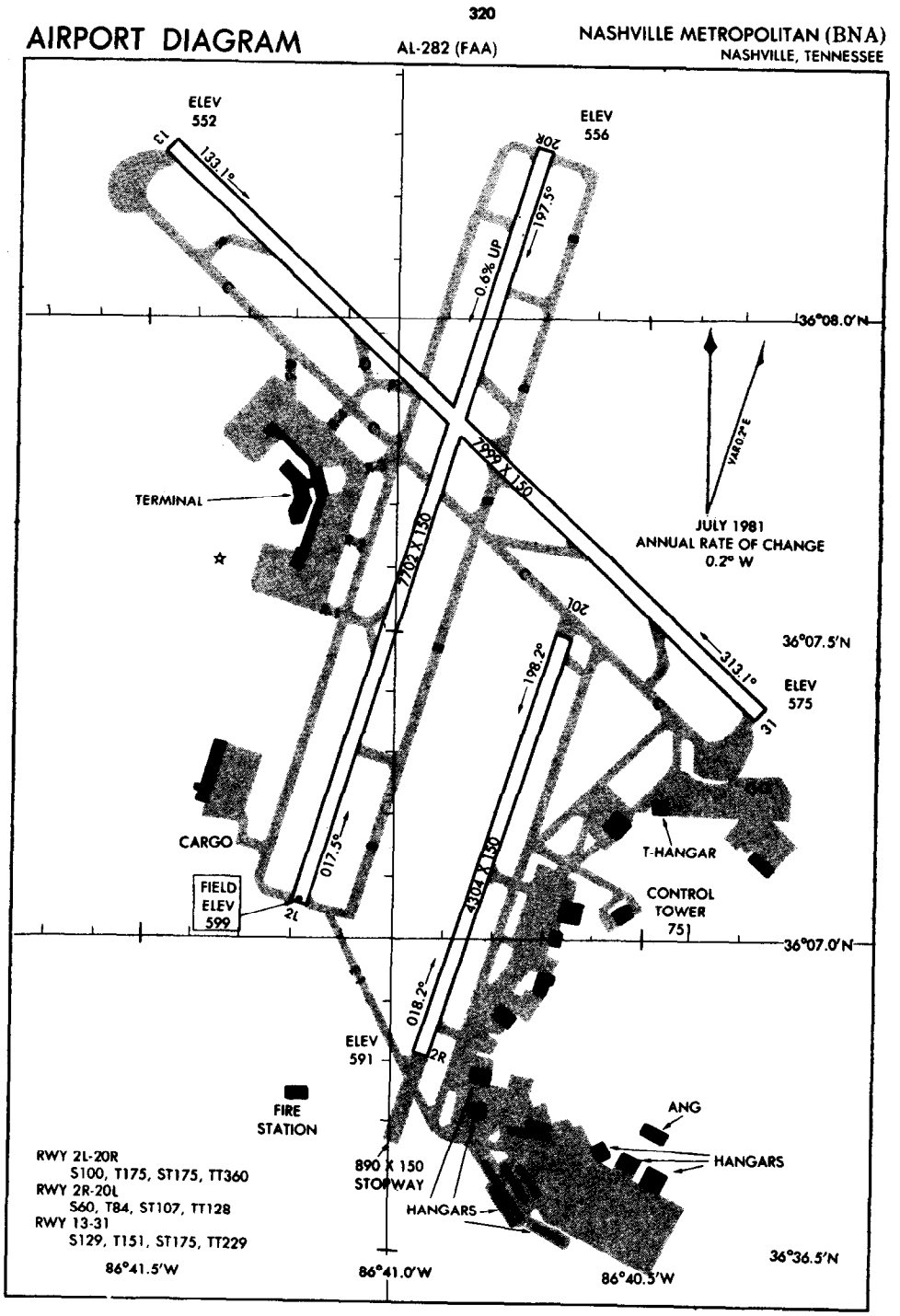
The runway configuration at the time of the incident was landings and departures on runways 20L and 13. The usual configuration was large aircraft landing and departing on runway 20R and small aircraft landing and departing on runway 20L. However, at the time of the incident, runway 20R was closed.

The LC said traffic at the time of the incident was moderate, which was normal for that time of day; the CIC/CC said traffic was busy. Before clearing N1727S to land on runway 20R, the LC cleared a Republic Airlines DC-9 to land on runway 13; she instructed N1727S that a Republic DC-9 would be landing on runway 13 and would cross in front of N1727S. The LC had two airplanes on approach for landing on runway 13 after AA449's departure; one was a BAC111 which had, she said, "a little over a minute before landing behind AA449 rotating." The LC said she issued the original clearance for takeoff to AA449, assuming that AA449 would clear runway 20L before N1727S landed. When the CIC/CC expressed doubt as to the separation, she agreed and cancelled AA449's takeoff clearance.

The LC said flightcrews usually acknowledged her instructions but periodically did not. She said the traffic level was a factor in her not insisting on an acknowledgment. When she saw AA449 stopping, she assumed her instructions were being heeded, and she turned her attention to other duties.

This incident represents a breakdown in the use of standard operating procedures. AA449 did not acknowledge the LC's instruction, and since the LC needed an acknowledgment to ensure traffic separation, the LC should have asked AA449 again for acknowledgment. The LC's failure to follow standard operating procedures suggests a failure in training, supervision, and evaluation procedures.

Other factors in this incident were an unusual runway departing and landing configuration and an approaching airplane that was expected to land soon after the departure of an airplane on the same runway. The Safety Board believes that the LC's attempt to accommodate the approaching airplane due "a little over a minute" after AA449's takeoff roll could have been a factor in her original clearance of AA449 to take off.


320
AIRPORT DIAGRAM
AL-282 (FAA)
NASHVILLE METROPOLITAN (BNA)
NASHVILLE, TENNESSEE
ELEV 552
ELEV 556
ELEV 575
ELEV 591
2L
133.1°
20R
197.5°
0.6% UP
36°08.0'N
7999 X 150
7702 X 150
VAR 0.2°E
JULY 1981
ANNUAL RATE OF CHANGE
0.2° W
TERMINAL
20L
313.1°
31
36°07.5'N
198.2°
CARGO
017.5°
T-HANGAR
FIELD ELEV 599
2L
2304 X 150
CONTROL TOWER 751
36°07.0'N
018.2°
2R
FIRE STATION
ANG
HANGARS
890 X 150 STOPWAY
HANGARS
RWY 2L-20R
S100, T175, ST175, TT360
RWY 2R-20L
S60, T84, ST107, TT128
RWY 13-31
S129, T151, ST175, TT229
86°41.5'W
86°41.0'W
86°40.5'W
36°36.5'N

20. Washington, D.C. - 9/24/85

At 1722 (EDT) on September 24, 1985, an Eastern Airlines Boeing 727 and a Bell 206 helicopter were cleared for takeoff by different controllers at about the same time at Washington National Airport, Washington, D.C. The aircraft almost collided over runway 36 as the airplane rotated for takeoff and the helicopter approached at low altitude intending to cross runway 36 from west to east. A collision was narrowly averted when the pilots of both aircraft took evasive action. The helicopter pilot pulled up and turned sharply to the left to avoid flying into the path of the airplane. The airplane captain rejected takeoff by closing the throttles, pushing the nose down, deploying the speed brake, and applying maximum braking. The airplane rolled beyond the north end of runway 36 onto the overrun and was finally brought to a stop about 40 yards short of the Potomac River.

The LC had cleared the airplane for takeoff on runway 36. The HC, who worked the helicopter control position, cleared the helicopter for takeoff in response to the helicopter pilot's request for a departure via "route one to Greenbelt." The HC cleared the helicopter for takeoff without amplification regarding direction of departure. The helicopter pilot departed to the east, the most direct route to Greenbelt, Maryland, via route 1 (a military route depicted on a Department of Defense, Special Military Helicopter VFR Route Chart). Although the most direct path to intercept route 1 to Greenbelt was to the east and over runway 36, the HC did not coordinate the helicopter's crossing of the active runway with the LC because she believed the pilot would depart to the northwest, away from all active runways.

The supervisor in the tower cab was working the local control position and was therefore unable to oversee and supervise the work of other controllers. The tower was adequately staffed to free the supervisor of controller duties. However, three controllers, who were qualified in all tower cab positions, were on break at the time of the incident.

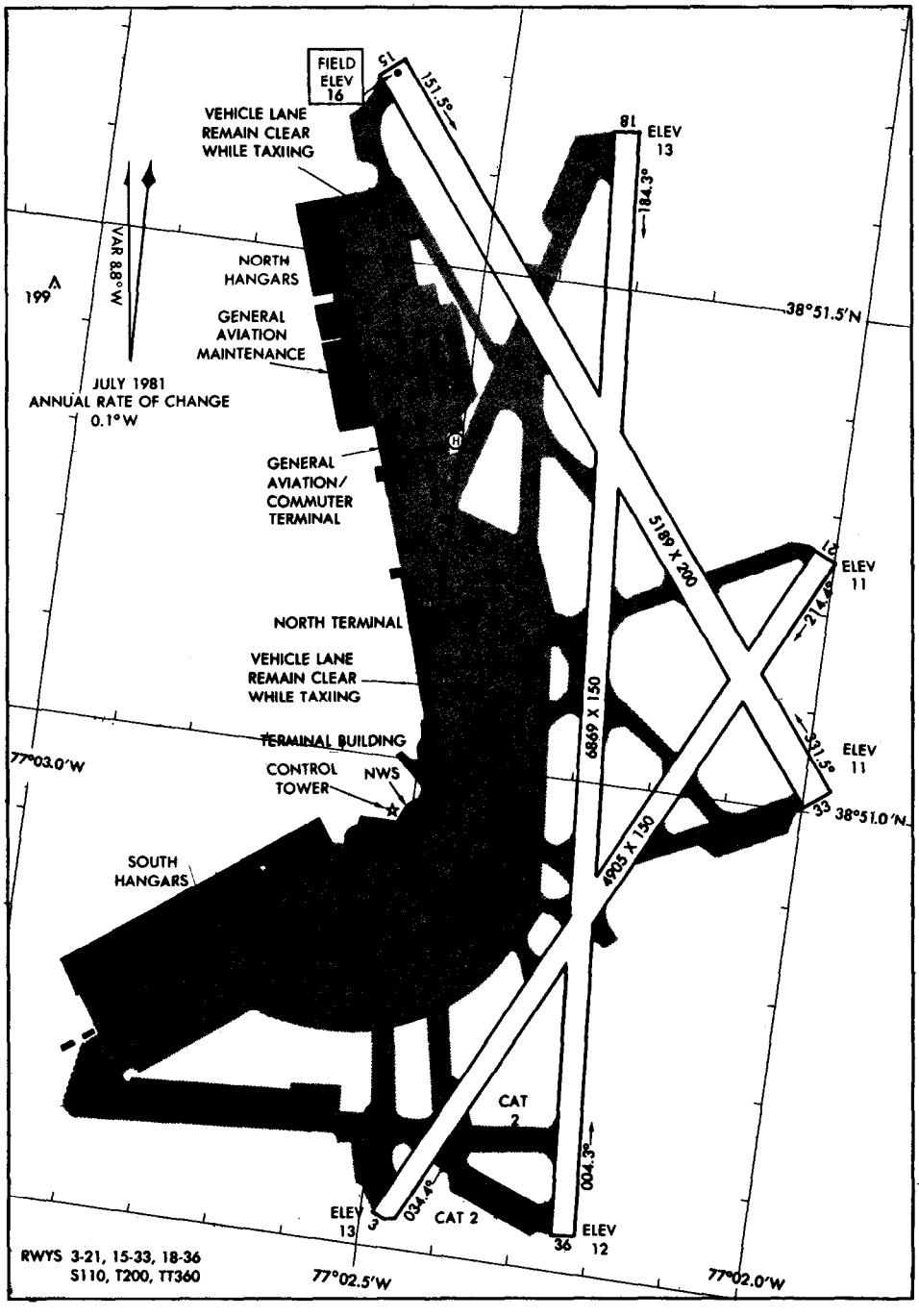
The Safety Board's investigation of the incident revealed that controllers at the airport did not agree on what the proper helicopter departure clearance should have been and what the helicopter pilot should have done under the circumstances. The military chart was not generally available to civilian helicopter users, and tower personnel had no assurance these users would have access to the charts or that they would comply with the routes depicted on the chart unless they had filed a letter of agreement with the tower. The helicopter pilot involved in this incident was not represented by any group addressed by letters of agreement on file at the airport. However, he was familiar with the military chart.

The Safety Board found the deficiencies in the HC's performance and knowledge disturbing. The HC did not realize that the clearance she issued allowed the pilot unintended flexibility in intercepting route 1. Although the HC had no intention of clearing the helicopter for a departure to the east, the imprecise takeoff clearance which she issued allowed that departure and led to the incident. Further, the lack of consensus demonstrated by controllers at the airport regarding helicopter control procedures illustrated that there were also deficiencies in training at the facility. A review of records related to controller training conducted at the airport revealed that there were deficiencies regarding both the substance and administration of the technical appraisal program, which evaluated facility compliance with FAA training and evaluation requirements. The Board addressed these issues and the issue of making military helicopter arrival/departure route charts available to civilian users in Safety Recommendations A-86-7 through -12 issued to the FAA on January 15, 1986.

AIRPORT DIAGRAM

304
AL-443 (FAA)

WASHINGTON NATIONAL AIRPORT (DCA)
WASHINGTON, D.C.



21. Bangor, Maine - 1/7/86

At 1005 (EST) on January 7, 1986, MAIZE84, a Boeing KC-135, operated by the Maine Air National Guard (MeANG), touched down on a closed portion of runway 33 at Bangor International Airport, Bangor, Maine, while airport personnel with equipment were conducting snow removal operations within the first 2,000 feet of the runway. About 5 minutes before the incident involving MAIZE84, Delta Air Lines flight 562 (DL562), a Boeing 727, landed on runway 33 over the closed portion of the runway. The LC had informed DL562 of the closed portion of the runway.

When MAIZE84 departed the airport earlier for a planned 1-hour local training flight, airport personnel were conducting snow removal operations on runway 33 adjacent to the runway 33 glide slope antenna. To conduct these snow removal operations, the first 2,000 feet of runway 33 was listed as "closed" on the ATIS, leaving 9,440 feet of the 11,400-foot runway "open."

At the time of the incident, the prevailing wind was from 300 degrees at about 10 knots with occasional gusts and the sky was clear with visibility 15 miles.

MAIZE84 was making a practice ILS approach to runway 33, intending to make a touch-and-go landing, when the incident occurred. The LC cleared MAIZE84 for the landing with the restriction that the first 2,000 feet of the runway was closed. The LC said MAIZE84 touched down in the designated closed portion of the runway. The premature touchdown reportedly was unintentional. The LC said that immediately after MAIZE84 touched down, it lifted off again and started to climb.

The GC said there were numerous snow removal vehicles within the first 2,000 feet of runway 33 and agreed that that portion of the runway was closed. The GC estimated that MAIZE84 touched down about 1,500 feet from the threshold of runway 33. The GC said that after MAIZE84 touched down, an airport employee who was in an airport vehicle on the closed portion of the runway contacted the GC and said the airplane touched down 1,200 feet from the runway 33 threshold.

The investigation revealed that, although a portion of runway 33 was closed, airport personnel did not initiate a NOTAM reporting the closure, as required by FAA Handbook 7930.2A, paragraph 603. The airport manager said it was common practice for the airport, during periods of good weather, to close up to the first 4,000 feet of runway 33 so airport personnel could perform maintenance on the runway. Maintenance personnel used this procedure because runway 15/33 was the airport's only runway and the procedure allowed the runway to remain open. The airport manager said airport maintenance personnel usually remained on the closed portion of the runway while aircraft landed over them. He said maintenance personnel would ask tower personnel for approval to work on a portion of the runway and that tower personnel would either approve or disapprove the request based upon traffic. The airport manager said NOTAMs were not issued during these maintenance operations and that closure information was disseminated only locally, usually by the tower to arriving aircraft. He said maintenance personnel rarely provided visual marking to identify temporarily displaced runway thresholds. He said portions of the runway usually were not closed for more than 4 hours at a time. The airport manager said he was reluctant to close the entire runway for any period of time beyond 15 minutes because he did not wish to discourage air carrier operations at the airport.

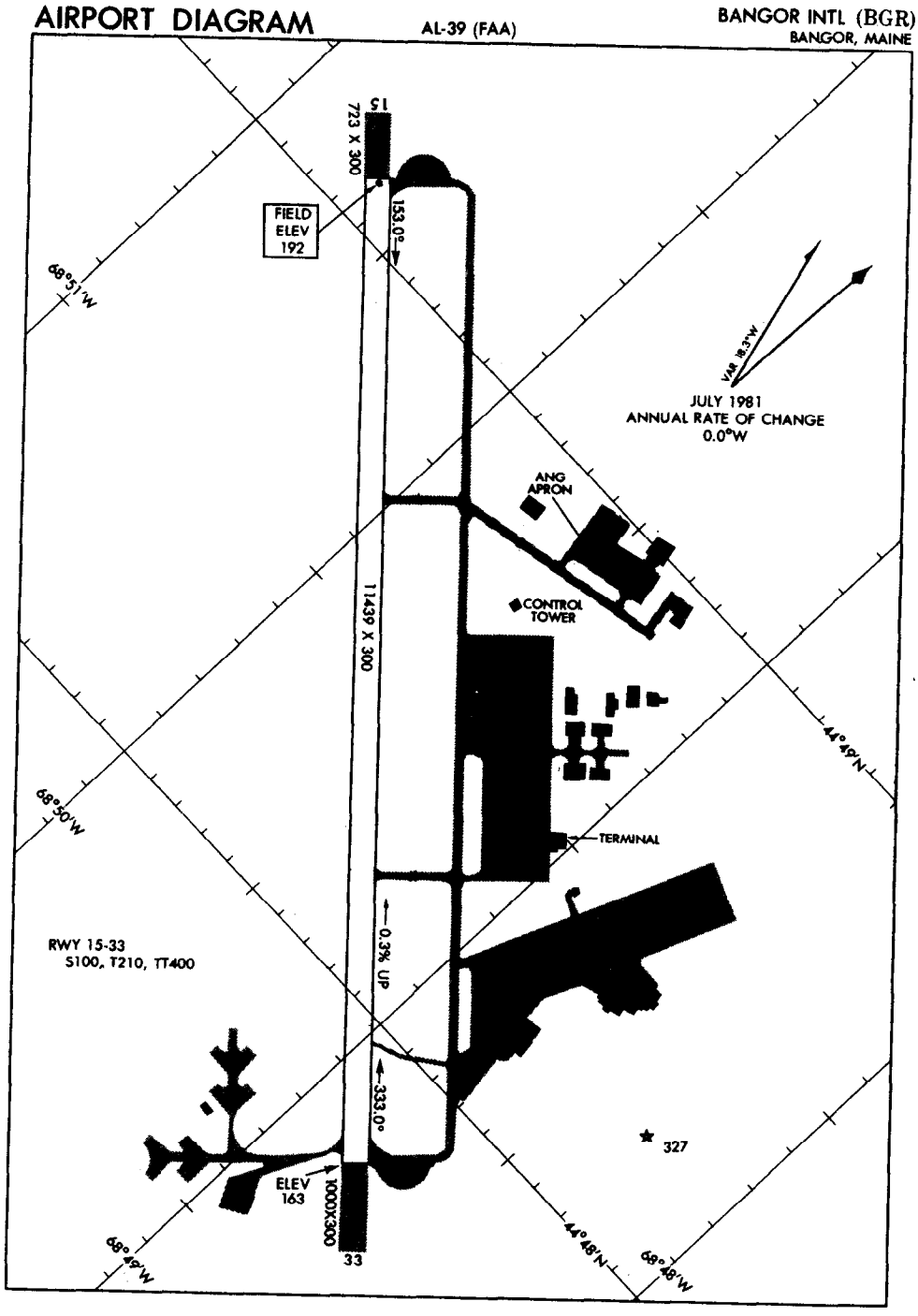
The pilot of MAIZE84 said he was aware that the first 2,000 feet of the runway was closed. He planned his landing touchdown point beyond the closed portion of runway 33. The pilot said the approach was normal until just before touchdown. Power had been retarded to idle in preparation for a landing at a point about 1,000 feet beyond the closed portion of the runway. However, shortly after retarding the power, at about 50 feet above the runway surface, the airplane's speed rapidly decreased by about 15 knots and a rapid sink rate developed. The pilot said he attempted to arrest the sink rate by immediately applying maximum thrust and by rotating the airplane's nose upward. The pilot said these actions resulted in decreasing the sink rate but he was not able to keep the airplane from contacting the runway short of his intended touchdown point.

The FSO from the MeANG's 101st Air Refueling Wing, the unit to which MAIZE84 was assigned, said he was aware that it was common for the airport to close a portion of the runway, usually at the approach end, to perform required maintenance and said he had experienced this practice many times. The FSO said his unit's aircrews were familiar with the practice and "worked around it" to complete flight training requirements.

An FSO assigned to U.S. Air Force (USAF) Headquarters, Washington, D.C., advised Safety Board investigators that closing the first 2,000 feet of a runway for snow removal was an accepted practice in some cases, but only after an airport submitted a formal request to the appropriate FSO. The FSO said the airport's request would be evaluated and the USAF Headquarters flight safety office would issue final approval. The FSO said his office was not aware of such a request having been submitted by the 101st Air Refueling Wing, MeANG. The FSO said a request to conduct such operations would be approved only for USAF aircraft based at the airport and only after aircrews based at and operating from the airport had been briefed extensively.

A senior flight manager for Delta Air Lines said its operating requirements prohibited landings on closed or partially closed runways and had Delta central dispatch been aware that any portion of the runway was closed, DL562 would not have been dispatched to the airport.

Although this incident might have been dismissed simply as an operational misjudgment by the flightcrew of MAIZE84, investigation into the incident revealed more significant errors that may relate to other runway incursion incidents. The practice of temporarily closing a portion of a runway yet allowing aircraft operations on the remaining runway endangers maintenance personnel who may be on the closed portion of the runway. To reduce the potential hazard to such personnel, the FAA requires that airport operators announce such intended closures by issuance of a NOTAM to ensure that flightcrews learn of the risk during flight planning. This incident occurred because the airport manager was unwilling to close the airport for runway maintenance or to announce his intent to close the runway by use of the NOTAM process. The USAF and Delta personnel involved in this case apparently were not fully aware of their own operational procedures.


AIRPORT DIAGRAM
AL-39 (FAA)
BANGOR INTL (BGR)
BANGOR, MAINE
15
723 X 300
FIELD ELEV 192
153.0°
68°51'W
VAR 18.3°W
JULY 1981
ANNUAL RATE OF CHANGE
0.0°W
ANG APRON
CONTROL TOWER
11439 X 300
44°49'N
68°50'W
TERMINAL
RWY 15-33
S100, T210, TT400
0.3% UP
333.0°
327
ELEV 163
10000X300
33
68°49'W
44°48'N
68°48'W

22. Chicago, Illinois - 2/25/86

At 0910 (CST) on February 25, 1986, at O'Hare International Airport, Chicago, Illinois, the captain of United Air Lines flight 127 (UA127), a McDonnell Douglas DC-8-71, which was on takeoff roll from runway 32L, avoided colliding with Air Wisconsin flight 842 (AW842), a Fokker F-27, which was on final approach for landing on intersecting runway 9L. The captain of UA127 saw AW842 and delayed rotation to a takeoff attitude until AW842 had crossed his departure path. AW842 overflew UA127 near the intersection of runway 32L and taxiway T7 at about 150 feet above the ground. The captain of UA127 said that had UA127 rotated and lifted off normally, the airplanes would have collided. Afterward, UA127 rotated and lifted off at 175 to 180 knots.

Day VMC prevailed with clear sky and excellent visibility.

The airplanes were cleared by different LCs for their respective takeoff and landing. Neither controller coordinated with the other controller regarding his airplane and both controllers said they did not see the incident. Thus, neither controller informed the airplane crews of conflicting traffic. The LC3, who issued the takeoff clearance to UA127, learned of the incident immediately afterward when the captain of UA127 reported it and advised that he considered it a near-collision. The LC3 apparently did not report the incident to his supervisor or to other tower management personnel. Tower management reportedly learned of the incident on February 26, 1986, when United Air Lines operations personnel telephoned to complain about the incident.

Before the incident, the airport was landing aircraft on runways 9L, 9R, and 4R; departing aircraft were using runways 4L, 9L, and 32L. Traffic was considered light to moderate by airport standards, but was sufficient to dictate a requirement to use three runways for arrivals (three runways are used for peak/rush hour traffic periods). Aircraft departing runway 32L were using taxiway T1 as their starting point, allowing 8,800 feet for takeoff roll and eliminating potential crossings of runway 9R by taxiing aircraft. Aircraft arriving on runway 9L were spaced at 6- to 8-mile intervals to allow separation between departures from runway 32L and arrivals to runway 9L. This procedure also eliminated any coordination requirement between the LC3 responsible for runway 32L departures and the LC handling runway 9L arrivals. The LC3 and LC4 positions had been combined earlier, but about 0850 the decision was made to reestablish the separate local control positions. The controller then assigned as LC3 was responsible for runways 32L and 9R. The LC4 was responsible for runways 9L and 4L.

The LC3 cleared UA127 for takeoff at 0909. At that time AW842 was on final approach and the LC4 had already cleared AW842 to land. The LC3 did not coordinate the departure with the LC4 because such action normally was not required with such large arrival intervals and because he believed AW842 was just west of (about to overfly) runway 32L. The LC3 had a BRITE display available to observe aircraft on approach to the airport. He said he observed AW842 just west of runway 32L, cleared UA127 for takeoff, and then turned his attention to an airplane that was on final approach to runway 9R. He said that because he was focusing his attention on that airplane, he did not see the incident. The investigation revealed that AW842 had to have been between 1.5 and 2 miles west of runway 32L when UA127 was cleared for takeoff.

The LC4 did not see the incident because he was focusing his attention on other traffic on the airport. A supervisor did not see the incident because he was assisting a GC on the other side of the tower cab. Staffing in the tower was considered adequate at the time of the incident. Traffic on the LC3's frequency apparently was not a factor because the LC3 was working only three airplanes. No equipment problems contributed to the incident.

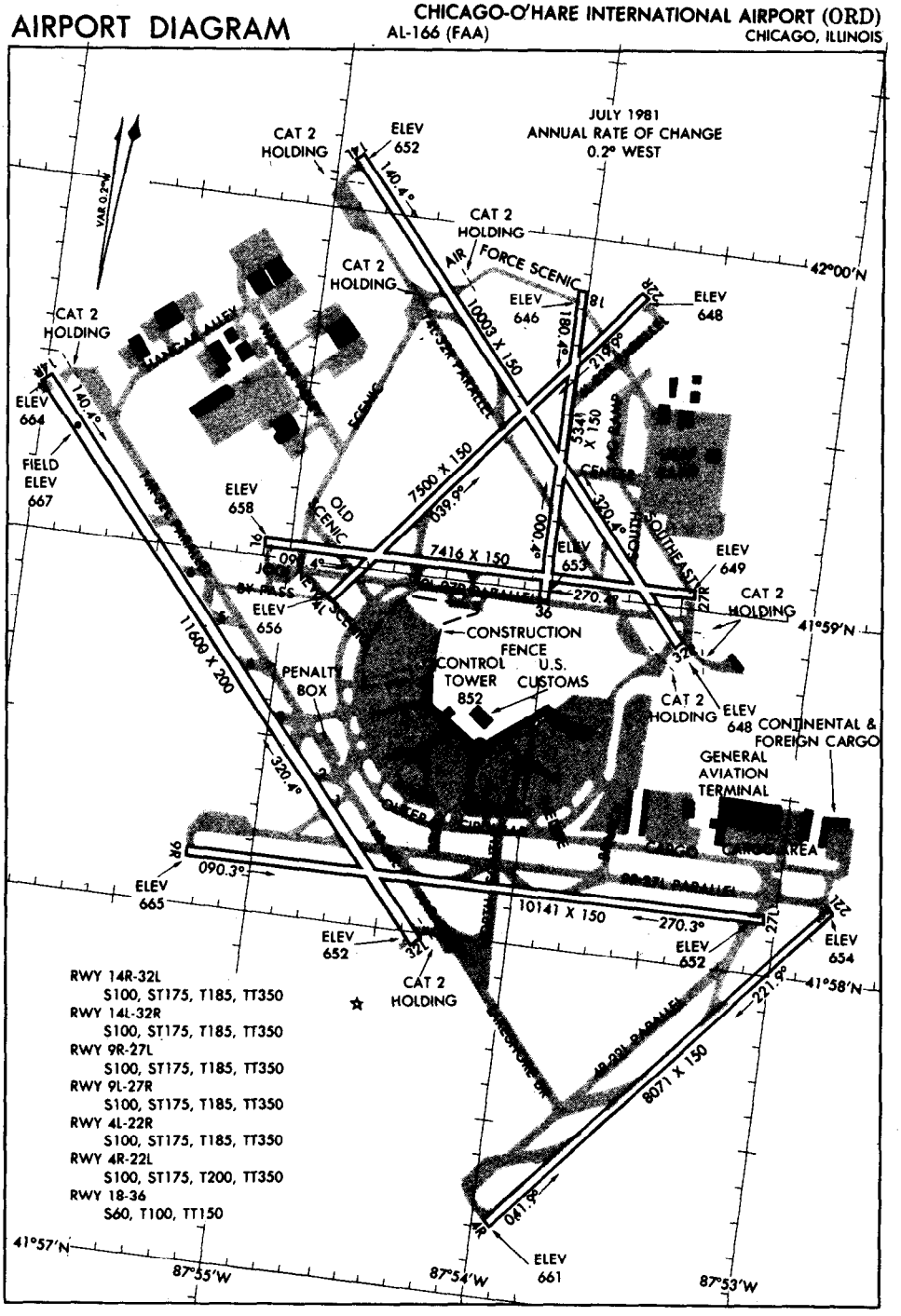
The Safety Board believes that the LC3 allowed this incident to occur because he issued a takeoff clearance without adequately scanning his operating area. The Board believes that the procedures in effect at the airport at the time of the incident were based on the assumption that the traffic spacing and a single controller's vigilance were sufficient to prevent conflicts between landing and departing aircraft on runways with intersecting flightpaths. This incident points out the error of that assumption. Where the possibility of inadequate scanning and decisionmaking of one controller is present, as it was in this case, coordination between the controllers controlling intersecting ground or air space is a necessary redundancy. The Board believes that coordination of the departure between the LC3 and the LC4 would have resulted in identification of the traffic and prevented the incident.

The Safety Board investigation also revealed evidence of previous performance deficiencies by the LC3 who was responsible for preventing collisions between aircraft arriving on runway 9L and aircraft departing runway 32L. The controller was involved in two other operational error incidents in the past year, the first involving improper authorization to taxi a small airplane behind a Boeing 747 that was operating its engines at high power, and the second involving incomplete coordination with another ATC sector that resulted in less than standard radar separation between two IFR aircraft.

Although the controller was not decertified following the first error, he received 10 hours of instruction and discussion from his supervisors and facility staff officers. The discussion included a review of pertinent facility orders and procedures. Following the second error, the controller was decertified. He received 15 hours of remedial training on radar control, separation, and coordination, after which he was to be reevaluated. Before the reevaluation the controller requested and received reassignment to work exclusively in the tower cab. The controller was decertified on all control positions in the tower following the February 25, 1986, operational error, was assigned to work only on the noncontrol FD/CD positions, and has requested reassignment to the DuPage, Illinois tower.

The Safety Board believes that the ATC procedures at the airport were not sufficient to prevent this incident. The procedures allowed one controller to cause a breakdown in the system of aircraft separation. While all reasonable human error cannot be eliminated by design, the Board believes that compliance with proper coordination procedures between controllers would make errors such as the one in this accident less likely.

(See airport diagram on page 67.)



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