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NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C.

ISSUED: NOV 9 1984

Forwarded to:

Honorable Donald D. Engen
Administrator
Federal Aviation Administration
Washington, D.C. 20591

SAFETY RECOMMENDATION(S)

A-84-116 through -122

The National Transportation Safety Board has investigated the circumstances which led to an air traffic control operational error on May 9, 1984, in the vicinity of the Philipsburg, Pennsylvania, very high frequency omni-directional range/tactical air navigation (VORTAC) facility (PSB). Four air carrier airplanes and one corporate jet were involved in the traffic situation which resulted in four distinct conflicts in which the acceptable separation of 2,000 feet vertical and/or 5 miles lateral was compromised.

About 1635, 1/ KLM Flight 621 (KLM 621), a Boeing 747, operating from Amsterdam, the Netherlands, to Atlanta, Georgia, was proceeding southwest at flight level (FL) 310 2/ toward Philipsburg. The flight was in airspace controlled by the Milton high altitude sector of the New York Air Route Traffic Control Center (ARTCC) and was approaching the boundary where it would enter airspace controlled by the East Texas high altitude sector, which is a part of the Washington, D.C., ARTCC. This boundary between the Milton sector and the East Texas sector is about 8 nmi north of Philipsburg. (See figure 1.)

As KLM 621 was proceeding toward Philipsburg, U.S. Air Flight 2 (US Air 2), a Boeing 737, was proceeding northeast toward Philipsburg and climbing to FL 330 in airspace controlled by the Cleveland ARTCC. On this routing the airplane would enter the Washington ARTCC East Texas sector about 4 nmi west of Philipsburg. Three other airplanes, United Flight 1009 (UAL 1009), a Boeing 737; Northwest 157 (NW 157), a Boeing 727; and a corporate Cessna Citation (N1252J), all were within the boundary of the East Texas sector, in level flight at FL 310, and approaching Philipsburg from the east with the

1/ All times shown are eastern daylight time and are based on the 24-hour clock.

2/ FL 310 signifies a flight level at a height where the pressure is equal to the pressure that exists at 31,000 feet above sea level in a standard atmosphere.

prescribed lateral separation. Thus, the three controllers ^{3/} who were assigned to the East Texas sector at the time were confronted with an immediate task of fitting KLM 621 and US Air 2 into the sequence of traffic converging on PSB at FL 310. This problem was only a part of the controllers' total responsibility which concurrently included providing the vertical or lateral separation for about 18 other aircraft which were on the sector radio communication frequency.

Under prescribed air traffic control procedures, the New York ARTCC and Cleveland ARTCC controllers were responsible for initiating the handoffs ^{4/} of KLM 621 and US Air 2, respectively, and the Washington ARTCC East Texas sector controllers were responsible for either accepting the control responsibility for the flights or advising the transferring controller(s) that they would be unable to fit the additional traffic into the existing traffic flow.

In the situation at hand, the New York ARTCC controller had initiated an automated interfacility handoff for KLM 621, causing the target to appear with the flashing alphanumeric data block on the East Texas sector controller's display when the aircraft was about 40 nmi north of the Washington ARTCC boundary. The Cleveland ARTCC controller also had initiated the automated handoff for US Air 2. The East Texas sector radar controller, noting the handoff, perceived that a conflict was developing between US Air 2 and UAL 1009, one of the flights approaching from the east. To resolve this conflict, the radar controller directed his handoff controller to tell the Cleveland ARTCC controller to have U.S. Air 2 turn to a new heading. At the same time, the East Texas sector radar controller directed UAL 1009 to turn 20° to the right. These steps minimized the collision hazard although the aircraft were separated by slightly less than 2,000 feet vertically and 1.2 nmi horizontally when they passed.

As the East Texas sector controllers were resolving this problem, they were not attentive to the display of KLM 621. When it became apparent to the New York ARTCC controller that the flight was nearing the ARTCC boundary where control options would expire, he attempted to contact the East Texas sector via landline voice communications. Although the East Texas sector controller did not respond immediately, the New York ARTCC controllers permitted KLM 621 to continue toward PSB. The East Texas sector radar controller later stated that he had noted KLM 621 and directed his handoff

^{3/} Depending upon the sector workload and the ARTCC facility staffing level, the sector may be manned by one to three controllers. If only one controller is assigned, he/she is required to perform all of the essential controller functions; that is, to monitor the displayed positions of all aircraft for which control responsibility has been accepted, to direct those aircraft so as to maintain acceptable vertical or lateral separation, to communicate with the aircraft, and to coordinate the transfer of the control of aircraft before they leave or enter the sector with the controllers of adjacent sectors. When the amount of traffic becomes too demanding for one person, a second controller assigned to the sector will perform the control transfer (handoff) functions or the ancillary duties required for planning the separation of traffic using nonradar procedures. During peak periods a third controller may be assigned specifically to perform these ancillary duties. When two or more controllers are assigned to a sector, the radar controller is free to concentrate on the primary function of traffic separation and communication.

^{4/} An action taken to transfer the control of an aircraft from one controller to another controller when the aircraft will enter the receiving controller's airspace and radio communications with the aircraft will be transferred. The handoff may be initiated by voice communication between controllers or electronically by the transferring controller using the ATC computer to shift the radar identification data to the receiving controller's console. The transferred target will appear on the receiving controllers display with a flashing alphanumeric data block.

controller to inform the New York ARTCC controller that "KLM is not going to fit, tell them to spin him." The handoff controller did not complete this assignment. The handoff controller said later that he was busy trying to catch up. Later, when he recognized the developing conflict involving KLM 621, he attempted to tell the New York ARTCC controllers to turn the flight 360° to the right to provide separation. The handoff controller, however, mistakenly activated the wrong landline voice circuit to the Cleveland ARTCC controller who had no responsibility for or knowledge of KLM 621. Thus, the New York ARTCC Milton sector controllers did not receive any response from the Washington ARTCC East Texas sector controllers.

The New York ARTCC Milton sector was being manned by three controllers; a trainee who was taking a radar certification check for the sector, a qualified radar controller who was responsible for the ATC sector operation, and a handoff controller. A supervisor was observing the Milton sector control operations to monitor the trainee's performance. As KLM 621 continued toward the Washington ARTCC boundary without a handoff acceptance, the supervisor observed that the Washington ARTCC East Texas sector controllers would have a traffic conflict with the other traffic approaching PSB at FL 310. He took immediate action to direct KLM 621 to turn left, and realizing that the action was too late to prevent the flight's intrusion into the East Texas sector, he issued an emergency clearance for the flight to descend to FL 300.

The East Texas sector radar controller noted that KLM 621 had started a left turn toward UAL 1009, and he immediately directed UAL 1009 to enter an emergency climb to FL 320. KLM 621 and UAL 1009 came within 1 nmi horizontally and 750 feet vertically of each other. As KLM 621 continued to turn to the left, it headed directly toward NW 157 and then toward the corporate jet, N1252J, both of which remained at FL 310. Noting this, the New York ARTCC Milton sector controller issued further emergency clearance to KLM 621 to descend to FL 290. KLM 621 and NW 157 passed within 1.8 nmi horizontally and 580 feet vertically and KLM 621 and N1252J passed within 3.4 nmi horizontally and 1,400 feet vertically. The flightpaths of these aircraft as determined from an analysis of the FAA ATC radar recordings are shown on figures 2 through 6.

The investigation of this incident prompted the Safety Board to focus on several broad issues related to the safety of the air traffic control system--the general adequacy of the air traffic control staffing level and management practices and the current ability of the system to cope with peak traffic loads, as well as specific issues related to the incident under investigation--the factors considered in establishing the geographical boundaries of the Washington ARTCC East Texas sector, and the traffic handoff procedures used by the New York and Washington ARTCCs.

Air Traffic Control Staffing and Management

The controllers who were on duty in the Washington ARTCC had reported to work at about 1500, an hour and a half before the incident occurred. The East Texas sector, which was a part of a designated area B, 5/ was initially manned by a single controller who was performing all of the radar separation, handoff, and ancillary functions required for the sector. The area B supervisor, in an interview after the incident, said that he had been directed to attend a meeting with other facility managers after reporting to work. Another supervisor who was normally assigned to area C was given the area B supervisory responsibility while the regular supervisor was absent. The area B supervisor stated that he

5/ ARTCC substructure area.

returned to resume his duties at about 1610 and that he noted immediately that the East Texas sector was busy. Consequently, he moved a controller from another sector to handle the handoff duties for the East Texas sector. Shortly thereafter, he assigned a third controller to the sector. The Safety Board believes that assigning only one controller to the East Texas sector and the absence of the regular supervisor at the beginning of the work shift contributed to the development of the operational error. The controller's workload associated with the sector traffic volume prohibited him from adequately preplanning his aircraft separation strategy in order to avoid the convergence of airplanes on PSB at the same flight level. The controller, who had over 25 years of experience, should have recognized sooner that he would require assistance to maintain an orderly traffic flow. Further, the regular area supervisor might have perceived the developing demands more quickly than the substitute supervisor who was less familiar with the sector and the personnel. The regular supervisor might have taken earlier actions to provide the controller with assistance. The Safety Board believes that the traffic situation was becoming complicated well before the second and third controllers were assigned to the sector.

On May 19, 1983, as a result of its followup study of the Air Traffic Control System, 6/ the Safety Board recommended that the Federal Aviation Administration:

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. (A-83-38)

The FAA acknowledged the recommendation and stated its intention to make supervisors continuously available during high volume traffic operations at facilities where staffing is adequate. The Safety Board does not view the scheduling of the meeting which took the area B supervisor away from his duties as consonant with this recommendation even though there was a supervisor continually assigned to oversee the performance of the East Texas sector controller during the period preceding the operational error. The substitute supervisor does not appear to have been as familiar with the control problems unique to the sector as the regular area supervisor. The circumstances of the operational error emphasize the importance of the supervisor's role and show that a supervisor must not only be available, but that he/she must be thoroughly familiar with the sector(s) under surveillance. The management of ARTCCs should be more considerate of peak workload when scheduling meetings involving area supervisors. Such meetings should be scheduled during periods of minimum demand.

Although the May 9, 1984, traffic count may have been higher than normal, the East Texas sector had been recognized as a sector which normally was busy during the late afternoon and early evening hours. On May 18, 1984, during the investigation of this incident, the Safety Board noted that, based on scheduled data, 23 air carrier airplanes were predicted to be in the East Texas sector within a 15-minute period. Consequently, the Safety Board does not understand the management decision to staff the sector with a single controller at the beginning of the shift.

6/ For additional information read "Followup Study of the United States Air Traffic Control System" (NTSB/SIR-83/1) and Safety Recommendation letter, dated May 19, 1983, to the FAA Administrator (Recommendations A-83-35 through -43).

The Safety Board believes that the assignment of only one controller to a sector during periods of moderate to heavy traffic activity should be discontinued. The safety of the air traffic control system depends upon the safeguards provided by redundancy. The possibility of a missed or misinterpreted communication or any other human error is always present, but the chance that the error will remain undetected and become significant is much greater when the controller is working alone. The Safety Board fully concurs in the FAA Administrator's recent decision to modify the structured staffing ^{7/} concept to permit all controllers to progress to the full performance level radar qualification, and to increase further the total controller workforce.

At the time that this incident occurred, Washington Center's Staffing Standards called for 153 radar controllers, 110 nonradar controllers, 34 flight data specialists, and 25 trainees, totalling 322 persons. Actual personnel assigned to Washington Center were 220 radar controllers, 34 radar developmentals, 40 nonradar developmentals, and 21 flight data specialists, totaling 315. For the pay period April 28 through May 12, 1984, Washington Center Controllers were paid 1,772 hours of overtime. The Safety Board views the need for this scheduled overtime, which represents a staffing shortage of more than 20 controllers, as evidence that even at the prescribed full strength, the staffing level is not adequate.

The Safety Board believes that the staffing level should allow for the assignment of at least two controllers to all sectors with moderate to heavy workload without the continuing need to schedule overtime. Further, the Board believes that the FAA should review ARTCC management practices to assure optimum use of controller and supervisory personnel during peak traffic periods.

Peak Traffic Flow

Even if the air traffic control system were fully staffed with qualified controllers and equipped with the most advanced automation systems, the number of aircraft which could be routed through a volume of airspace or past a given position during a defined period of time would be limited by the prescribed separation between aircraft. When this operational error occurred, the number of aircraft transiting the East Texas sector and routed over the PSB VORTAC was nearing that saturation level.

The Safety Board recognized during its followup study of the Air Traffic Control system in May 1983, that an unrestricted growth of air traffic could lead to a saturation of the system during peak load periods.

The Safety Board recommended that the Federal Aviation Administration:

Revise the criteria for lifting restrictions on air traffic control services to postpone planned increases in air traffic volume and services at facilities until sufficient controllers are trained and qualified and have gained sufficient experience to allow supervisors and key staff members to resume direct first-line supervision and oversight of operations.
(A-83-42)

^{7/} An air traffic controller staffing concept which incorporates three categories or functional areas of work; the flight data aid, the nonradar controller, and the radar controller. Progression to radar controller status is competitive and contingent on a radar controller position vacancy.

The Safety Board has not evaluated the overall strength and experience of the ATC controller staff in comparison with the rate of traffic growth. However, nearly all of the restrictions which had been imposed during the period of recuperation following the air traffic controllers' strike 8/ have been lifted, and our investigation of this operational error indicates that the potential may already exist for periodic instances of traffic saturation. The traffic growth in the Washington ARTCC during recent months is cause for concern. Prior to the air traffic controllers' strike on August 3, 1981, the daily average traffic count in the Washington ARTCC was 4,400. Even with the flow restrictions imposed, the daily traffic count during the 2 years following the strike was permitted to increase to an average daily traffic count of 5,700. This daily traffic count has continued to increase rapidly since the beginning of 1984. During the period when this operational error occurred, the routine daily traffic counts in the Washington ARTCC were between 6,500 and 7,000. On May 9, 1984, the traffic count was 6,909.

The Safety Board believes that continued unrestricted access to the Air Traffic Control system without an effective means of predicting and preventing peak period saturation will lead to more operational errors and possibly accidents. The Safety Board is aware that this concern is being addressed by the FAA's Enroute Metering program and related enhancement programs, and for the more immediate future by the development of an en route sector loading prediction program (the ELOD program).

The Board understands that the ELOD program initially will use the scheduled departure times for those flights included in the Official Airline Guide and the projected routes of the flights to predict the traffic density for each of the high altitude sectors at any period of time. Although a prediction of traffic density based upon airline schedules

8/ Following the August 1981 Air Traffic Controller strike, the FAA implemented programs to limit the number of aircraft using the Air Traffic Control system. The regulation of scheduled airline aircraft using the system was effected by a national allocation of instrument flight plan "slots" distributed among the carriers. The influx of general aviation aircraft was controlled by a reservation program which required pilots to file instrument flight plans at least 24 hours before a planned flight. The number of flight plans accepted served to limit the general aviation and unscheduled traffic using the system. These national programs which placed controls on the amount of traffic to be served by the Air Traffic Control system augmented those flow control measures which were already in effect to prevent the buildup of traffic as a result of dynamic factors such as weather delays or peak scheduling. This flow control is effected by a central facility which monitors the traffic programmed to arrive at major terminal airports for the purpose of anticipating saturation and consequent delays. The program is designed to hold traffic at departure airports in order to minimize airborne traffic holding and en route ATC saturation.

The general aviation reservation program was terminated December 1983 and the program for allocating slots to scheduled air carriers was officially terminated on April 1, 1984. There are five high density terminal airports where the numbers of scheduled air carrier operations remained limited. This limitation is based upon the maximum acceptance rate for air carrier operations at the terminal rather than the air traffic control workload.

The Central Flow Control Facility continues to monitor the dynamic peaks of the system and limit scheduled departures of air carrier aircraft based upon anticipated airborne delays at the destination airport. The only other flow control measures are those imposed by the controllers in the ARTCCs as they determine separation and define the handoff acceptance rate for traffic entering the sectors.

may indicate trends of peak density, the ability to effect flow management with these data alone probably is limited. During a 1 hour period spanning the time at which this operational error occurred, 53 airplanes had transited the East Texas sector of the Washington ARTCC. Only 27 of these were scheduled air carrier airplanes, the other 26 being general aviation business airplanes. The Safety Board believes that the further development of this program to include real-time dynamic data based upon the actual departures and projected routing of all IFR aircraft operating in the system is essential to the implementation of effective traffic flow management. The development and implementation of a traffic flow prediction and potential sector overload alarm program which will permit the early imposition of the restrictions or rerouting of aircraft should be given priority consideration.

The implementation of an effective automated traffic flow control system is not imminent. Consequently, the FAA should consider interim action to prevent peak periods of traffic saturation. The Safety Board believes that the FAA must take additional interim measures to control traffic access to the ATC system.

ARTCC Sector Geographical Boundaries

The geographical boundary between the New York ARTCC and the Washington ARTCC was shifted following the Air Traffic Controller strike in order to optimize resources of the respective centers during the recuperation period. The shift placed the East Texas sector and others originally controlled by New York in the Washington Center. This ARTCC boundary shift intensified operational problems in a sector which was not designed to FAA criteria in the first instance.

Appendix 2 of FAA Order 7210.46, "Establishment and Validation of En Route Sectors" details the principal criteria which should be considered in the geographical design of ARTCC sectors. One criterion is that multiple conflict points involving major traffic flows should be avoided; specifically, "conflict points should not be located near the boundary of a sector as to create the need for excessive coordination when action to separate individual aircraft is required." Contrary to this design criterion, the design of the East Texas sector boundaries places the PSB VORTAC in the extreme northwest corner of the sector. In all, eight radials define the airway structure emanating from the VORTAC. Two of these radials cross the northern boundary of the sector and three cross the western boundary all within 10 nmi of the facility. This means that airplanes inbound to PSB on any of these airways must be sequenced before the airplanes enter the East Texas sector so that separation is assured since there is not sufficient distance to effect separation maneuvers once the airplanes cross the sector boundaries. In order to assure separation, the East Texas sector controller(s) must monitor the flow of traffic inbound from the north and west and coordinate required separation maneuvers with the controllers of the adjacent bounding sectors. Such coordination can be difficult even when the bounding sectors are controlled within the same ARTCC. However, for sectors in the same ARTCC, provisions exist for direct communication between the controllers of adjacent sectors. On May 9, 1984, the Washington ARTCC East Texas sector handoff controller was required to communicate with the Cleveland ARTCC and the New York ARTCC by using landline voice circuits which added to the sector workload and increased the possibility for an error. Thus, the need to monitor the traffic in this complex situation and to effect telephone coordination with two centers created an extraordinary workload for the East Texas controllers. The East Texas sector handoff controller's failure to inform the New York ARTCC that he was unable to accept the handoff was a significant factor in the development of this operational error. This failure in turn was the result of delays arising from the inadvertent use of the wrong landline voice circuit.

The Safety Board believes that the restoration of the ARTCC boundaries to the prestrike configuration which followed this incident has eased the controllers' task but that it does not resolve totally the deficiency in the East Texas sector design.

The Safety Board notes that the FAA has begun a complete review of its sector system structure to determine what "fine tuning" can be achieved to enable controllers to handle air traffic more smoothly and efficiently. ^{9/} The Board urges that this effort be expedited and that sector boundaries be modified as needed to conform to the criteria of FAA Order 7210.46.

New York and Washington ARTCC Handoff Procedures

The investigation of the circumstances leading to this operational error disclosed deficiencies in the procedures and practices used by the controllers to effect the handoff of traffic. According to FAA Order 7110.65B, the Air Traffic Control Handbook, the transferring controller is to complete a radar handoff prior to an aircraft entering the airspace delegated to the receiving controller. However, the procedures are not specific regarding the transferring controller's responsibility to assure that the handoff has been completed before the aircraft reaches a position where penetration of the receiving sector boundary is inevitable.

The procedures, as generally defined in Letters of Agreement between adjacent ARTCCs, specify that the receiving controller is responsible for advising the transferring controller if he cannot accept the inbound traffic. This presents a dilemma for the transferring controller who permits the aircraft to continue toward the sector boundary anticipating that the handoff will be accepted by the receiving controller. In practice aircraft often are permitted to go without formal handoff acceptance, beyond the point at which a boundary crossing is inevitable and the handoff is accomplished without a problem. However, as illustrated in this operational error, instances can occur in which the receiving controller's workload is too demanding and an airplane will intrude into a sector without a handoff acceptance or transfer of communications.

The Safety Board urges the FAA to review the radar handoff procedures described in the Air Traffic Control Handbook and pertinent Letters of Agreement and to revise them as needed to assure that the procedures provide for sufficient redundancy to prevent an aircraft from intruding into a receiving controller's airspace in the event of communication difficulties. The procedures should require that voice communication between controllers be established before the airplane is permitted to proceed beyond a point where control options are no longer available to the transferring controller to prevent an intrusion into the receiving controller's airspace.

Therefore, the National Transportation Safety Board recommends that the Federal Aviation Administration:

Issue a General Notice (GENOT) directing the management of Air Route Traffic Control Centers (ARTCC) to provide redundancy of the Air Traffic Control system by having at least two controllers present at each sector (or combined sector) control station at all times during the periods when traffic density is, or is predicted to be, above a minimum level. (Class II, Priority Action) (A-84-116)

^{9/} FAA letter to Representative Levitas on Air Traffic Control System dated August 3, 1984.

Issue a General Notice (GENOT) directing the management of all Air Traffic Control facilities to schedule ancillary activity of supervisors so as to minimize interruption of their controller supervision function during periods of high traffic demands. (Class II, Priority Action) (A-84-117)

Establish a formal program to periodically review controller staffing requirements of Air Traffic Control facilities and allocate personnel to facilities to provide sufficient controllers at all control stations during periods or moderate to high traffic demand and to eliminate the recurrent need for scheduled overtime. (Class II, Priority Action) (A-84-118)

Expedite the development and adoption of the en route sector loading prediction program (the ELOD program) to effect ARTCC flow control management based upon dynamic real-time traffic flow data. (Class II, Priority Action) (A-84-119)

Until such time as more effective flow control management can be effected take interim measures to control traffic access to the Air Traffic Control system. (Class II, Priority Action) (A-84-120)

Identify ARTCCs and individual sectors which have multiple or inappropriately located conflict points which increase unnecessarily the need for controller intercenter coordination and take action to revise sector boundaries and preferential IFR routing to reduce potential traffic conflict. (Class II, Priority Action) (A-84-121)

Develop and put into effect radar handoff procedures which require that either an automated interfacility handoff be completed or that voice communications between controllers be established before an airplane is permitted to proceed beyond a defined point where control options are no longer available to the transferring controller to prevent an intrusion into the receiving controller's airspace. (Class II, Priority Action) (A-84-122)

BURNETT, Chairman, GOLDMAN, Vice Chairman, and BURSLEY, Member, concurred in these recommendations.


By: Jim Burnett
Chairman

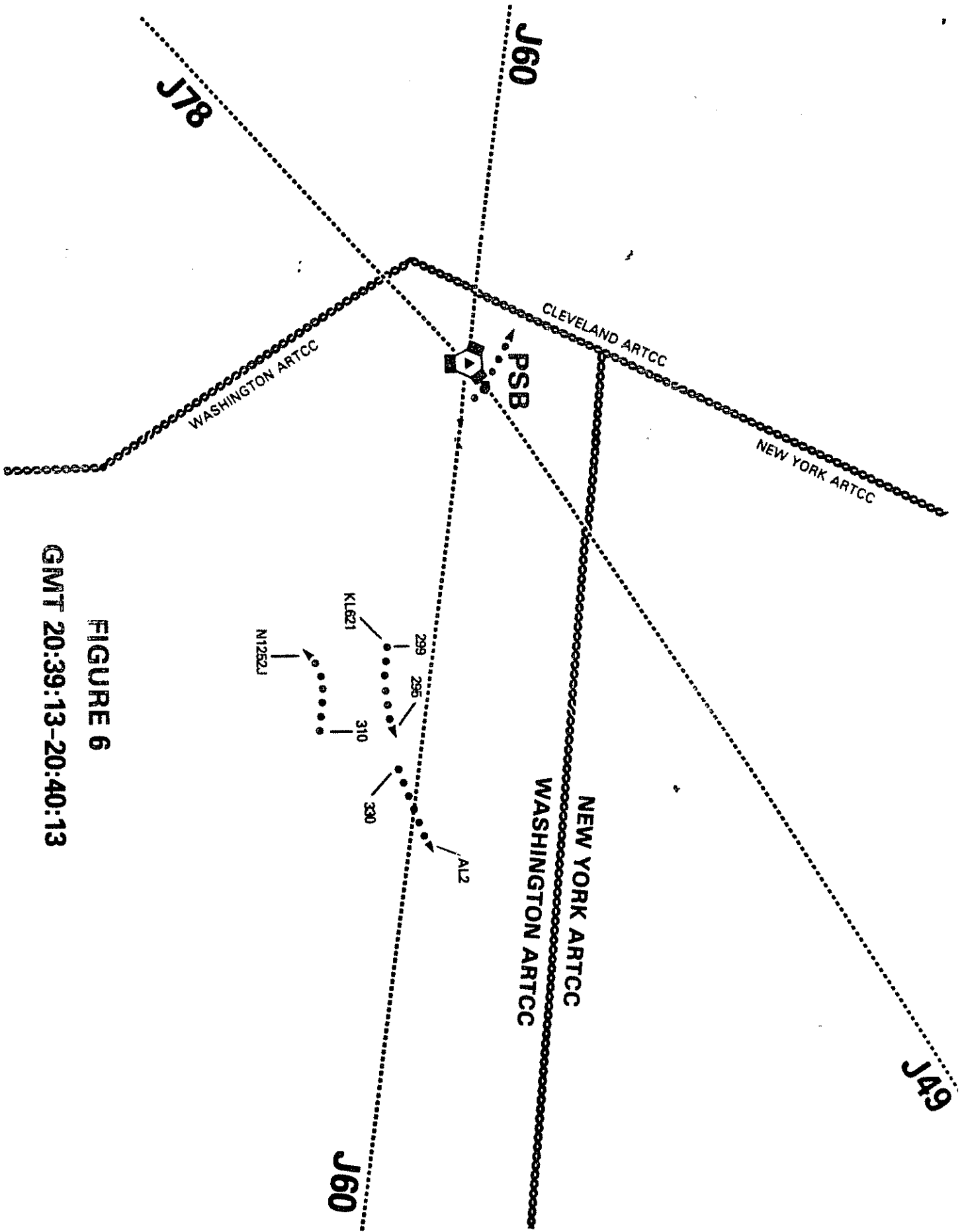


FIGURE 6

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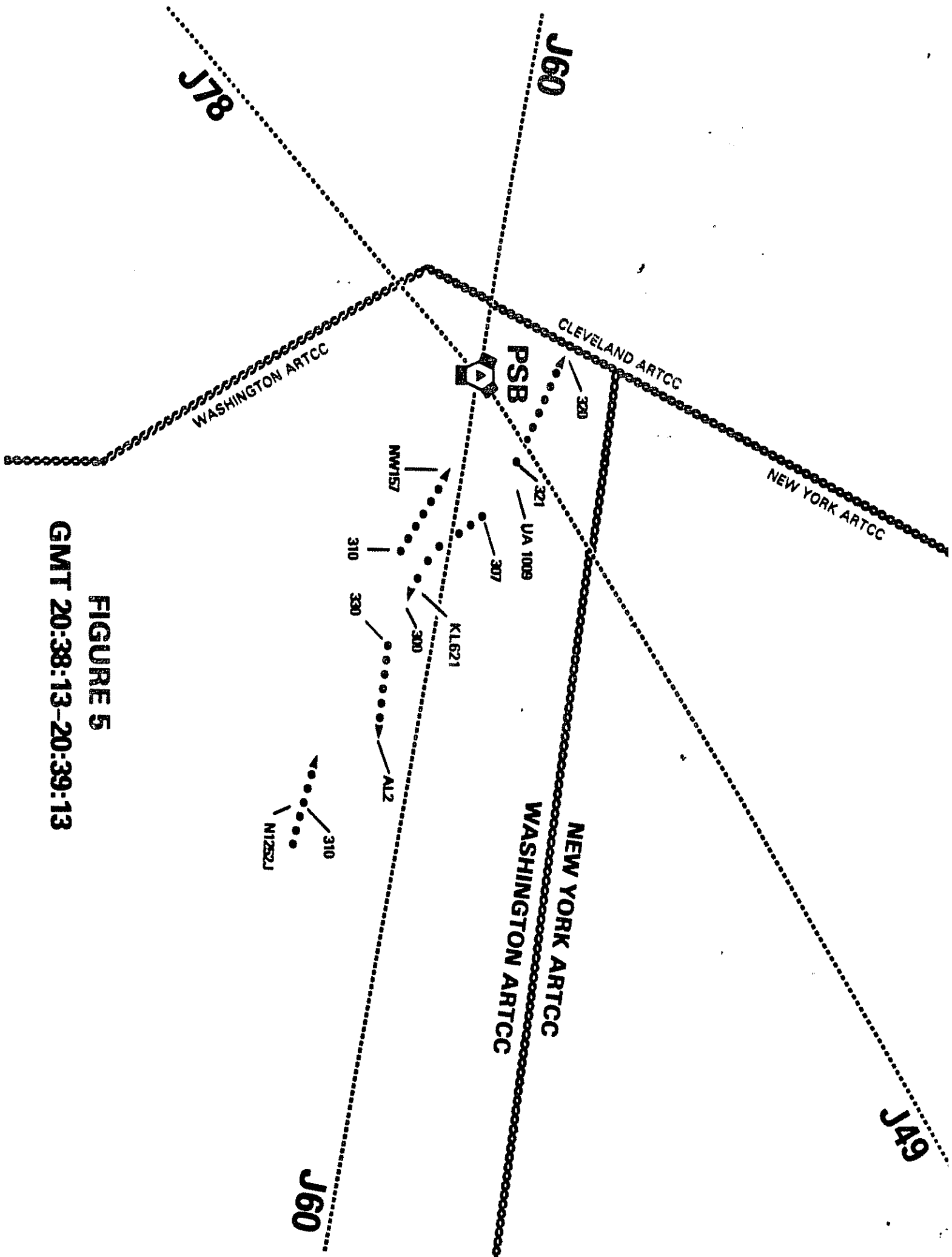


FIGURE 5

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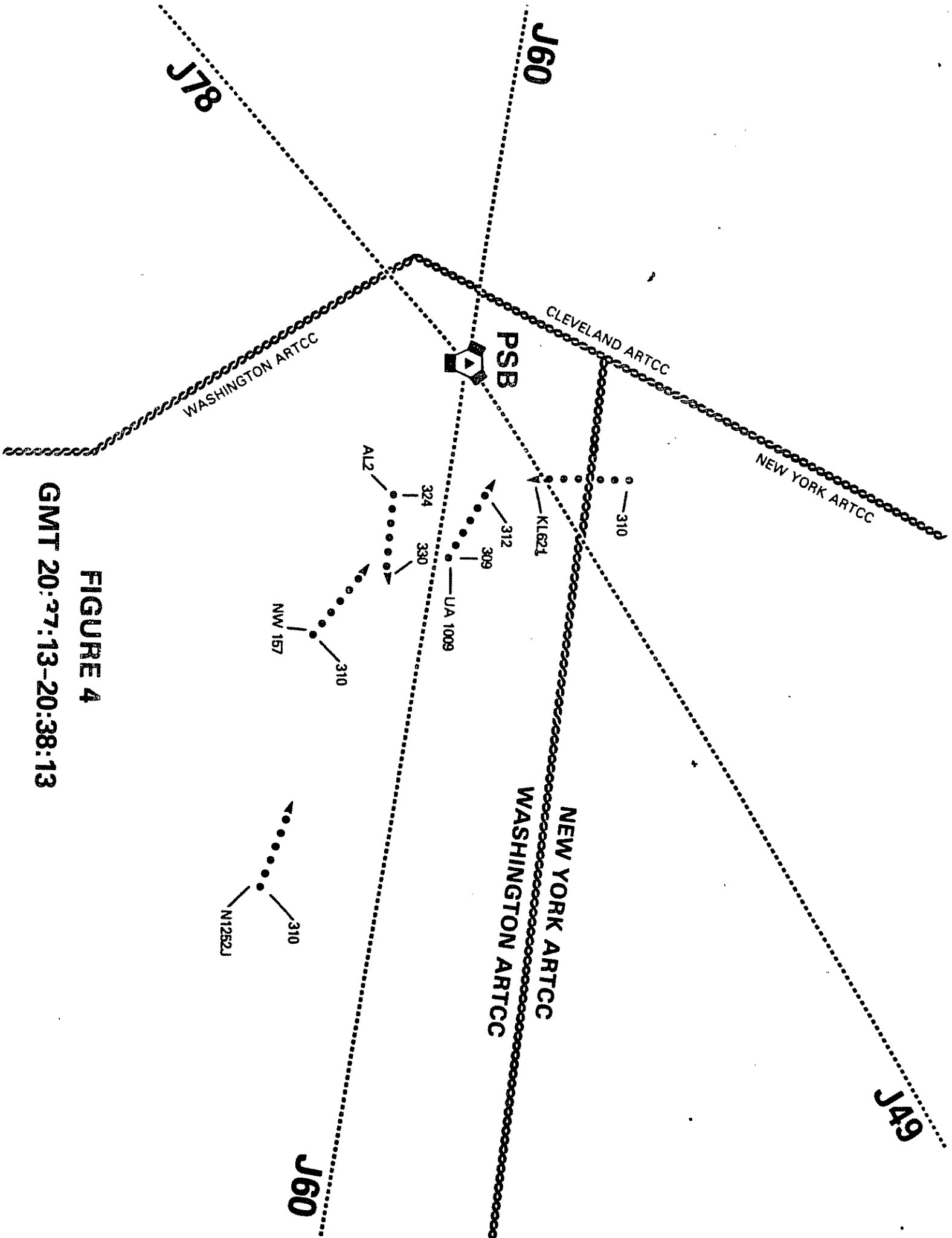


FIGURE 4

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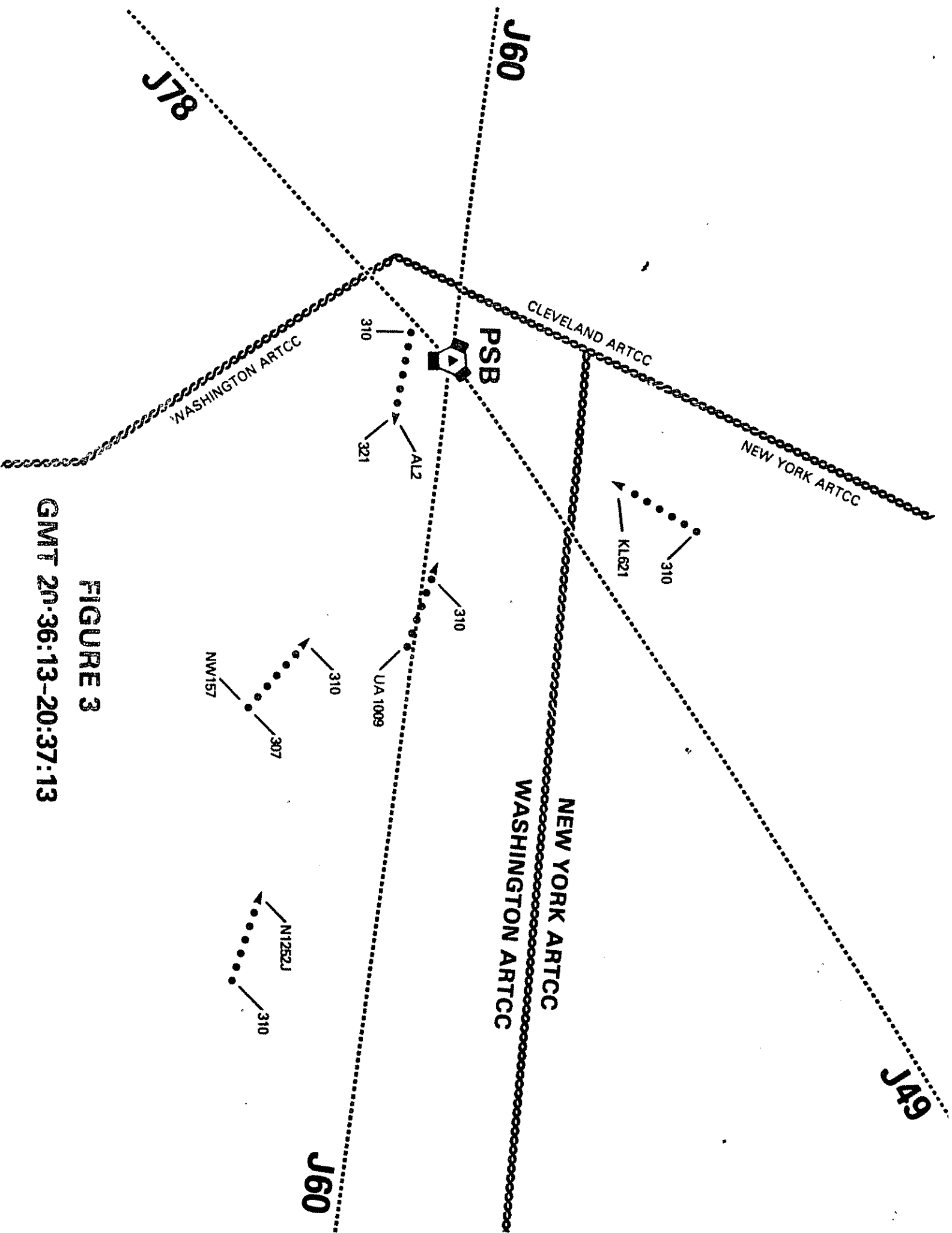


FIGURE 3

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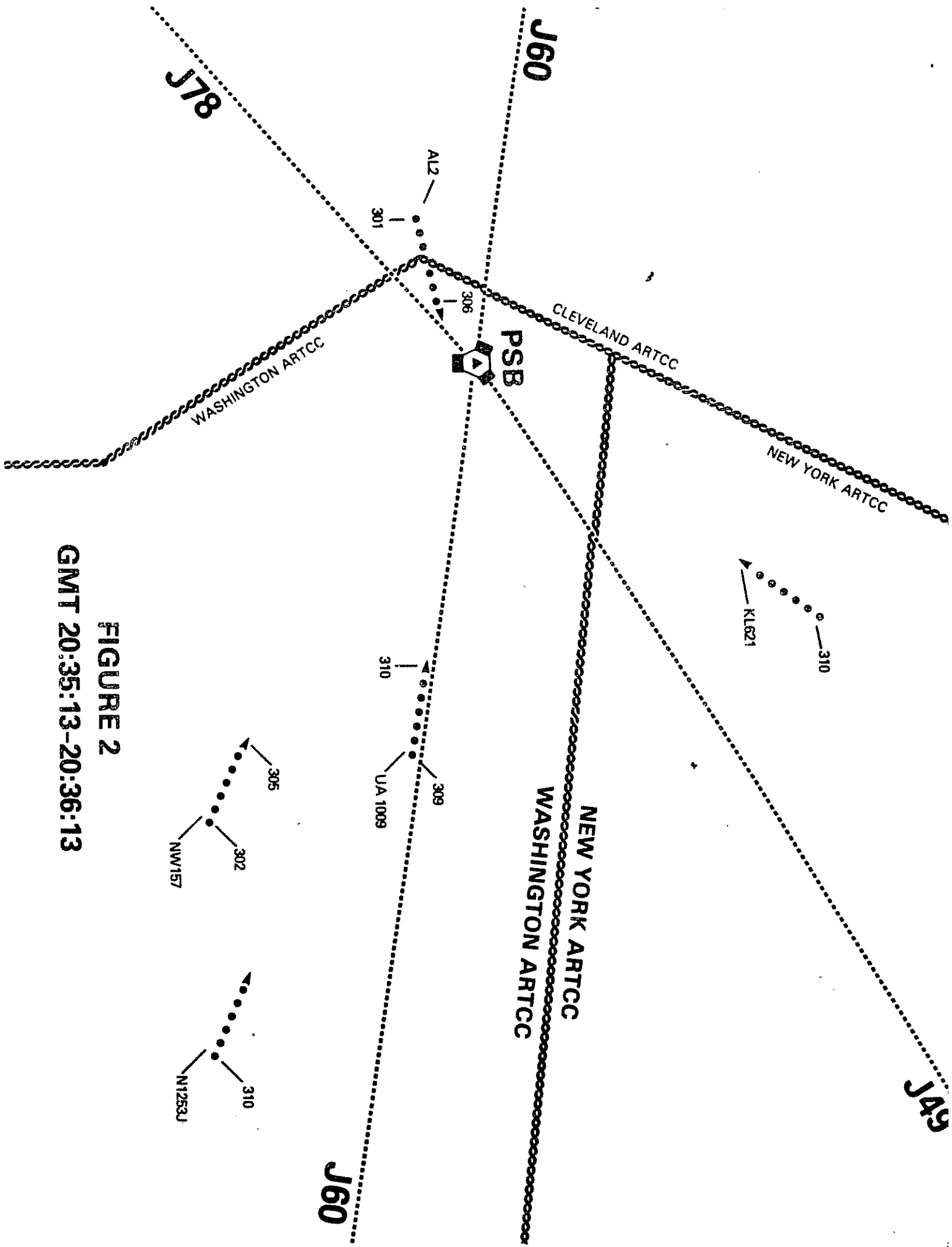


FIGURE 2

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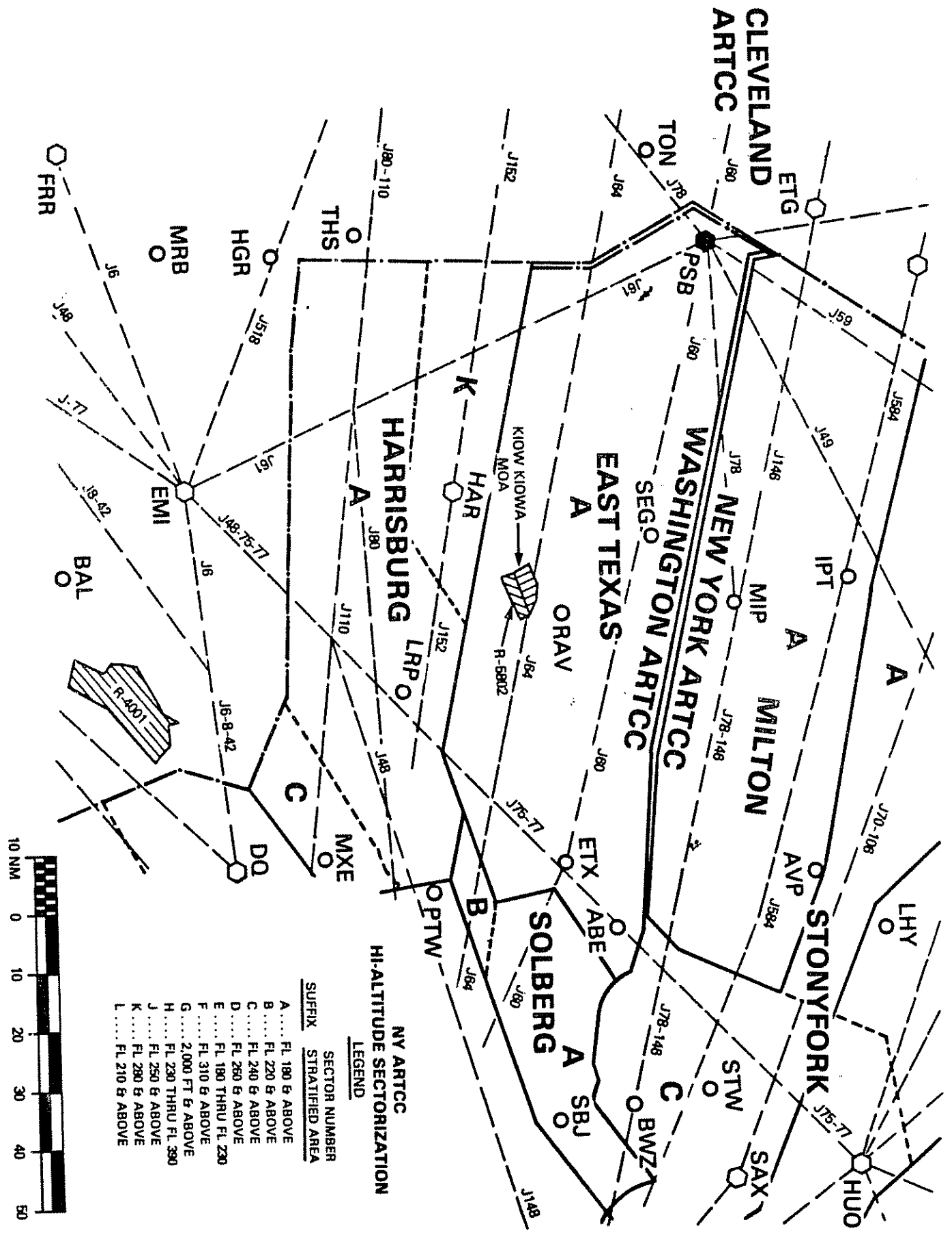


FIGURE 1