NATIONAL TRANSPORTATION SAFETY BOARD
Office of Aviation Safety
Washington D.C. 20594

October 27, 1998

Meteorological Factual Report
DCA98MA015

A. ACCIDENT

Location: 32 degrees 31 minutes north latitude 157 degrees 27 minutes east longitude
Date: December 28, 1997
Time: About 1340Z
Aircraft: Boeing 747-122, N4723U, United Airlines Flight 826 [UAL826]

B. WEATHER GROUP

Chairman:

Gregory D. Salottolo, National Transportation Safety Board [NTSB]

Members:

Donald Eick, NTSB

Bill Phaneuf, Air Line Pilots Association [ALPA]

Steven Chenault, Federal Aviation Administration [FAA]

Carl Knable, United Airlines

C. DETAILS OF INVESTIGATION

Note in the report all times Coordinated Universal Time [UTC] time based on the 24 hour clock unless noted. All heights above mean sea level (MSL) unless noted. All directions with reference to true north unless noted. Z = UTC. McIDAS - Man computer Interactive Data Access System. McIDAS is an interactive meteorological analysis and data management computer system. McIDAS is administered by personnel at the Space Science

and Engineering Center at the University of Wisconsin at Madison. Data are accessed and analyzed on an Hewlett Packard 9000/730 Workstation running McIDAS-X software.

Synoptic Situation

The December 28, 1997, 1200Z, Surface Analysis chart issued by the Japan Meteorological Agency showed a low pressure center near 36 degrees north latitude and 158 degrees east longitude, moving east-northeastward at 35 knots. An occluded front stretched from the low southward to about 32 degrees north latitude and 158 degrees east longitude. At this point a cold front extended southward and a warm front extended southeastward. See Attachment 1.

Satellite Data

Geostationary Meteorological Satellite [GMS-5] data from the Japan Meteorological Satellite were reviewed on the Safety Board's McIDAS Workstation. GMS-5 infrared images for 1332Z and 1432Z showed radiative temperatures of 262.4 degrees K [-10.8 degrees C] and 239.8 degrees K [-33.4 degrees C] at the accident location. Using temperature data from the Medium Range Forecast [MRF] model for December 28, 1997 1200Z for a forecast time = 0 hour, cloud heights corresponding to the above radiative temperatures are less than Flight Level 24,000 feet [FL 240] and about FL 280. A GMS-5 water vapor image for 1332Z and 1432Z showed upper level moisture in the area of the accident. A 5 pixel by 5 pixel box centered at the accident location [GMS-5 infrared data, 5 kilometer resolution] showed the following:

Time: Image time in Z
MIN: Minimum radiative temperature in degrees C
MAX: Maximum radiative temperature in degrees C
Mean: Mean radiative temperature in degrees C
SD: Standard deviation in degrees C

Time	MIN	MAX	Mean	SD
1332	-28.6	-2.0	-10.4	7.9
1432	-33.4	-2.0	-17.3	10.7

The 1332Z GMS-5 infrared data showed a minimum radiative temperature of about 235.4 degrees K [-37.8 degrees C] about 17 nautical miles northwest of the accident site. The 1432Z GMS-5 infrared data showed a minimum radiative temperature of about 239.8 degrees K [-33.4 degrees C] within 2 miles of the accident location. These

temperatures correspond to cloud tops of about FL 300 and FL 280 respectively. The 1332Z GMS-5 infrared data showed cloud tops at about FL 360 about 31 nautical miles south-southeast of the accident site. The time of the accident was approximately 1340Z.

Attachments 2 and 3 ... GMS-5 infrared images [Band=2]; 1332Z and 1432Z; 2 kilometers [blow up resolution]; color enhanced [Table THUNDER]; accident location noted by solid box.

THUNDER Color Enhancement Table

Temperature range 273 degrees K (-0.2 degrees C) to [illegible] degrees C (-80.2 degrees C)

Segment #	Temp deg K	Temp deg C
1	273	-0.2
2	262.5	-10.7
3	252.5	-20.7
4	242.5	-30.7
5	232	-41.2
6	222	-51.2
7	212	-61.2
8	202	-71.2

Attachments 4 and 5... GMS-5 infrared images; 1332Z and 1432Z; .25 kilometer [blow up resolution]; radiative temperature contours in degrees K plotted [interval = 2 degrees K]; solid box = accident location; colors correspond to cloud heights; green FL 240 to <FL 280, yellow FL 280 to < FL 310, orange FL 310 to <FL 350, red to white >FL 350 [heights based on MRF temperature data for 12/28/97 1200Z].

Attachments 6 and 7 ... GMS-5 water vapor images; time 1332Z and 1432Z; 1 kilometer [blow up resolution]; images are contrast stretched.

Attachment 8... GMS-5 infrared image; 2 kilometer [blow up] resolution; color enhanced [THUNDER]; streamlines and wind speed in knots plotted; time 1332Z; solid box = accident location [northern most point of line segment on image].

Attachment 9 ... Plot of MRF Temperature data [degrees C] versus Height [feet] for the accident location.

Upper Air Data

MRF data for December 28, 1997 at 1200Z, forecast hour = 0, were reviewed on the Safety Board's McIDAS Workstation. The data showed westerly winds at about 105 knots at 300 millibars, westerly winds at about 125 knots at 250 millibars, and westerly winds at about 140 knots at 200 millibars in the area of the accident. Significant horizontal wind shears were evident in the area of the accident at 300, 250, and 200 millibars. A horizontal wind change of 71 knots per 100 nautical miles was calculated for the area of the accident at 300 millibars. A vertical wind change [vector] of 13 meters per second [25 knots] between 300 millibars and 250 millibars was calculated for the area of the accident. A maximum value of 20 meters per second [39 knots] was noted about 115 nautical miles to the east of the accident location. Between 250 millibars and 200 millibars a vertical wind change of 9 meters per second [18 knots] was noted. A maximum value of 20 meters per second [39 knots] was noted about 245 nautical miles northeast of the accident site.

In the standard atmosphere:
400 millibars = 23,574 feet
300 millibars = 30,065 feet
250 millibars = 33,999 feet
200 millibars = 38,662 feet

The following Attachments were developed from the 1200Z MRF data for December 28, 1997 [forecast hour = 0] using McIDAS. The solid box = the accident site.

Attachments 10 - 13 ... Streamlines and wind speed contours in knots for 400, 300, 250, and 200 millibars.
Attachments 14 and 15 ... Vertical wind change in meters per second from 300 to 250 millibars and from 250 to 200 millibars.
Attachments 16 -19 ... Contours of divergence, vorticity, deformation shear, and deformation stretch at 300 millibars; units per second.
Attachment 20 ... Four panel chart of contours of temperature in degrees C for 400, 300, 250, and 200 millibars.
Attachments 21 and 22 ... Base map and base map for 4 panel chart.

Excerpts from Tokyo Radio

13:36:45Z UAL 826 UAL 826 roger and message for ATC UAL 826 at position 3231 north 15727 east encountering severe turbulence and requesting any higher altitude over.

14:30:55Z Tokyo Roger where did you encounter severe turbulence.

14:34:14Z UAL 826 UAL 826 we were at Flight Level 310 track 12 approximately 3230 north 158 to 159 east go ahead.

Attachments 23 - 32 ... Transcription of UAL 826 and Tokyo Radio.

In-Flight Weather Advisories

The following SIGMETs were issued by the Japan Meteorological Agency on December 28, 1997:

SIGMET 3 issued at 0840Z and valid until at 1240Z...

Tokyo Flight Information Region [FIR] moderate to severe turbulence forecast between Flight Level 29,000 feet to Flight Level 35,000 feet moving east-northeast at 15 knots and intensifying. See Attachment 33 for area affected. The area encompassed by this SIGMET did not include the accident location.

SIGMET 4 issued at 1240Z and valid until 1640Z ..

Tokyo FIR moderate to severe turbulence forecast between Flight Level 29,000 feet and Flight Level 35,000 feet moving east-northeast at 15 knots no change in intensity. See Attachment 34 for area affected. The area encompassed by this SIGMET did not include the accident location.

International Civil Aviation Organization [ICAO] Annex 3

The following was obtained from the ICAO document Annex 3 [1/1/96]...

SIGMET information..
SIGMET information shall be issued by a meteorological watch office and shall give a concise description in abbreviated language concerning the occurrence and/or expected occurrence of specified en-route weather phenomena, which may affect the safety of aircraft operations, and of the development of those phenomena in time and space.

SIGMETs are issued for:
thunderstorms
tropical cyclone
severe turbulence
severe icing and severe icing due to freezing rain
severe mountain wave
heavy duststorm

heavy sandstorm
volcanic ash

See Attachments 35 and 36.

Aircraft Observations and Reports..
Each contracting state shall arrange, according to the provisions of this chapter, for observations to be made by aircraft of its registry operating on international air routes and for the recording and reporting of these observations.

The following aircraft observations shall be made:
a) routine aircraft observations during en-route and climb-out phases of the flight; and
b) special and other non-routine aircraft observations during any phase of the flight.

Special observations shall be made by all aircraft whenever the following conditions are encountered or observed [partial list]:

a) severe turbulence
b) severe icing
c) severe mountain wave
d) thunderstorms

See Attachment 37.

Meteorological Report and Meteorologist Statement from United Airlines

The following are excerpts from a report produced by a meteorologist at United Airlines [dated January 7, 1998] regarding the severe turbulence encounter of Flight 826 at **32.5 degrees north latitude and 158.9 degrees east longitude.

** Note the accident location was revised subsequent to the preparation of this report to approximately 32.5 degrees north latitude and 157.5 degrees east longitude.

Based on information available, four significant features associated with turbulence appear to be present at or near the incident site: thunderstorms with tops at cruise levels, significant vertical wind shears, an inversion, and the difluence (splitting) of the jet core. As such the turbulence could have been caused by: 1) flight through or near a thunderstorm top, 2) strong vertical wind shear independent of the thunderstorm environment, or 3) the interaction of the thunderstorms with the existing wind field causing downstream turbulence. Information available at the time of this report suggests either cause 2 or 3, as listed above.

Aircraft Weather Reports for a location of 32 degrees north latitude and 160 degrees east longitude for the time period 1149Z to 1502Z were contained in the report. Average wind speeds of 130 knots and an average temperature of -54 degrees C were noted for an altitude of 39,000 feet [2 aircraft reports]. Average wind speeds of 132 knots and an average temperature of -49.5 degrees C were noted for an altitude of 37,000 feet [6 aircraft reports]. Average wind speeds of 124 knots and an average temperature of -48 degrees C were noted for an altitude of 35,000 feet [8 aircraft reports]. Average wind speeds of 111 knots and an average temperature of -45 degrees C were noted for an altitude of 33,000 feet [4 aircraft reports]. Average wind speeds of 83 knots and an average temperature of -44 degrees C were noted for an altitude of 31,000 feet [2 aircraft reports]. One aircraft report of a wind speed of 55 knots and a temperature of -38 degrees C at an altitude of 29,000 feet.

Vertical wind shears in knots per 1,000 feet of altitude were: 14 from 29,000 feet to 31,000 feet; 14 from 31,000 feet to 33,000 feet; 6.5 from 33,000 feet to 35,000 feet; 3 [independent calculation shows 4] from 35,000 feet to 37,000 feet; and 1 from 37,000 feet to 39,000 feet. None of the 23 aircraft reports indicated the presence of turbulence.

A chart valid December 28 at 1200Z showed an area of scattered to broken thunderstorms beginning at about 157 degrees east longitude. Low pressure was located at about 30 degrees north latitude and 156 degrees east longitude.

A Significant Weather Chart issued by the Washington Regional Area Forecast Center valid December 28 at 1200Z showed an area of frequent [5/8 to 8/8 coverage] cumulonimbus from about 155 degrees east longitude to about 162 degrees east longitude with tops to 42,000 feet.

A meteorologist working the midnight shift in the United Airlines Meteorology Department [December 28 at 0515Z to December 28 at 1345Z] stated that to the best of his knowledge, he had no discussions concerning and made no actions during his shift that specifically related to Flight 826.

Attachments 39 - 50 ... Meteorological Report and Meteorologist Statement; from United Airlines; January 14, 1998.

Weather Information Provided to Flight Crew

The following weather information was provided to the crew of Flight 826 prior to departure:

a) Information regarding possible moderate turbulence vicinity 145 degrees east longitude from Flight Level 28,000 feet [FL 280] to FL 380, and 160 degrees east to 170 degrees east longitude from FL 310 to FL 400.

b) Information regarding possible isolated [less than 1/8 coverage] cumulonimbus in the vicinity of 155 degrees east to 160 degrees east longitude with tops to FL 380.

c) Information from SIGMET 3 valid from December 28 at 0840Z to December 28 at 1240Z. SIGMET 3 called for moderate to severe turbulence between Flight Level FL 290 to FL 350. The area encompassed by this SIGMET did not include the accident location.

d) Surface weather observations and forecasts for Narit.. ..pan and Honolulu, Hawaii.

e) A Significant Weather Chart valid December 28, 1997 at 1200Z issued by the Regional Area Forecast Center [RAFC] Tokyo. Along Track 12 the chart showed an area of forecast moderate turbulence the western extent beginning at about 158 degrees east longitude. Along Track 12 occasional [1/8 to 4/8 coverage] embedded cumulonimbus activity was forecast starting at about 161 degrees east longitude with tops to 50,000 feet. A surface warm front was forecast to be located at about 32 degrees 30 minutes north latitude and 159 degrees east longitude.

f) The following Pilot Report [PIREP]... over 39 degrees north latitude 160 degrees east longitude / time 0908Z / FL 350 / occasional light chop from 158:00 east longitude to 162 degrees east longitude.

g) A Vertical Cross Section of weather conditions from Narita to Honolulu [36 degrees north 150 degrees east, to 35 degrees north 160 degrees east, to 33 degrees north 170 degrees east ... Honolulu] prepared by the Japan Meteorological Agency. According to United Airlines this information is only provided for certain routes.

Attachments 51 - 64 ... Flight Papers for Flight 826; from United Airlines; January 12, 1998.

Statements from Northwest Airlines' Crew Members

The following are summarized excerpts from a written statement provided by the Captain of Northwest Flight 22:

The flight was from Narita, Japan [NRT] to Honolulu, Hawaii [HNL]. After leveling off at FL 330 the Captain called Northwest 10 for a Pilot Report [PIREP]. A crewmember of Northwest 10 replied "smooth so far, I'll give you a call if it gets bad." Northwest Flight 10 left Narita about 30 minutes ahead of Northwest Flight 22.

At this time Northwest Flight 22 could see the lights of UA826 about 20 to 30 miles ahead. At about 1340Z the captain received a radio call from UA826. A crewmember of UA826 noted that he "just experienced the worst turbulence of his career " and that there were numerous injuries and possible aircraft damage. The Captain of Northwest 22 then turned on the seat belt sign and made a Public Address [PA] telling all Flight Attendants and passengers to return to their seats and "strap in." The captain noted that they did not "get a bump" and that there were no radar returns and no lightning. The winds were exactly as forecast .. 270 degrees at 160 knots. The captain noted that winds of 170 knots in the winter in the Pacific are normal.

The following are summarized excerpts from a written statement provided by the Captain of Northwest Flight 80:

The flight was from NRT to HNL. The aircraft was a B-747. In the vicinity of 160 east longitude they encountered moderate to severe turbulence [Northwest Airlines turbulence code 3 to 4 reported .. light to moderate to moderate turbulence] at FL 330 that lasted 2 to 3 minutes. The time was about 1220Z. This was followed by 10 to 12 minutes of light to moderate turbulence. The aircraft was controllable throughout and the speed was reduced to Mach.81 to .82. After passing through turbulent area while in smooth air aircraft suddenly swerved / lurched as if encountering a trough [roll cloud, Jetstream, etc] for a brief duration. Prior to 160 degrees east longitude the seat belt sign was turned on [in smooth air] based on a Northwest Airlines code 2 turbulence forecast [light turbulence], which was accurate. Having done that, we avoided injuries as this was the worst turbulence that I ever encountered.

Attachments 65 - 78 ... Submission from Northwest Airlines; January 6, 1998.

NTSB Questions to United Airlines

The following are answers to questions submitted by the NTSB to United Airlines. Responses to these questions were received in a letter dated February 27, 1998. According to United Airlines, the responses were compiled from discussions with the captain of the incident flight, United's manager of meteorology, and United's ALPA chief investigator.

1) The flight plan indicated a Flight Level of 35,000 feet [FL 350] at MASON. Why was the aircraft not at this Flight Level [ATC or other reasons]?

Answer: NRT clearance delivery did not make FL350 available to the flight at departure time. The incident flight was unable to obtain a higher flight level prior to the event.

2) What type of weather radar was onboard?

Answer: C-band.

Was the radar functioning normally?

Answer: Yes.

What was seen on the weather radar? What was the location and intensity of the echoes seen?

Answer: 50 to 60 miles ahead, to the right of course, there were some light green (no amber or red) echoes. There was no visual sightings of lightning.

What tilt and range was the weather radar set on?

Answer: The radar was set on the 80 mile range with a 5 degree tilt down. The crew occasionally scanned at 10-15 degrees down for confirmation of surface return (functionality).

Does the radar have a turbulence display?

Answer: The radar has a "Precip Only," "Both" and "Doppler Only" modes. At the time of the incident, the radar was set in the "Both" mode.

3) What weather information was received while enroute? How, from whom, and when was the information received?

Answer: The incident flight received a ride report from an aircraft on the same track approximately 30 miles ahead, at a higher flight level. The ride report was, "occasional ripple, but basically a smooth ride." There were no reports of turbulence received from other flights.

4) What were the cloud tops?

Answer: The pilots reported that they were in the clear from level-off at FL310 ("stars above", tops below FL310).

5) What are crew procedures regarding when to turn the fasten seat belt sign on?

Answer: Attached are "OI" and "ALL WX" pages from our Flight Operations Manual.

6) What information is provided by UAL to flightcrews regarding turbulence and thunderstorms?

Answer: Basic weather is provided in the form of the computer generated Weather Briefing Message (WBM). Any text forecasts of thunderstorms, turbulence (CAT/mountain wave), or tropical storms valid for the route of flight are included. These forecasts can consist of sigmets, convective sigmets, severe weather watch areas, and company issued turbulence forecasts. The WBM also includes all pireps / aireps of turbulence along the route of flight for the past three hours. All crews are also provided with some form of high level significant weather product, either in the form of an ICAO flight weather documentation package, Jeppesen fax product, or via WSI Pilotbrief. In addition, dispatchers append last minute thunderstorm / turbulence data to the flight plan release, as well as providing voice / ACARS uplink of current data to enroute flights.

7) Was the crew aware that isolated cumulonimbus activity was forecast from 155 degrees east longitude to 160 degrees east longitude with tops to FL 380 [noted in the Flight Release]? Was the seat belt sign on at 155 degrees east longitude? If not, why was the seat belt sign not on?

Answer: As part of the flight planning process, the pilots did in fact review all weather products available to them and briefed both flight attendants and passengers on the possibility of turbulence along their flight path. Momentary light turbulence was encountered at 145E. Because of this light turbulence, the fasten seat belt signs was illuminated for approximately :15 minutes. The seat belt sign was turned off because the turbulence disappeared and conditions smoothed.

8) Was the crew aware that moderate turbulence was forecast beginning at about 158 degrees east longitude from 33,000 feet to 40,000 feet [Significant Weather Prog attached to Flight Release valid 1200Z 12/28]? Was the seat belt sign on at this location? If not, why was the seat belt sign not on?

Answer: As part of the flight planning process, the pilots did in fact review all weather products available to them and briefed both flight attendants and passengers on the possibility of turbulence along their flight path. The turbulence "event" occurred prior to 158E at 157-27E (agreed to location of the event). The seat belt sign was on for passengers approximately two minutes prior to the event.

9) Was the crew aware of a forecast for moderate turbulence in the vicinity of 145 degrees east longitude from FL 280 to FL 380 [noted in Flight Release]? Was the seat belt sign on at this location? If the seat belt sign was not on why was it not on?

Answer: As part of the flight planning process, the pilots did in fact review all weather products available to them and briefed both flight attendants and passengers on the possibility of turbulence along their flight path. Momentary light turbulence was encountered at 145E. Because of this light turbulence, the fasten seat belt signs was illuminated for approximately :15 minutes. The seat belt sign was turned off because the turbulence disappeared and conditions smoothed.

10) What turbulence forecasting techniques do UAL meteorologists use? What weather information do UAL meteorologists use in generating products? Where does the weather information come from? What prompted issuance of the forecast for cumulonimbus activity and turbulence noted in questions 7 and 9? What prompted issuance of the forecast for moderate turbulence in the vicinity of 160 degrees east longitude to 170 degrees east longitude from FL 310 to FL 400 [noted in Flight Release]?

Answer: UAL meteorologists use standard turbulence pattern recognition techniques that have been developed over the past 30 years and are used on an industry-wide basis. This includes in-house developed CAT and mountain wave techniques that have been adopted by many other organizations, including the NWS and USAF.

UAL meteorologist have at their disposal a full range of meteorological data sets including: All Family of Service alpha-numeric data including HRS, drops on two FAA weather circuits, all NEXRAD data including composites and single site from two sources - UNISYS and WSI, direct readout earth stations for GOES8 and GOES9, a dedicated earth station for direct readout of GMS, vendor provided METEOSAT data, lightning data, and all NWS DIFAX products. All of these data sets are integrated on high power UNIX based workstations. In addition, this information is supplemented by UAL automated ACARS weather downlink data. UAL ACARS provides approximately 12,000 daily reports of winds, temperatures, and peak vertical acceleration (turbulence).

Finally, all meteorologists have INTERNET access at their workstations, thus providing access to all weather-related sites.

Data sources are as indicated above - vendors (UNISYS, WSI, Alden, GAI), government, direct satellite readout, aircraft, and INTERNET.

The forecasts referenced in questions 7 and 9 came from monitoring of real time GMS satellite data, pireps / aireps, and high level significant weather progs.

11) What weather products do UAL meteorologists issue related to turbulence and thunderstorms? How are these products disseminated?

Answer: Routine forecasts of CAT / mountain wave are issued for the U.S. and eastern Pacific. Thunderstorm forecasts are provided for the U.S., eastern Pacific, and for all routes affected by thunderstorms generated by organized tropical storms. Verbal briefings regarding turbulence reports, shears, significant thunderstorms, etc, are provided to dispatchers on a routine basis.

Forecast products are provided in text based format via the WBM and the mainframe data base. The same products are provided in graphic format to all dispatchers and operations control personnel via an operational PC LAN.

Attachments 79 - 94 ... Answers from United Airlines and other data; February 27, 1998.

Summarized Excerpts to Questions

The following are summarized excerpts to questions submitted to the Deputy Chief Investigator of the Japan Aircraft Accident Investigation Commission [reply dated March 3, 1998] .

The Tokyo Aviation Weather Service Center (New Tokyo AWSC) of the Japan Meteorological Agency (JMA) is responsible to issue SIGMET information for the Tokyo FIR.

New Tokyo AWSC issues SIGMET information concerning turbulence, thunderstorms, tropical cyclones, icing, and volcanic ash for the area above around 8,000 meters in the Tokyo FIR in the following cases:

a) SIGMET information for turbulence is issued when an aircraft observation is reported and the phenomenon is expected to continue; or the occurrence of severe turbulence is expected by examining weather charts, GMS cloud imagery, etc.

b) SIGMET information for turbulence is issued when a cluster of cumulonimbus clouds covers more than around a square of 100 kilometers by 100 kilometers.

c) SIGMET information for thunderstorms is issued when a cluster of cumulonimbus clouds covers more than around a square of 200 kilometers by 200 kilometers. SIGMETs for thunderstorms do not include references to associated turbulence.

Messages of SIGMET 3 and 4 were issued since the occurrence of severe turbulence was expected by examining weather charts, GMS cloud imagery, etc.

There were no SIGMETs in effect for the time and area of the accident because by examining weather charts, GMS cloud imagery etc, no occurrence of severe Clear Air Turbulence (CAT) was expected around 32 degrees 30 minutes north, 159 degrees east at nearly 1400 UTC on 28 December. Although a cluster of cumulonimbus clouds was observed around the point, its scale was small and it was not expected to develop into a large-scale cluster of cumulonimbus clouds.

The following Routine Air Reports were received from aircraft at 32 degrees north and 160 degrees east....
1312 UTC NWA 10 FL 350 CODE 0 (Smooth)
1339 UTC NWA 90 FL 350 CODE 1 (Occasional Light)
1351 UTC NWA 22 FL 350 CODE 0 (Smooth)
1502 UTC JAL 72 FL 370 No Turbulence

When Tokyo Radio relayed ATC speed instructions to UAL 826 at 1336 UTC, UAL 826 requested higher altitude due to encountering severe turbulence at 32 degrees 31 minutes north and 157 degrees 27 minutes east. Then Tokyo radio relayed the ATC clearance for FL 330 at 1344 UTC. Later at 1410 UTC, UAL 826 requested ATC clearance for returning to Narita, and UAL 826 replied upon questions from Tokyo Radio, that they had encountered severe turbulence and (...) numerous injuries on board, numerous passenger injuries. Tokyo Radio asked UAL 826 where did they encounter severe turbulence. At 1434 UTC, UAL 826 answered that they were FL 310 track 12, approximately 32 degrees 30 minutes north 158 to 159 degrees east. At 1436 UTC, Tokyo Radio informed this information to UAL, Tokyo Area Control Center, and JMA as an AIREP special, JMA disseminated this AIREP special to the Meteorological Watch Offices [MWOs] in the ICAO Asia and Pacific Regions, World Area Forecast Center [WAFC] Washington, neighboring Regional Area Forecast Centers [RAFCs], aviation weather offices of JMA and some airlines* at around 1438 UTC.

* this is an option for the airlines which have the necessary arrangements for the distribution of meteorological information including SIGMET messages and AIREP reports. United Airlines has not requested to JMA for such arrangements. According to United Airlines they did not know about this arrangement. This is their first indication that such an arrangement is possible [e-mail from United Airlines May 29, 1998].

Attachments 95 - 99 ... Questions supplied by the NTSB; January 6, 1998; and answers from the Japan Aircraft Accident Investigation Commission; March 3, 1998.

Summarized excerpts to questions submitted to the Deputy Chief Investigator [letter dated April 7, 1998].....

The following pilot report from Northwest Flight 80 was found:
NWA80 / 32 degrees north latitude 160 degrees east longitude / 1229Z / FL 330/ turbulence Code 3.

See Attachments 99A, 99B, 99C, 99D, 99E, and 99F.

Advisory Circular No. 00-30B [AC-00-30B]

Summarized excerpts from AC-00-30B, Atmospheric Turbulence Avoidance:

Clear Air Turbulence has been defined in many ways, but the most comprehensive definition is : "turbulence encountered outside of convective clouds." This includes turbulence in cirrus clouds, in some cases in clear air in the vicinity of thunderstorms. Generally, though, CAT definitions exclude turbulence caused by thunderstorms.

One of the principal areas where CAT is found is in the vicinity of the jetstreams. A jetstream is a river-like flow of high-altitude wind following the planetary atmospheric wave pattern, with speeds of 50 knots or greater.

CAT is most frequently found on the poleward side of the jetstream. It is additionally common in the vicinity of a jetstream maxima.

CAT is very difficuly to predict accurately, due in part to the fact that CAT is spotty in both dimensions and time. Common dimensions of a turbulent area associated with a jetstream are on the order of 100 to 300 miles long, elongated in the direction of the wind, 50 to 100 miles wide, and 5,000 feet deep. These areas may persist from 30 minutes to a day.

The threshold windspeed in the jetstream for CAT is generally considered to be 110 knots. It is not the windspeed itself that causes CAT; it is the windshear or difference in windspeed from one level or point to another that causes the wave motion or overturning in the atmosphere that is turbulence to aircraft. Moderate CAT is considered likely when the vertical windshear is 5 knots per 1,000 feet, or greater, and/or the horizontal windshear is 40 knots per 150 miles or greater.

Jetstreams stronger than 110 knots (at the core) have potential for generating significant turbulence near the sloping tropopause [a very thin layer marking the boundary between the troposphere and the stratosphere] above the core, in the jetstream front below the core, and on the low-pressure side of the core.

On charts for standard isobaric surfaces, such as 300 millibars, if a 20-knot isotachs are spaced closer than 150 nautical miles [2 ½ degrees latitude], there is sufficient horizontal shear for CAT. This area is normally on the poleward (low-pressure side) of the jetstream axis).

Turbulence is also related to vertical shear. If vertical shear is greater than 5 knots per 1,000 feet, turbulence is likely.

Curving jetstreams are more apt to have turbulent edges than straight ones, especially jetstreams which curve around a deep pressure trough.

"Rules of Thumb" for Turbulence Avoidance...

If jetstream turbulence is encountered with direct tailwinds or headwinds, the pilot should consider a change of flight level or course since these turbulent areas are elongated with the wind and are shallow and narrow.

If jetstream turbulence is encountered in a crosswind, it is not so important to change course or flight level since the rough areas are narrow across the wind.

Monitor your radio -- pilot reports can be invaluable and if you get caught by "the CAT," file a PIREP!

A Model for a Clear Air Turbulence Avoidance System.....

An appropriate initial and recurrent training program.

A dedicated planning/dispatch function.

A fully supported operational implementation of a pilot reporting/communications system (not ATC based).

Attachments 100 - 108 ... AC-00-30B.

Selected Turbulence Encounters

Altitude in Feet.
G Load = Vertical Acceleration in G's ... Delta G's = Change in G's

Date	Aircraft	Location	Altitude	G Load	Delta G's
11/3/75	DC-10	Calgary, Canada	33,000	+1.6 -0.2	1.8
4/4/81	DC-10	Hannibal, MO	37,000	+1.7 -1.0	2.7
7/16/82	DC-10	Morton, NY	39,000	+1.6 -0.6	2.2
10/12/83	DC-10	Near Bermuda	37,000	+1.6 -0.6	2.2
11/25/83	L-1011	Offshore, SC	37,000	+2.1 -1.0	3.1
1/22/85	B-747	Over Greenland	33,000	+2.7 -0.0	2.7
4/7/86	DC-10	Jamestown, NY	40,000	+1.8 -0.4	2.2
9/27/87	L-1011	Near Bermuda	31,000	+2.2 -0.5	2.7
11/12/87	A-310	Near Bermuda	33,000	+2.0 -0.6	2.6
½0/88	B-767	Chicago, IL	25,000	+1.4 -0.2	1.6
3/24/88	B-767	Cimarron, NM	33,000	+1.7 -0.2	1.9
6/6/89	DC-10	Garden City, KS	37,000	+1.9 -0.9	2.8
6/16/89	L-1011	Jackscreek, TN	24,000	+2.2 -1.0	3.2
3/31/93	B-747	Anchorage, AK	2,000	+1.8 +0.6	1.2
12/28/98	B-747	Pacific Ocean	31,000	+1.4 -0.8	2.2

Data from NTSB Accident Report AAR-93-06; In-Flight Engine Seperation, Japan Airlines, Inc., Flight 46E, Boeing 747-121, N473EV, Anchorage Alaska, March 31, 1993. UAL 826 accident included in the above Table.

The following relates the intensity of turbulence to the change in vertical G:
Moderate Turbulence ... Change in Vertical G of 0.5 to 1.0.
Severe Turbulence ... Change in Vertical G of 1.0 to 2.0.
Extreme Turbulence ... Change in Vertical G greater than 2.0.
Source: U.S. National Weather Service.

Summary of Answers to Questions Submitted to Northwest Airlines

The following are summarized excerpts of answers to questions [see Attachments 109 to 113] submitted to Northwest Airlines [letter dated April 8, 1998]...

NWA 80 did report the turbulence encountered and it was received by our Tokyo dispatch office. The crew classified it as Code 3 [NWA definition code 3 is light occasionally moderate turbulence]. The information transmitted did not accurately reflect the captain's [NWA 80] description of the turbulence encountered [reference Attachment 75] as "the worst I've ever encountered" as confirmed by subsequent discussion with him. He should have assigned it a code 5 or 6 [code 5 .. moderate occasional severe turbulence; code 6 .. severe turbulence].

Since the report was only for code 3 and since a Northwest Turbulence Plot [TP] message was already in place for code 2 [light turbulence] in the area no further action was taken by Northwest dispatch or meteorology. If a code 5 or 6 report comes in, meteorology will immediately re-evaluate the current TP or issue one for Northwest Flights if there is not one currently in effect.

Northwest pilot reports are not disseminated outside of Northwest Airlines because there is no mechanism in effect to do so. Those reports given as part of international flight's position reports are accessible to other airlines dispatch centers but, to the best of my knowledge, are not routinely monitored by other airlines (nor does Northwest routinely monitor other airlines' reports).

Northwest has concluded an agreement with SkySource wherein our TP messages will be accessible by other airlines or service providers. This still will not provide pilot reports from Northwest flights.

Meeting at the Naval Research Laboratory [NRL] in Monterey, California

On July 16, 1998 a meeting was held at the NRL in Monterey, California to discuss a review of the meteorology associated with the UAL 826 turbulence accident. Present at the meeting were representatives from ALPA, UAL, FAA, the National Center for Atmospheric Research [NCAR], and NRL. The following is a summary (composed 7/16/98) of NRL and NCAR findings [note in bold clarifications made to the original summary]:

Satellite analyses indicated the presence of a rapidly-developing frontal wave system in the 6 hours leading up to the incident, which suggested synoptic and mesoscale circulation. A region of convective storms appeared **to be forming** [changed from to form...NRL correspondence 12/15/98] to the southwest of this developing wave, just prior to the penetration **of this region by the accident aircraft** [changed from penetration of the accident aircraft ... NRL correspondence 12/15/98]; these cells continued to develop rapidly after the accident, as evident in the satellite data. Convection is at or just below the altitude of the aircraft altitude of FL 310 (9.5 kilometers and approximately -40 degrees C).

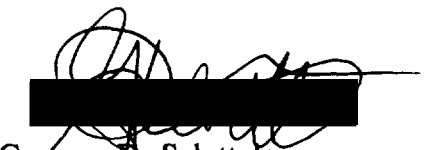
COAMPS analyses indicated a rapidly deepening frontal wave and cyclonic circulation developed in the 12 hours preceding the accident, which moved as it developed to the east. The model appeared to confirm that a region of convection **existed [added to sentence ... NRL correspondence 12/15/98] to the southwest of the primary wave, in the vicinity of the accident site. The model indicated a strong jet stream immediately above the flight (60 meters/second from the west) and the development of an extensive region of turbulence kinetic energy (TKE) immediately to the east of the event region. There are indications of mesoscale gravity wave structure in and around the system.

The turbulence linked to this incident may have been associated with convection reaching up to or just below flight altitude, with a possible encounter within the convective cell, or immediately above it, or adjacent to such a cell. [replaced the sentence Turbulence may have been associated with convection with turbulence reaching flight altitude, or clear air turbulence just above rising convection ... NRL correspondence 12/15/98].

> **COAMPS is an acronym for "The Coupled Ocean/Atmosphere Mesoscale Prediction System" and it represents an analysis-nowcast and short-term (up to 48 hours) forecast tool applicable for any given region of the earth. COAMPS includes an atmospheric data assimilation system comprised of data quality control, analysis, initialization, and nonhydrostatic atmospheric model components and a choice of two hydrostatic ocean models. The atmospheric

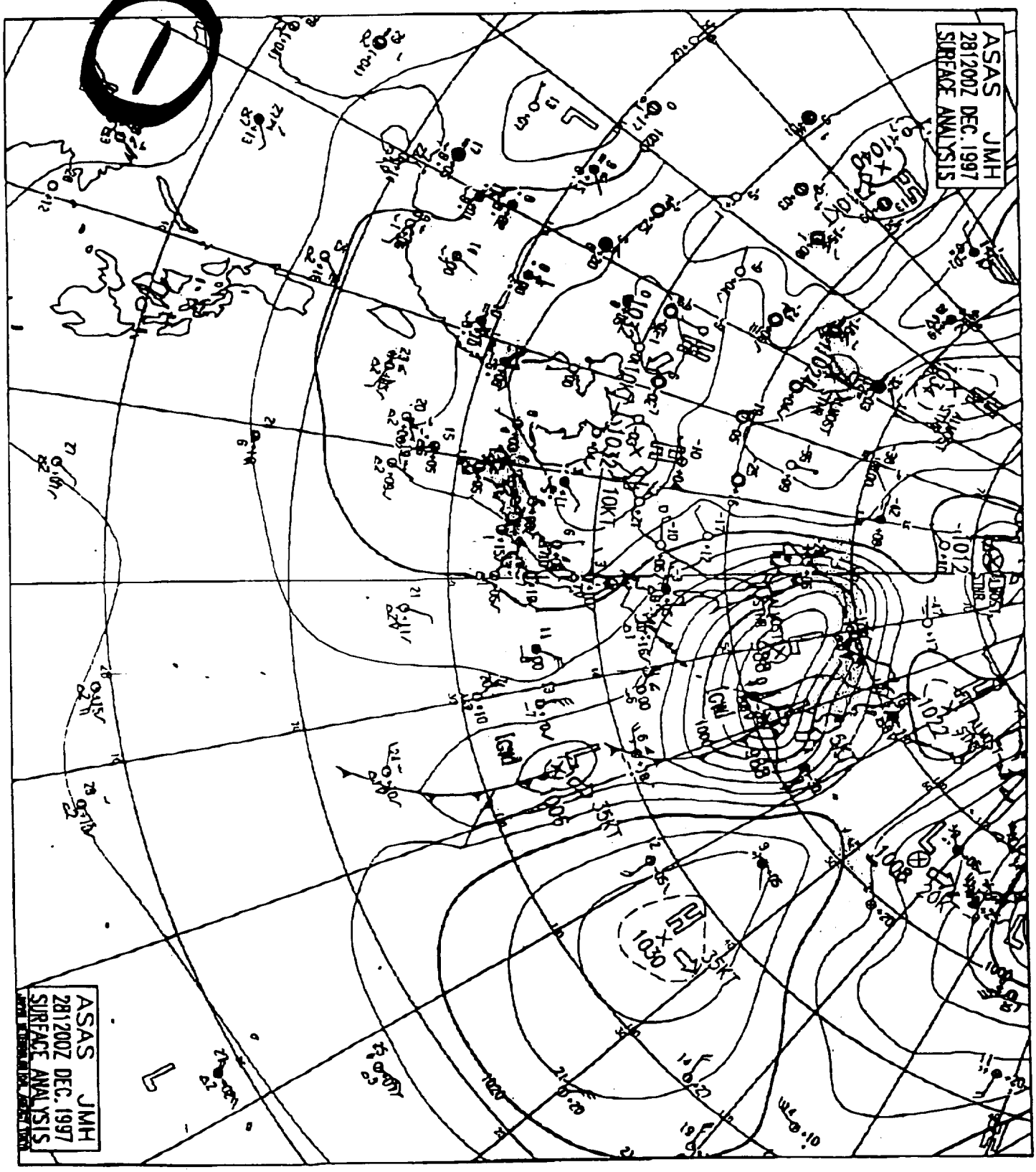
component of COAMPS can be used for real-data simulations, the analysis can use global fields from the Navy Operational Global Atmospheric Prediction System (NOGAPS) or the most recent COAMPS forecast as the first-guess. Observations from aircraft, rawinsondes, ships, and satellites are blended with the first-guess fields to generate the current analysis. For the idealized experiments, the initial fields are specified using an analytic function and/or empirical data (such as a single sounding) to study the atmosphere in a more controlled and simplified setting. The atmospheric model uses nested grids to achieve high-resolution for a given area and contains parameterizations for sub-grid scale mixing, cumulus parameterization, radiation, and explicit moist physics. Typical mesoscale phenomena that COAMPS has been applied to includes mountain waves, land-sea breezes, terrain-induced circulations, tropical cyclones, mesoscale convective system, coastal rainbands, and frontal systems. The model grid size, usually referred to as grid resolution, can range from a few hundred kilometers (synoptic scale) down to approximately one meter when using the large-scale eddy (LES) mode. In practice, real data simulations are typically made with resolutions of a few kilometers or larger, with LES simulations limited to simulations of idealized data. The COAMPS model domain covers a limited area on the earth. The actual dimensions used depend on the scale of the phenomena the user is interested in simulating. The model dimensions can be set so as to produce any rectilinear pattern and can also be rotated to align with any surface feature, such as the terrain or a coastline. COAMPS can be run with any number of nested grids, with the grid resolution in any mesh one-third that of the next coarser mesh.

COAMPS also contains an option to utilize either the Modular Ocean Model (MOM) or the Princeton Ocean Model (POM). In a fully-coupled mode, the atmospheric and ocean models can be integrated simultaneously so that the precipitation and the surface fluxes of heat, moisture, and momentum are exchanged across the air-ocean interface every time step. Optionally, the atmospheric model or either of the ocean models can be used as a stand-alone system. At this time, the option to utilize an ocean model within COAMPS is limited to our in-house R&D effort. Our plans call for exhaustive testing of the capabilities of a fully-coupled system before this system is transitioned for use to operations.



Gregory D. Salottolo
National Resource Specialist
Meteorology

Attachments to the Meteorological Factual Report
DCA98MA015
(119 Pages)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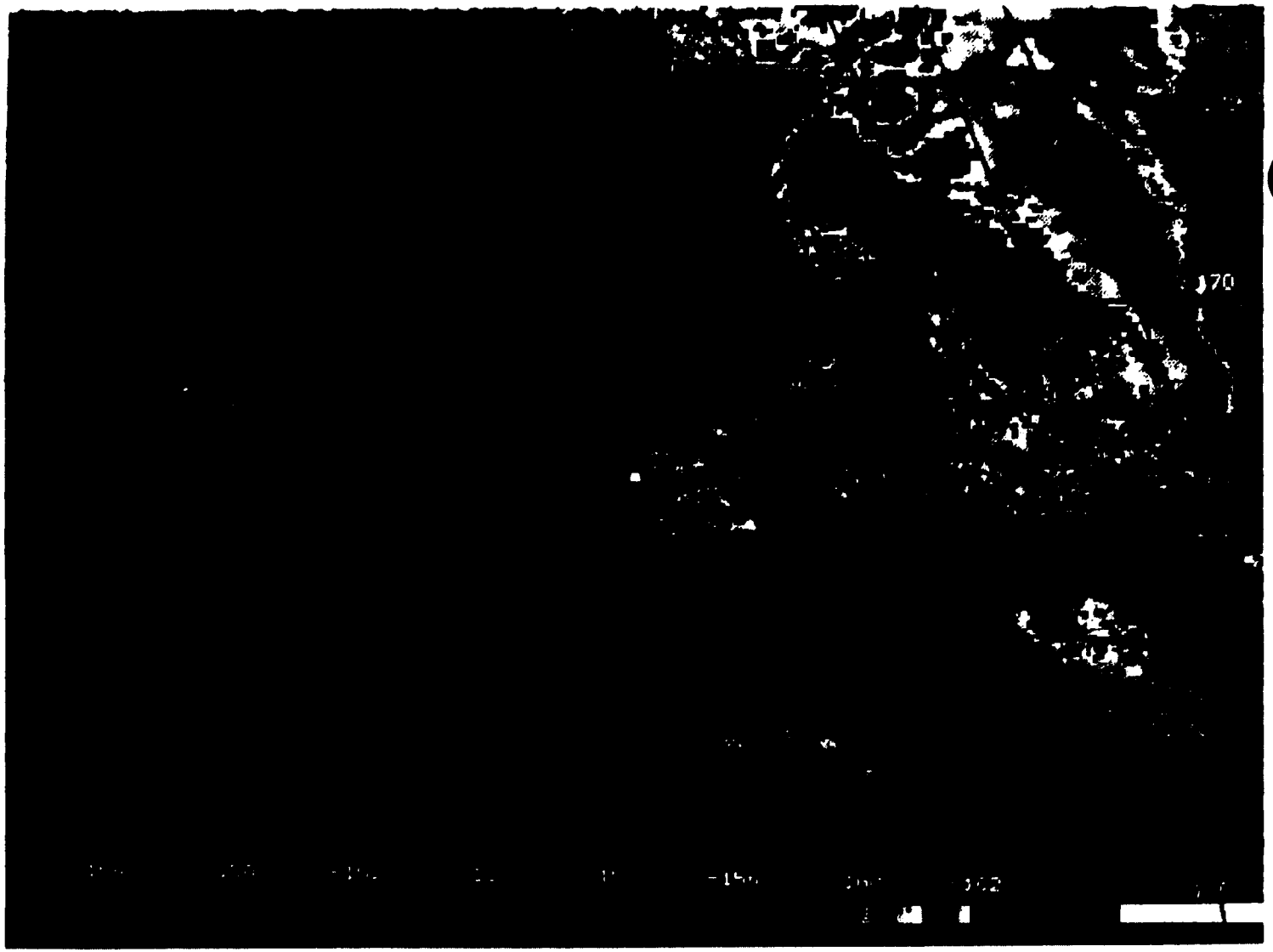
SURFACE ANALYSIS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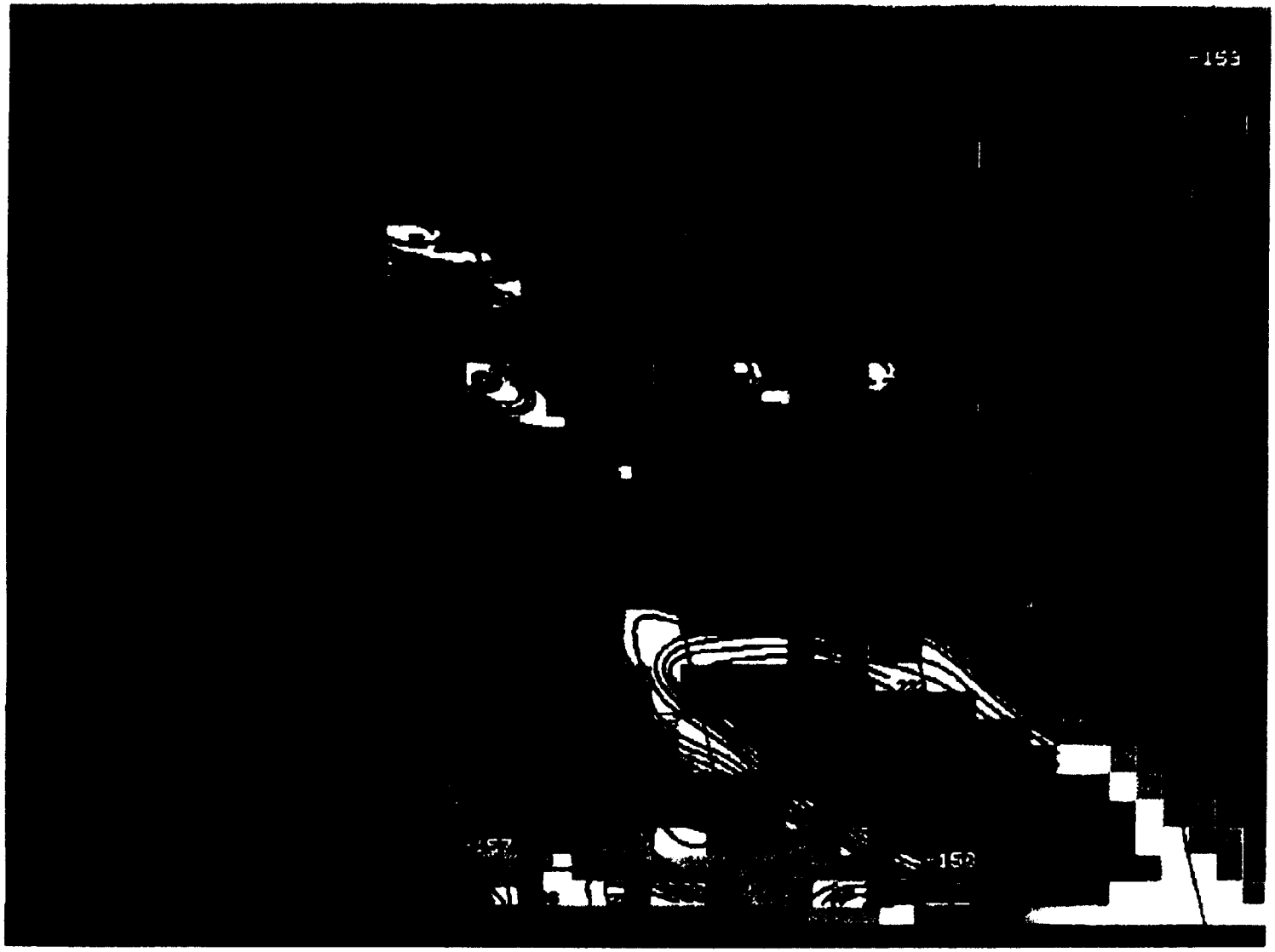
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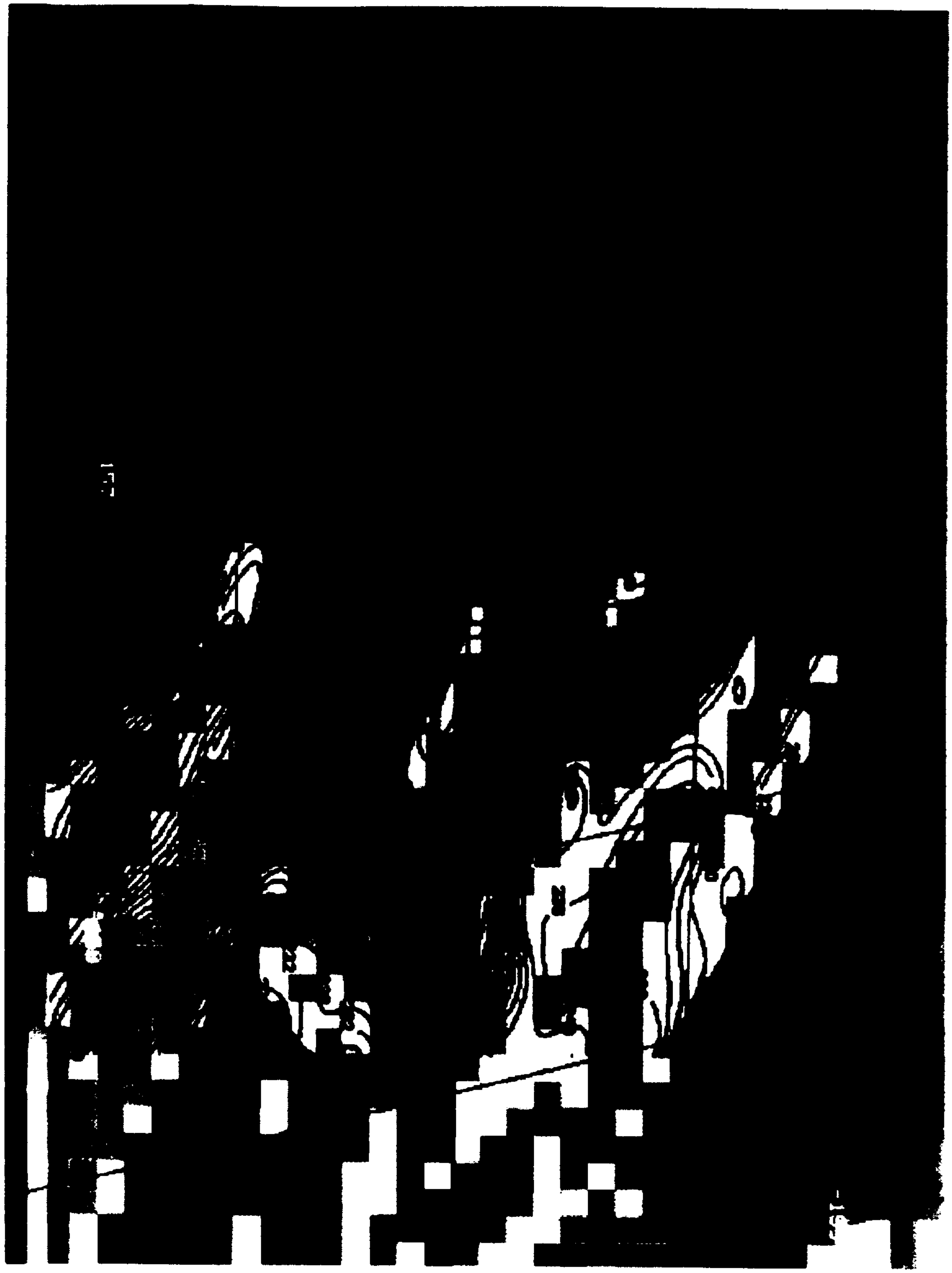

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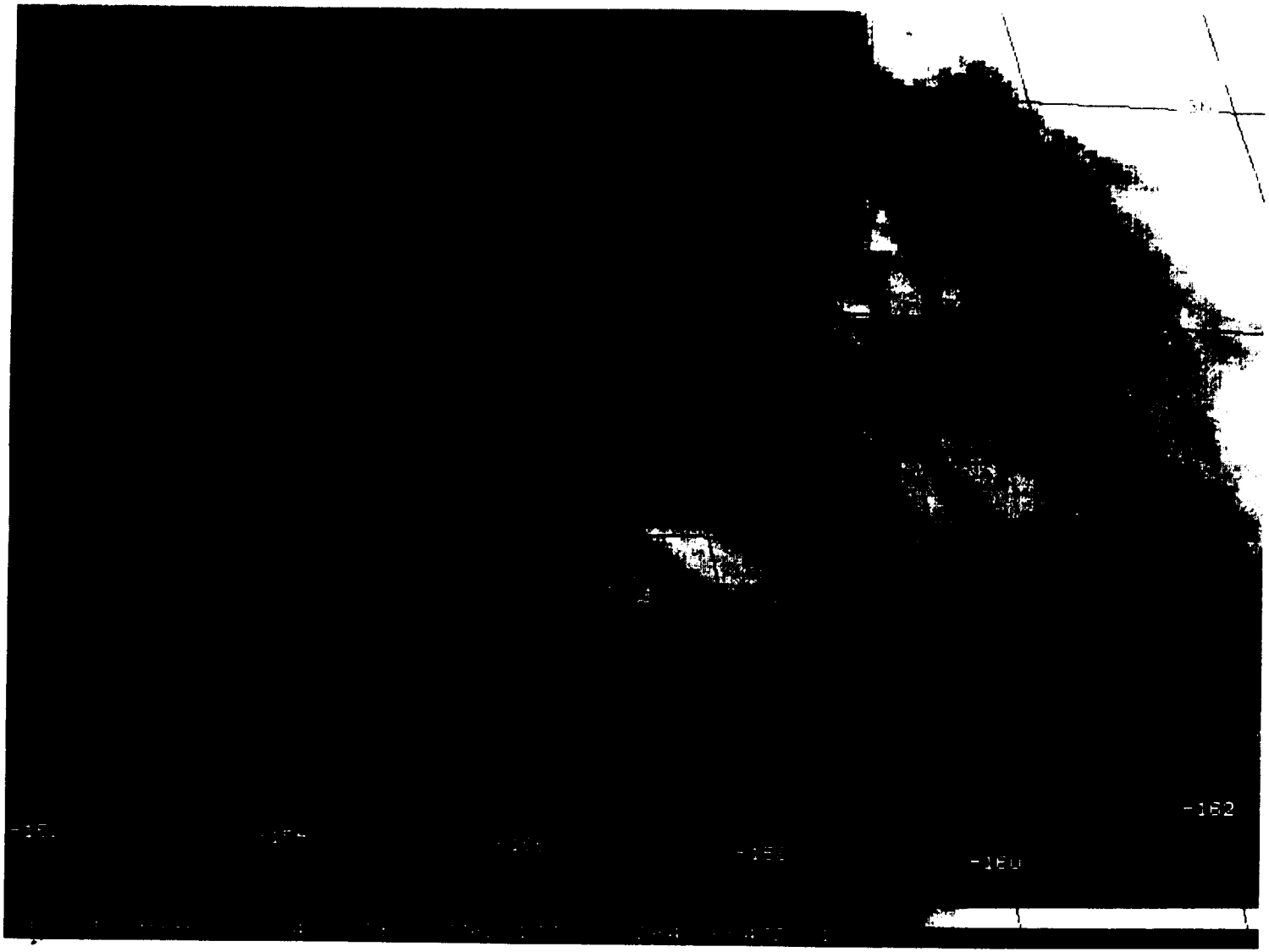

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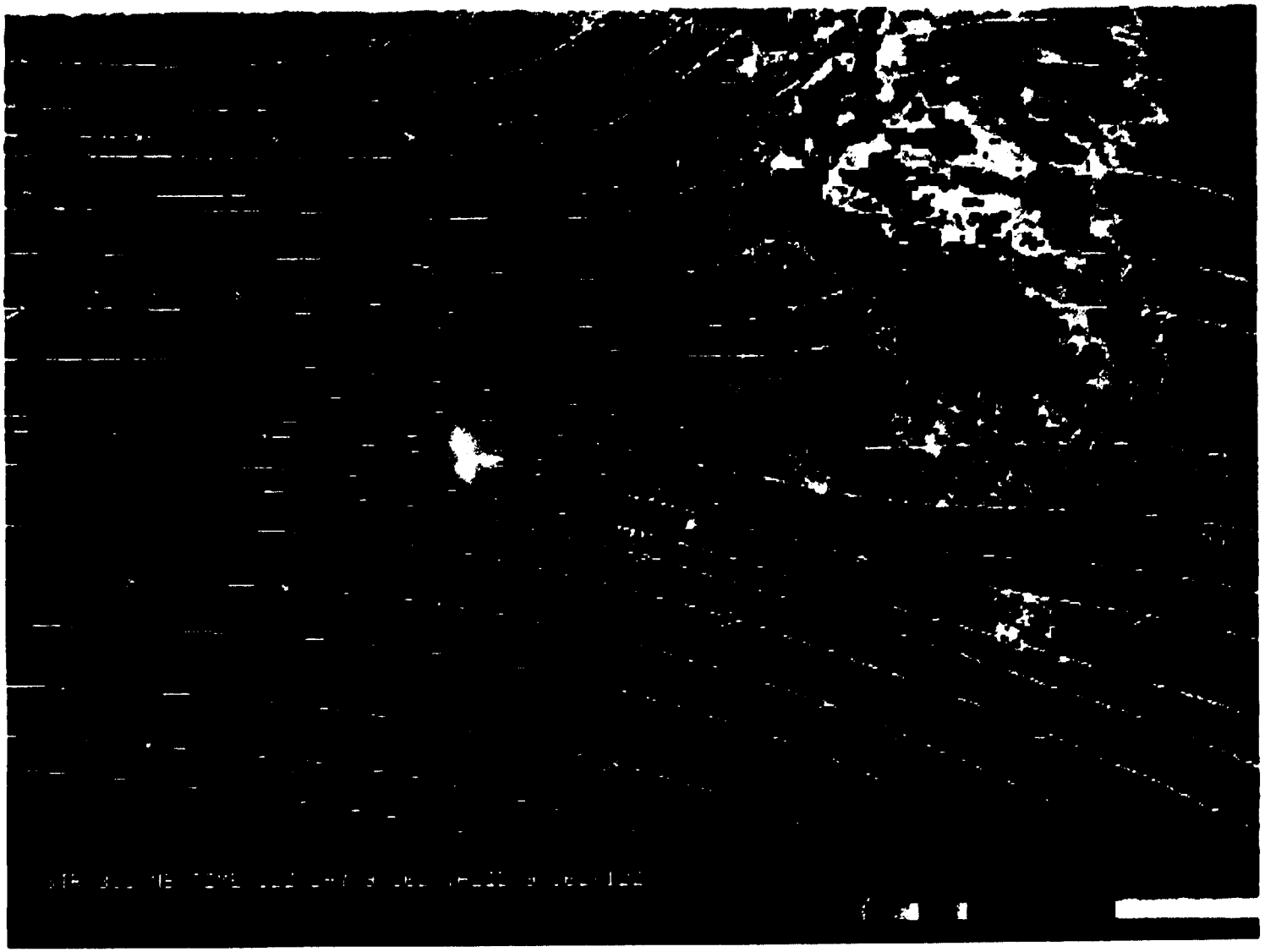

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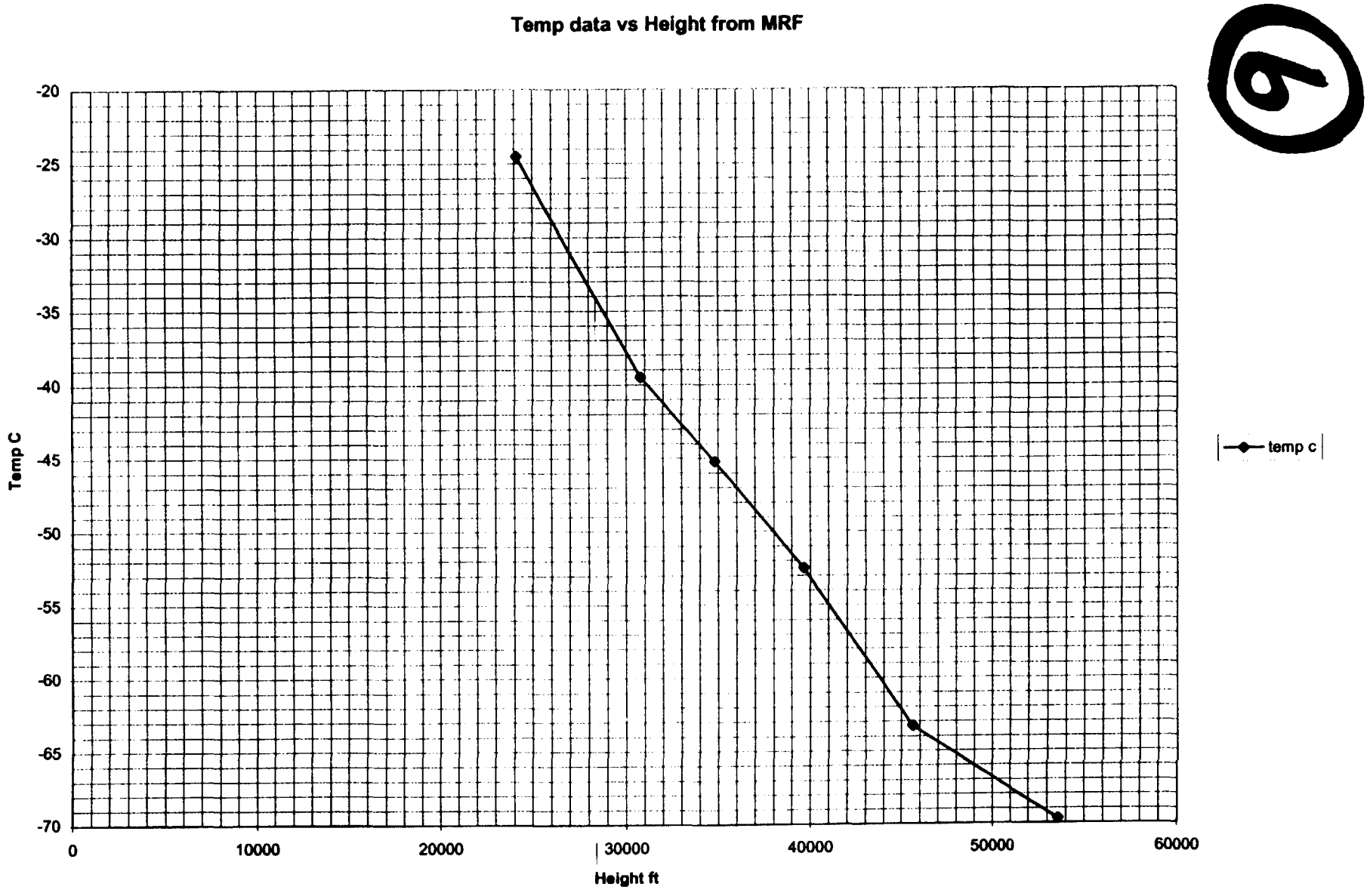
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60000
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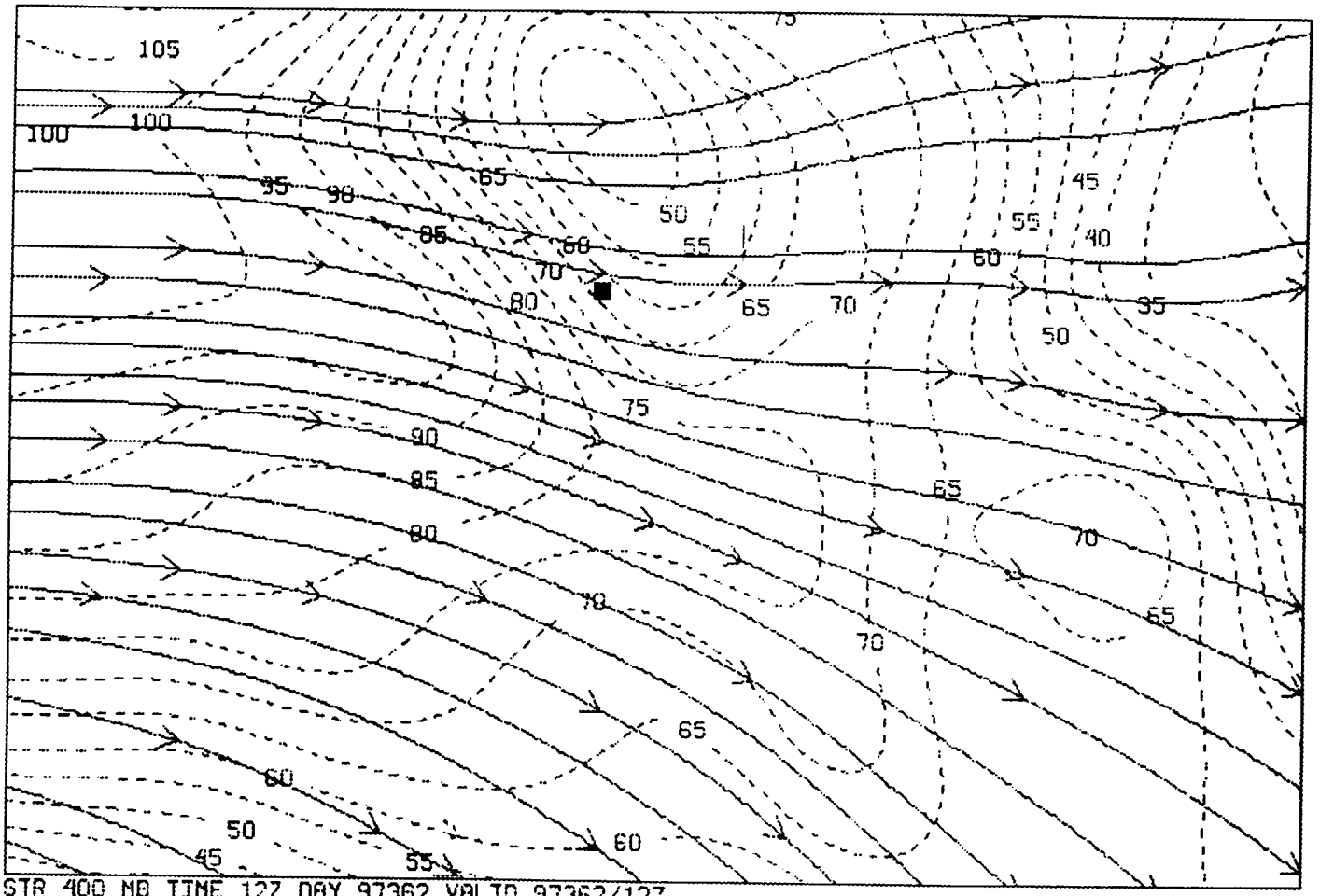
temp c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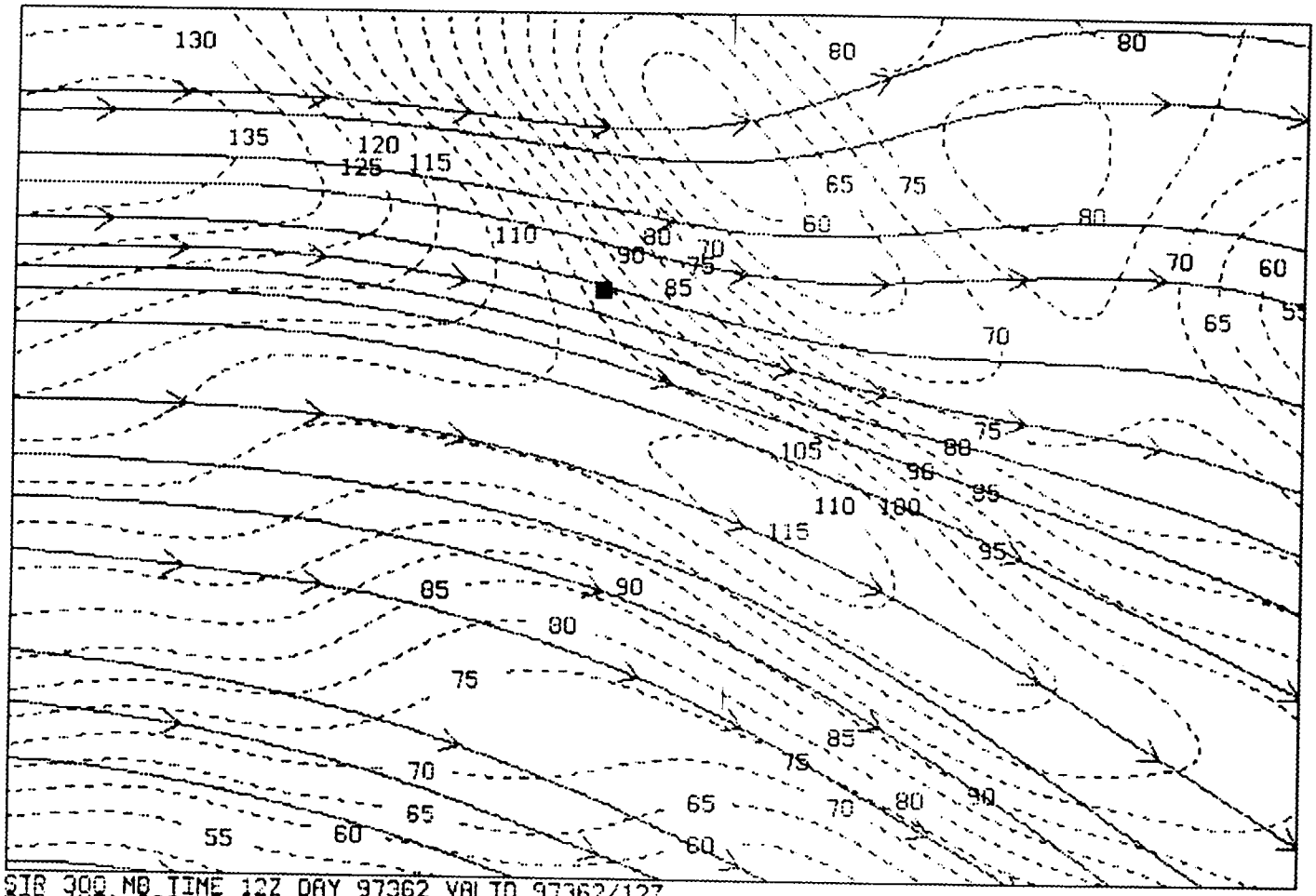
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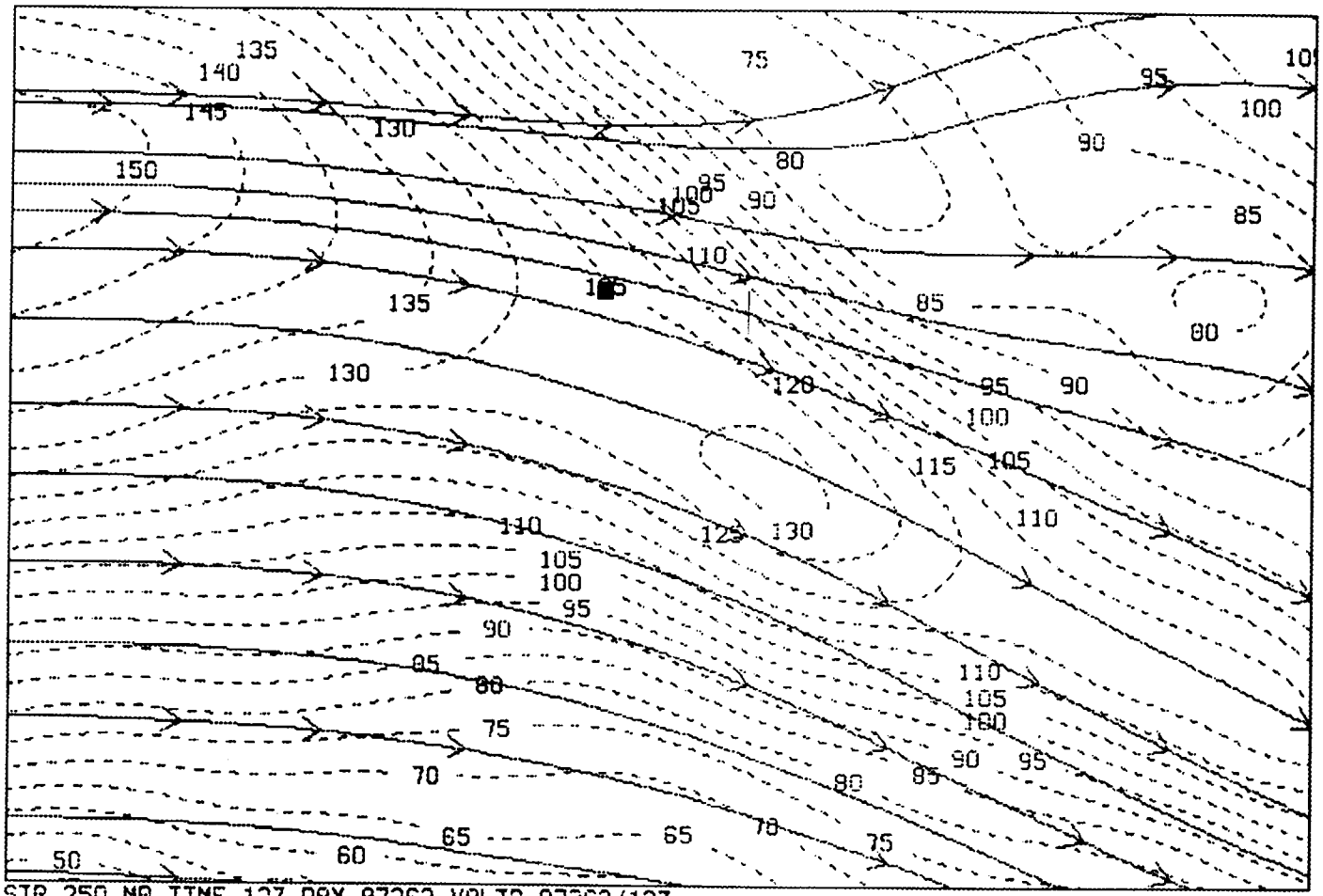
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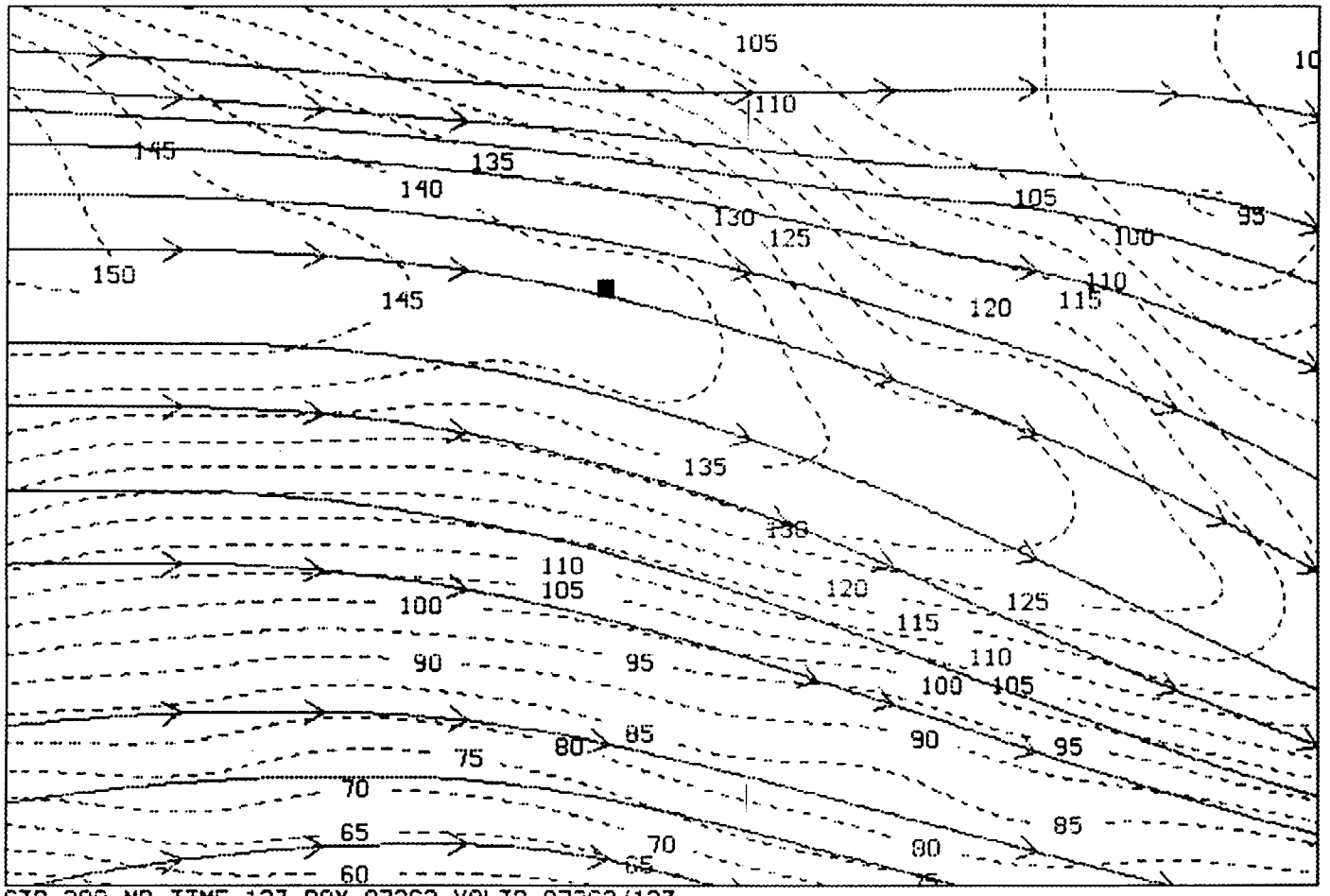

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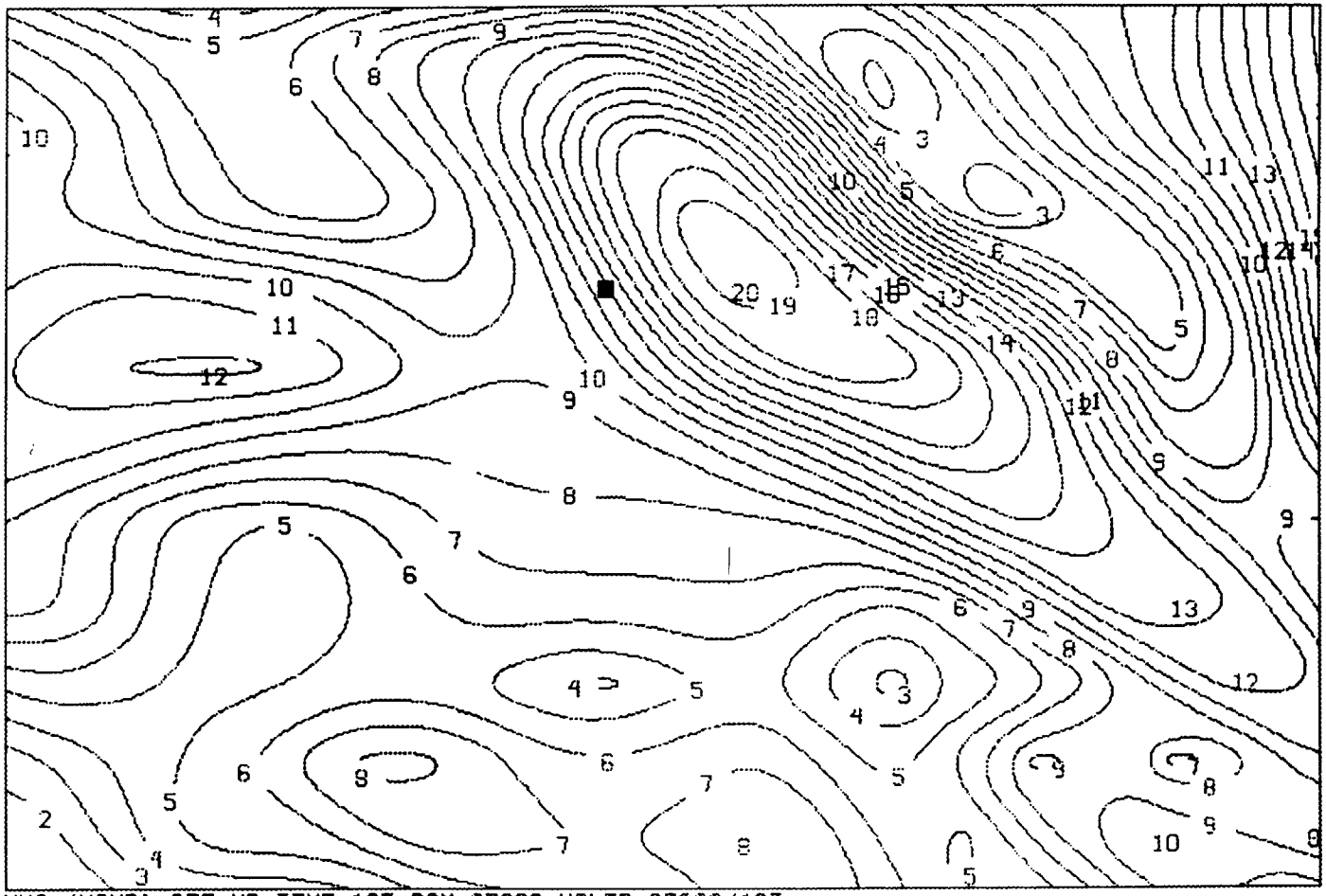

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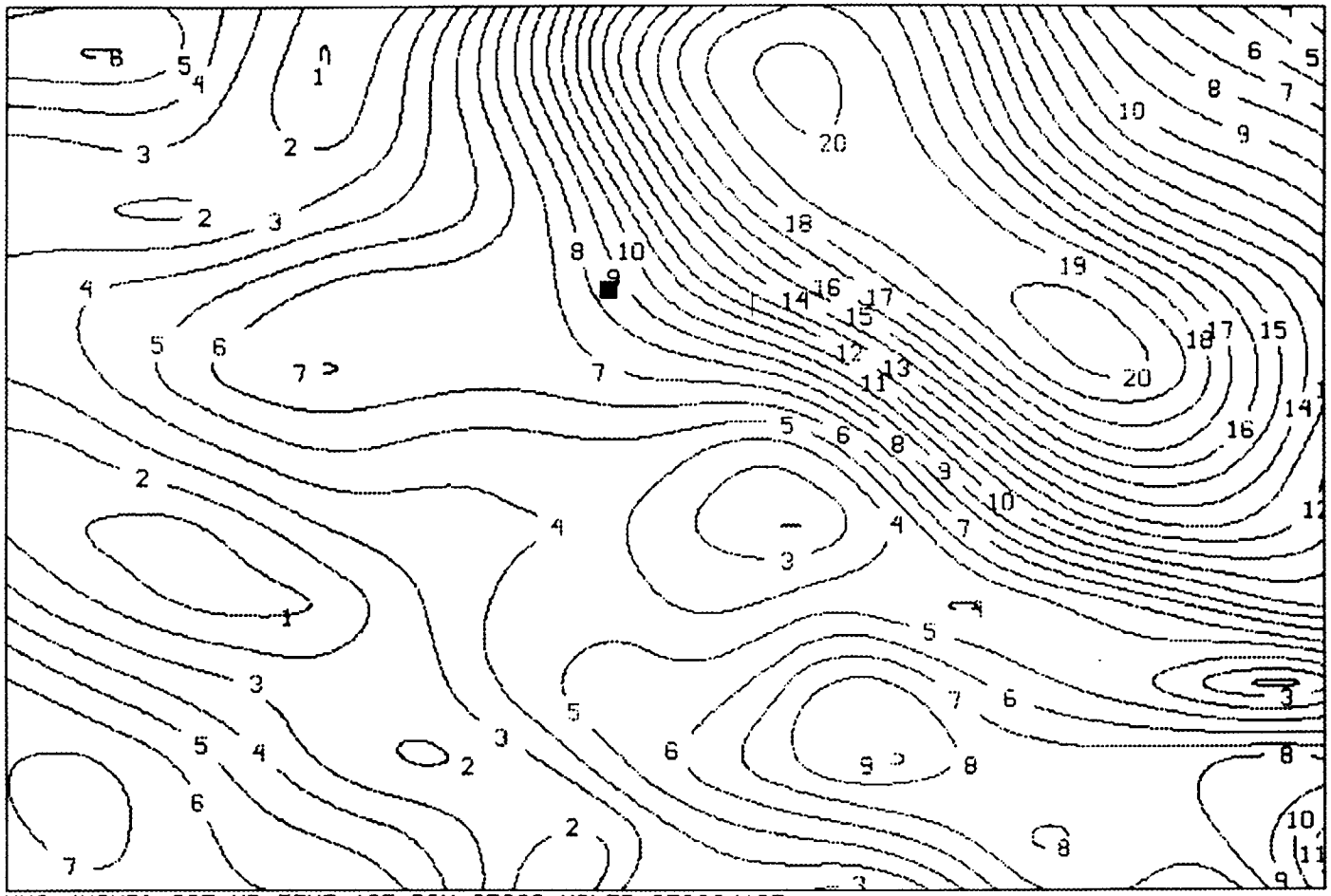

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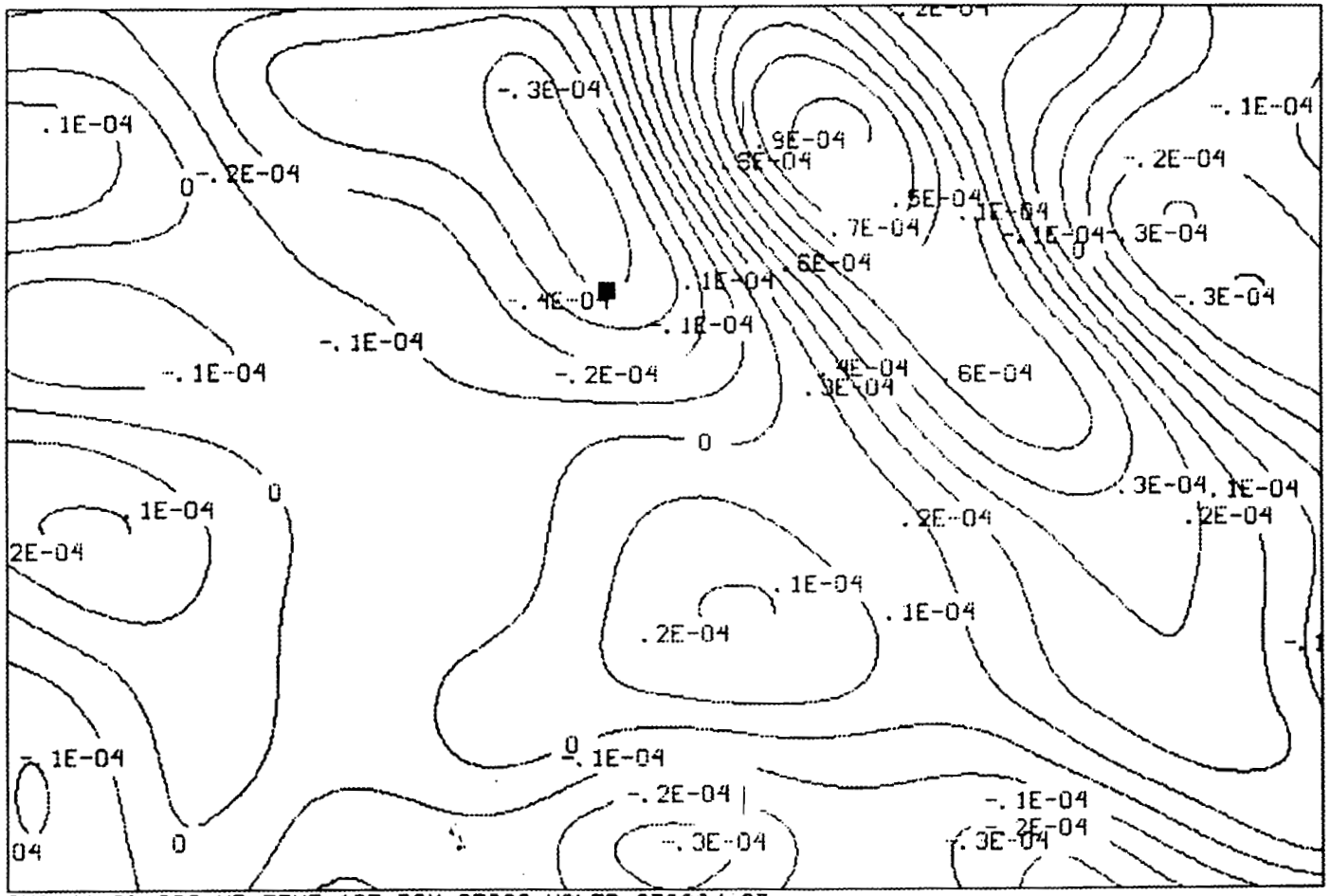
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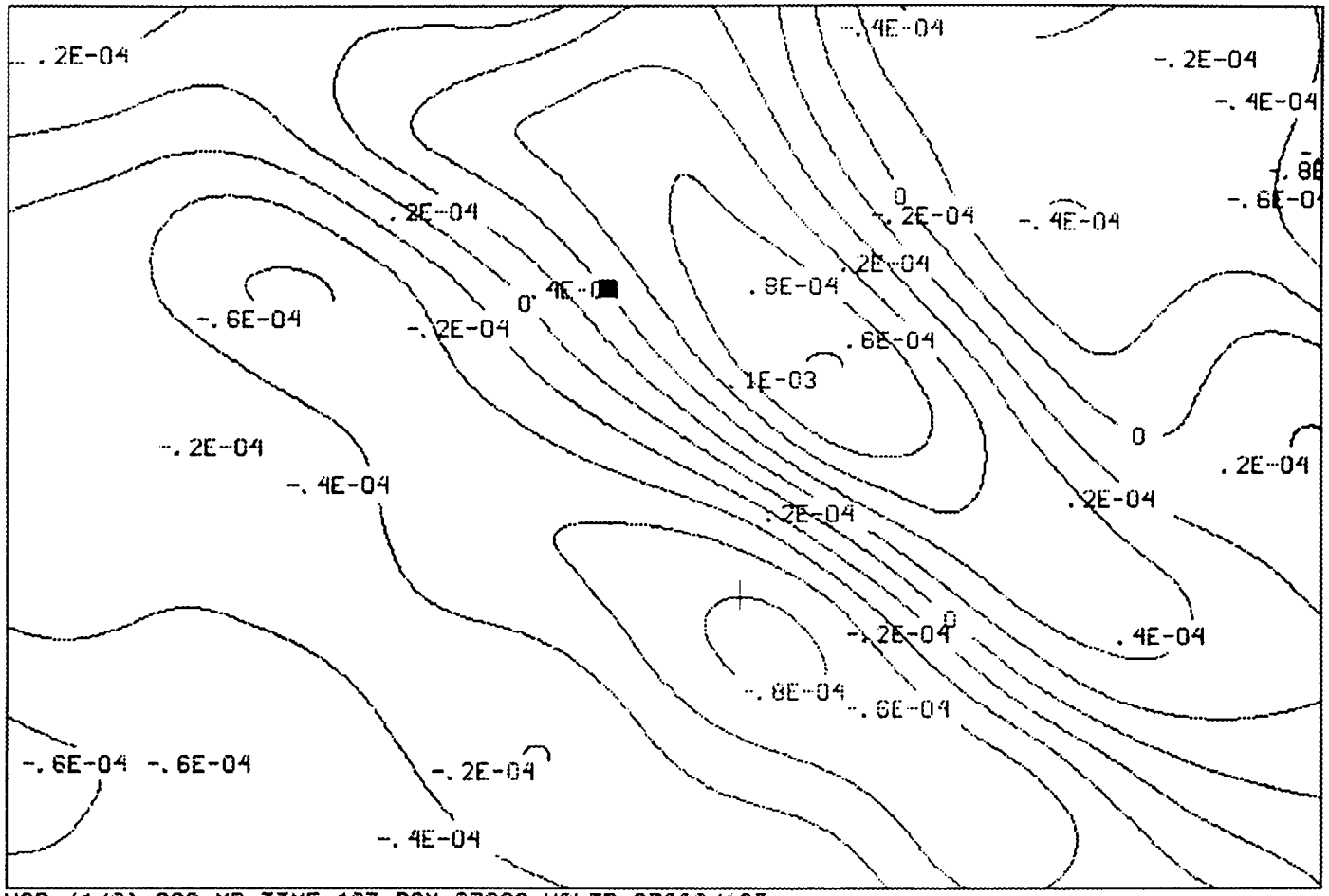

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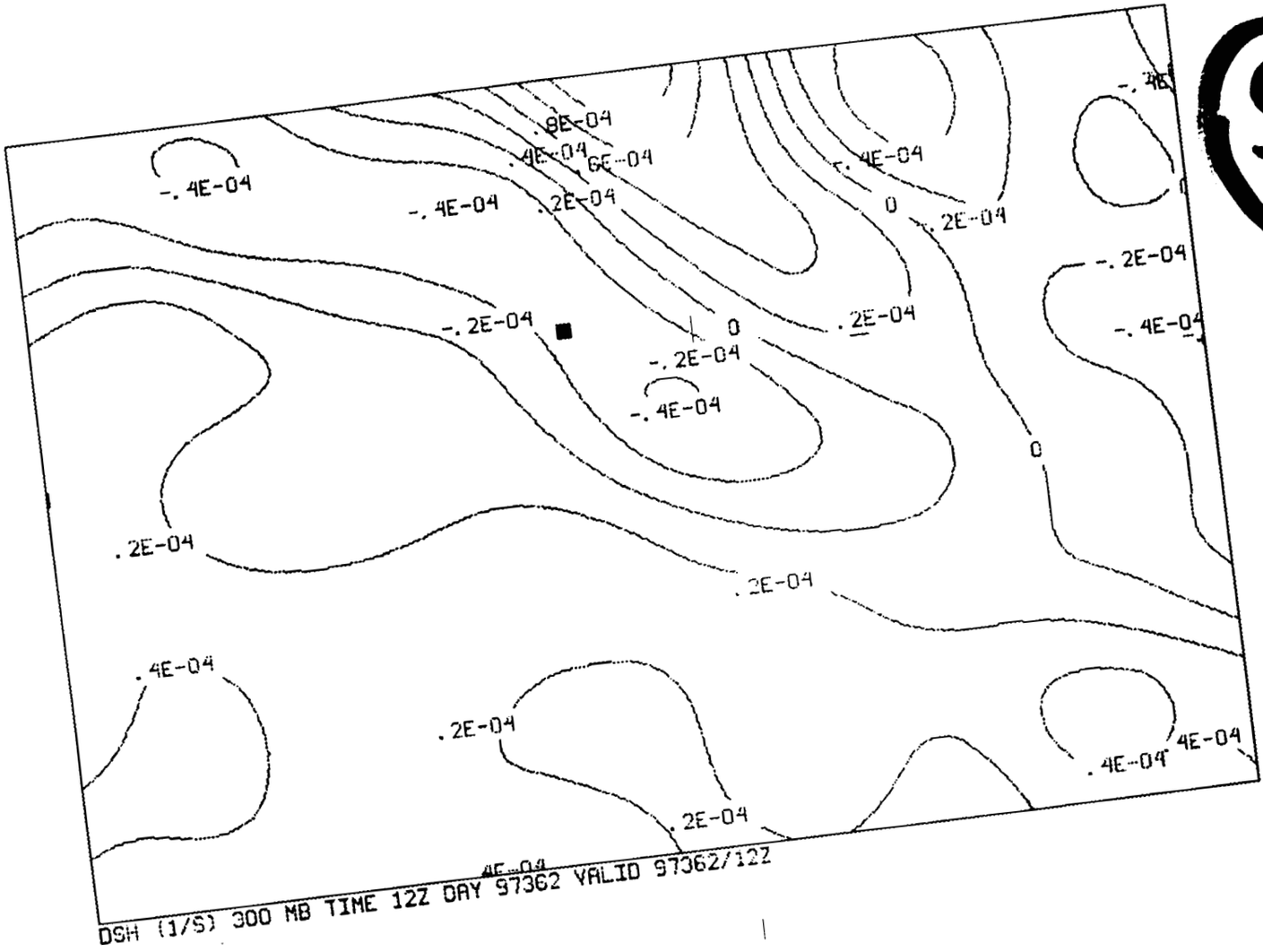

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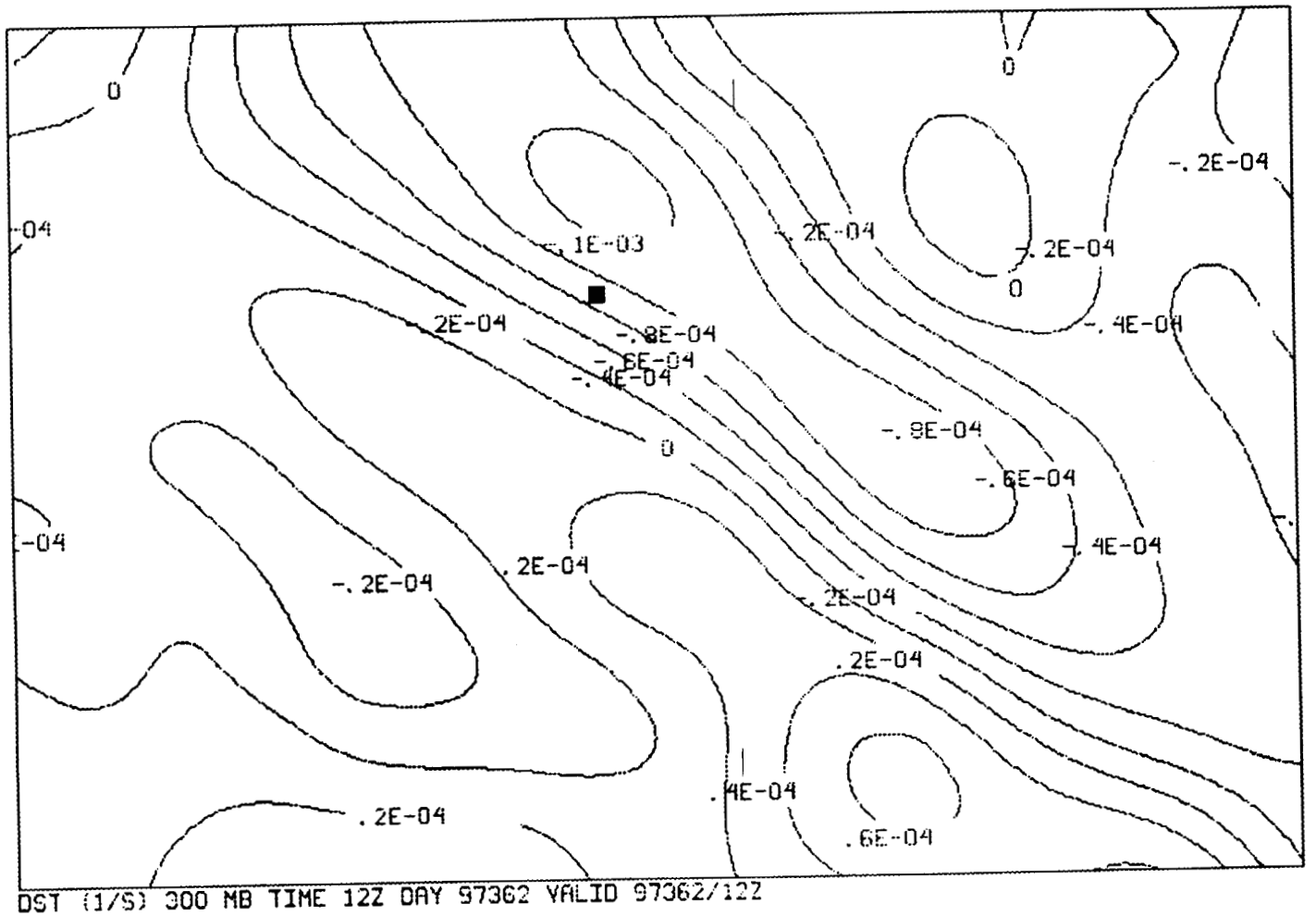
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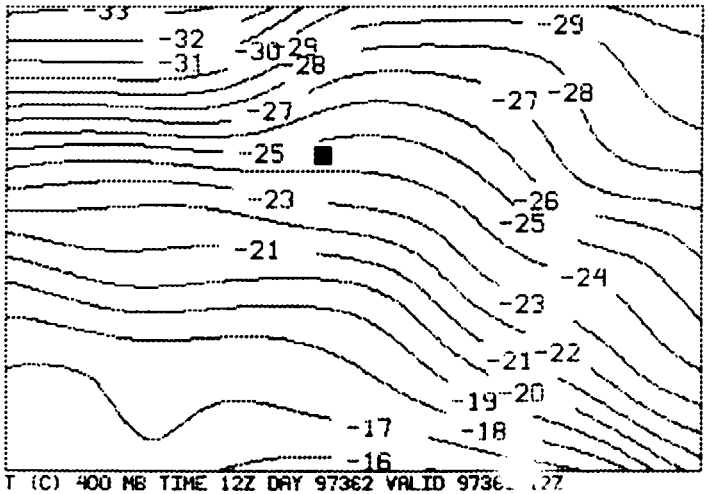

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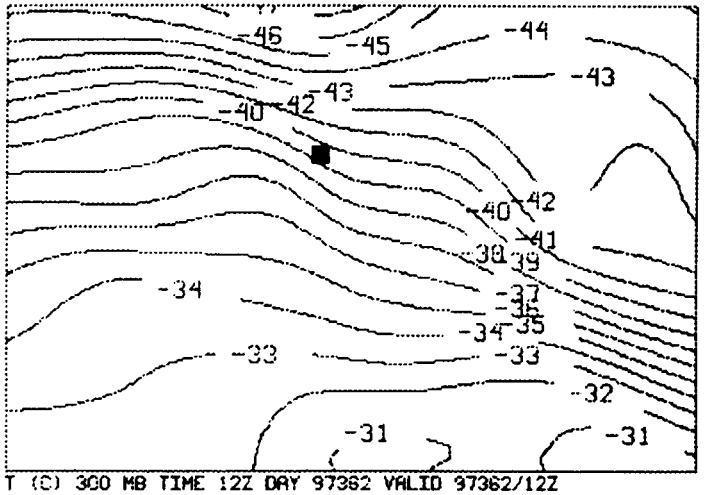

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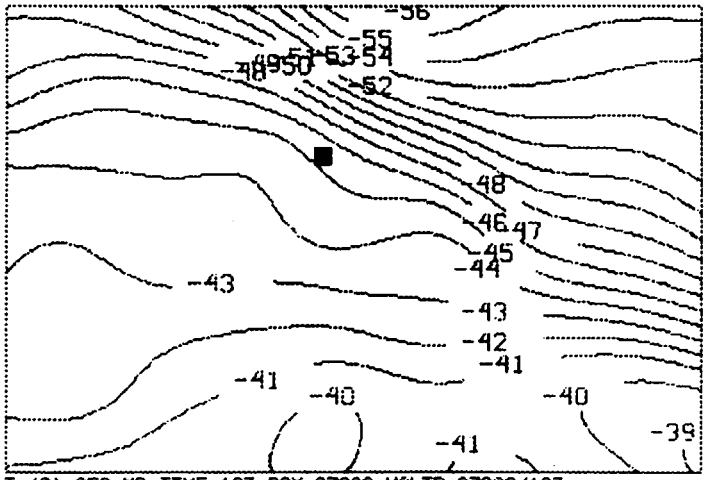

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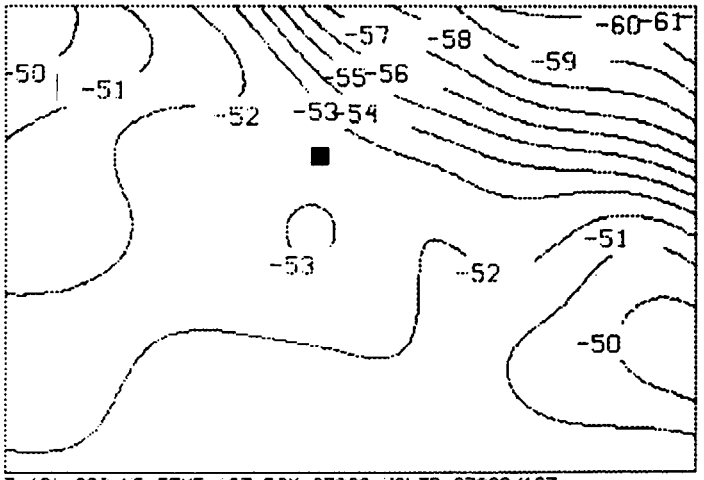

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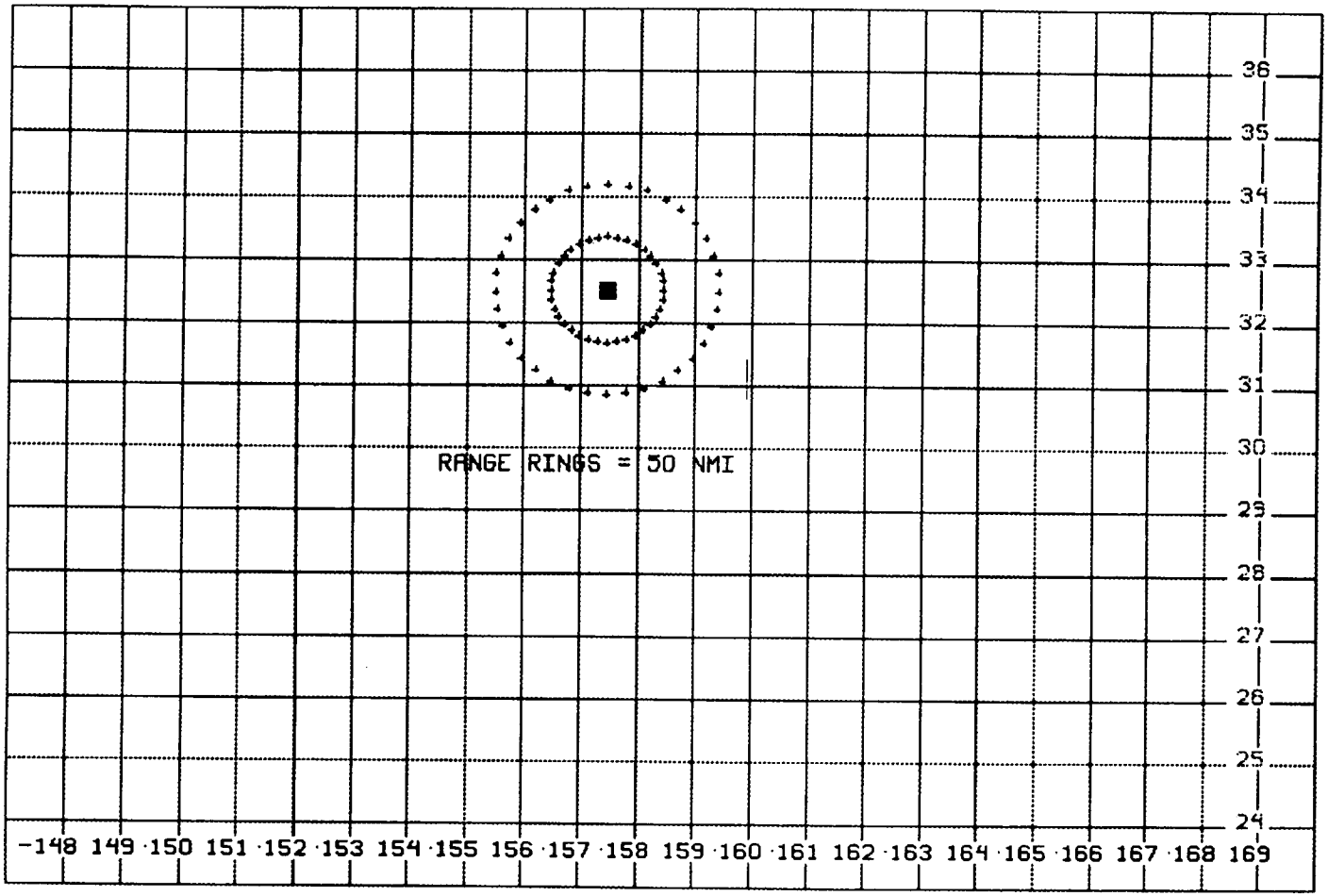
RANGE RINGS = 50 NMI
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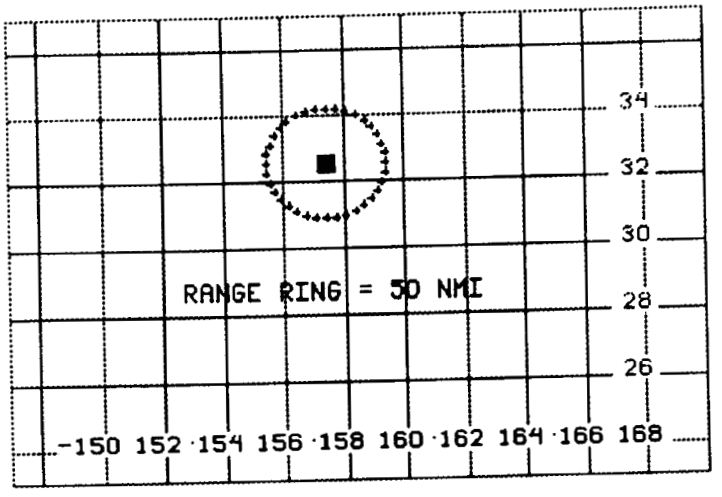
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RANGE RING = 50 NMI
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TRANSCRIPTION OF UAL826 AND TOKYO RADIO

1997 28TH DEC
TIME:UTC

TIME (Z)	CALL SIGN	COMMUNICATIONS
11:42:44	UAL826	TOKYO UAL826
	TOKYO	STATION CALLING TOKYO GO AHEAD
	UAL826	REQUEST HIGH FREQUENCY FOR HONOLULU
	TOKYO	SAY AGAIN YOUR CALL SIGN
	UAL826	SAY AGAIN
	TOKYO	SAY AGAIN YOUR CALL SIGN
	UAL826	UAL826 ALFA FOXTROT DELTA KILO
	TOKYO	MAKE PRIMARY 3455 SECONDARY 4666
	UAL826	3455 4666 THANK YOU
11:47:00	UAL826	TOKYO UAL826 RADIO CHECK ON 3455
	TOKYO	JUST STAND BY PLEASE
11:47:18	TOKYO	BREAK UAL826 STAND BY SELCAL CHECK ALFA FOXTROT DELTA KILO (SENT SELCAL SIGNAL)
	UAL826	SELCAL CHECK UAL824 ...ER 826
	TOKYO	TOKYO
12:31:31	UAL826	TOKYO CONTROL UAL826
	TOKYO	SAY AGAIN YOUR CALL SIGN OVER
	UAL826	UAL826
	TOKYO	UAL826 GO AHEAD
	UAL826	CHECK SMOLT AT 1230 FLIGHT LEVEL 310 ESTIMATE MASON 1300 32 NORTH 160 EAST NEXT
	TOKYO	UAL826 TOKYO ROGER REPORT MASON 3455 PRIMARY 4666 SECONDARY
	UAL826	ROGER UAL826
	TOKYO	TOKYO
12:34:58	UAL826	TOKYO RADIO UAL826
	TOKYO	UAL826 TOKYO GO AHEAD.
	UAL826	ROGER PLEASE TO THE ATC UAL826 REQUEST FLIGHT LEVEL 350
	TOKYO	REQUEST FLIGHT LEVEL 350 STAND BY ONE CALL YOU BACK
12:37:30	TOKYO	UAL826 TOKYO
	UAL826	ER 826 GO AHEAD

23

	TOKYO	ATC ADVISES UAL826 UNABLE ANY HIGHER DUE TO TRAFFIC OVER
	UAL826	O-KAY UAL826 THANK YOU
13:04:10	UAL826	TOKYO UAL826
	UAL826	TOKYO TOKYO UAL826
	TOKYO	UAL826 TOKYO GO AHEAD
	UAL826	UAL826 MASON 1300 FLIGHT LEVEL 310 ESTIMATING 32 NORTH 160 EAST AT 1348 30 NORTH 170 EAST NEXT FUEL 153.4 MINUS 40 270 DIAGONAL 130 OVER
	TOKYO	TOKYO ROGER UAL826 AND TOKYO STAND BY SELCAL CHECK ALFA FOXTROT DELTA KILO (SENT SELCAL SIGNAL)
	UAL826	ROGER UAL826
13:36:45	TOKYO	UAL826 TOKYO (SENT SELCAL SIGNAL) UAL826 TOKYO
	UAL826	ANSWERING SELCAL
	TOKYO	CLEARANCE ATC CLEARS UAL826 MAINTAIN MACH POINT 84 DUE TO TRAFFIC OVER
	UAL826	UAL826 ROGER AND MESSAGE FOR ATC UAL826 AT POSITION 3231 NORTH 15727 EAST ENCOUNTERING SEVERE - TURBULENCE AND REQUESTING ANY HIGHER ALTITUDE OVER
	TOKYO	UAL826 TOKYO STAND BY YOUR REQUEST
13:44:35	TOKYO	UAL826 TOKYO (SENT SELCAL SIGNAL)
	UAL826	GO AHEAD TOKYO
	TOKYO	UAL826 CLEARANCE ATC CLEARS UAL826 CLIMB AND MAINTAIN LEVEL 330 REPORT REACHING MAINTAIN MACH POINT 84 OVER
	UAL826	ATC CLEARS UAL826 CLIMB TO AND MAINTAIN 330 MACH 84 REPORT REACHING
	TOKYO	TOKYO
13:48:23	UAL826	UAL826 FLIGHT LEVEL 330
	TOKYO	UAL826 REACHING FLIGHT LEVEL 330 TOKYO ROGER
13:55:20	UAL826	TOKYO UAL826 POSITION
	TOKYO	UAL826 STAND BY ONE STAND BY ONE
	TOKYO	UAL826 TOKYO GO AHEAD
	UAL826	UAL826 POSITION 32 NORTH 160 EAST AT 1352 FLIGHT LEVEL 330 ESTIMATING 30 NORTH 170 EAST AT 1446 FUEL 131.9 MINUS 44 290 DIAGONAL 110 OVER
	TOKYO	TOKYO ROGER CONTACT SAN FRANCISCO 4666 PRIMARY 6532 SECONDARY AT FIR GO AHEAD

	UAL826	ROGER 4666 PRIMARY AND SAY AGAIN SECONDARY OVER
	TOKYO	SECONDARY 6532 OVER
	UAL826	6532 THANK YOU
	TOKYO	TOKYO
14:10:55	UAL826	TOKYO TOKYO UAL826 OVER
	TOKYO	UAL826 TOKYO ER GO AHEAD GO AHEAD
	UAL826	YES SIR NO CONTACT 14 4666 AND AT PRESENT POSITION WE ARE GOING TO DIRECT PRESENT POSITION DIRECT 33 NORTH 160 EAST AND TURNING TO TOKYO REQUESTING CLEARANCE FOR ATC
	TOKYO	UAL826 TOKYO ROGER STAND BY CHECK AND CALL YOU BACK STAND BY ON THIS FREQUENCY
14:17:05	UAL826	UAL826 ANSWERING SELCAL
	TOKYO	UAL826 CLEARANCE FOR YOU ARE YOU READY TO COPY
	UAL826	ER ROGER GO AHEAD
	TOKYO	ROGER ATC CLEARS UAL826 TO NARITA AIRPORT VIA 33 NORTH 160 EAST DIRECT MASON OTR15 SMOLT THEN DIRECT OVER
	UAL826	O-KAY UNDERSTAND ATC CLEARS UAL826 33 NORTH 160 EAST DIRECT MASON OTR15 SMOLT DIRECT OVER
	TOKYO	READ BACK IS CORRECT TOKYO ALSO ATC REQUESTS PRESENT POSITION AND ESTIMATING TIME AT 33 NORTH 160 EAST OVER
	UAL826	ROGER SIR AND DID THEY GIVE OUR ALTITUDE OVER
	TOKYO	SAY AGAIN PLEASE
	UAL826	WHAT, I SAY AGAIN. WHAT ALTITUDE IN THE CLEARANCE
	TOKYO	OH ROGER O-KAY CHECK AND CALL YOU BACK SOON AND ARE YOU NOW MAINTAINING 330
	UAL826	WE ARE MAINTAINING 335 335 OVER
	TOKYO	MAINTAIN 365 ROGER CHECK ALTITUDE STAND BY PLEASE
	UAL826	UAL826 IS ESTIMATING 33 NORTH 160 EAST AT 1530 OVER
	TOKYO	OH ROGER TOKYO AND GIVE ME YOUR PRESENT POSITION WITH COORDINATE OVER
	UAL826	POSITION IS 3240 NORTH 16122 EAST OVER
	TOKYO	CONFIRM 2416 NORTH 16122 EAST IS THAT CORRECT
	UAL826	32 3234 THAT'S 3234 NORTH OVER
	TOKYO	ROGER TOKYO COPIED AND STAND BY FOR ALTITUDE STAND BY PLEASE

14:19:10	TOKYO	UAL826 TOKYO
	UAL826	826 GO AHEAD
	TOKYO	ROGER ATC CLEARS UAL826 MAINTAIN FLIGHT LEVEL 330 OVER
	UAL826	O-KAY UNDERSTAND MAINTAIN FLIGHT LEVEL 330 UAL826
	TOKYO	TOKYO
14:21:09	UAL826	TOKYO UAL826
	TOKYO	UAL826 TOKYO GO AHEAD
	UAL826	ROGER REQUEST ATC FOR 350 OR 370 WE ARE STILL ENCOUNTERING TURBULENCE
	TOKYO	ROGER TOKYO UNDERSTAND STAND BY YOUR REQUEST CALL YOU BACK
14:22:15	TOKYO	(SENT SELCAL SIGNAL)
	UAL826	UAL826 GO AHEAD
	TOKYO	ROGER TOKYO REQUEST YOUR REASON FOR RETURN TO NARITA AND SAY YOUR ETA NARITA OVER
	UAL826	ROGER SIR WE WILL GET BACK TO YOU THE ETA. WE HAVE ENCOUNTERED SEVERE TURBULENCE , AND HAVE NUMEROUS INJURIES ON BOARD, NUMEROUS PASSENGER INJURIES
	TOKYO	JAL88 TOKYO STAND BY STAND BY PLEASE BREAK UAL826 TOKYO ER COULD YOU SAY AGAIN REASON FOR RETURN TO NARITA PLEASE
	UAL826	ROGER SIR, WE HAVE HAD IT AN ENCOUNTER WAS SEVERE TURBULENCE AND WE HAVE NUMEROUS SERIOUS INJURIES ON BOARD OVER
	TOKYO	ROGER TOKYO AND STANDING BY YOUR ETA NARITA
	UAL826	ROGER ROGER
	TOKYO	TOKYO
14:24:32	UAL826	TOKYO UAL826 ETA
	TOKYO	ROGER GO AHEAD UAL826 GO AHEAD
	UAL826	UAL826 ESTIMATING TOKYO AT 1625 OVER
	TOKYO	ROGER TOKYO THANK YOU
14:29:10	TOKYO	UAL826 TOKYO DO YOU READ (SENT SELCAL SIGNAL)
	UAL826	GO AHEAD TOKYO
	TOKYO	ROGER TOKYO UAL826 ATC ADVISES UNABLE ANY HIGHER DUE TO TRAFFIC BUT FLIGHT LEVEL 310 IS AVAILABLE REQUEST YOUR INTENTION OVER
	UAL826	STAY 330 OR GO HIGHER NO LOWER

	TOKYO	ROGER TOKYO 330 STAY 330 TOKYO ROGER
14:30:55	TOKYO	BREAK UAL826 TOKYO
	UAL826	GO AHEAD 826
	TOKYO	ROGER WHERE DID YOU ENCOUNTER SEVERE TURBULENCE OVER
	UAL826	SAY AGAIN
	TOKYO	ROGER WHERE WHERE DID YOU ENCOUNTER SEVERE TURBULENCE
	UAL826	JUST RIGHT BACK TO YOU TOO BUSY
	TOKYO	ROGER TOKYO
	UAL826	UAL826
14:34:14	TOKYO	STATION CALLING TOKYO
	UAL826	UAL826 WE WERE AT FLIGHT LEVEL 310 TRACK 12 APPROXIMATELY 3230 NORTH 158 EAST TO 159 EAST GO AHEAD
	TOKYO	ROGER THANK YOU SO MUCH THANK YOU
14:46:00	TOKYO	(SENT SELCAL SIGNAL)
	UAL826	UAL826 GO AHEAD
	TOKYO	UAL826 TOKYO ATC ADVISES UAL826 FLIGHT LEVEL 350 IS AVAILABLE REQUEST YOUR INTENTION OVER
	UAL826	ROGER LEAVING 330 TO 350 AT THIS TIME AND WE'LL REPORT REACHING
	TOKYO	JUST A MOMENT PLEASE JUST A MOMENT PLEASE
	UAL826	UAL826 STAND BY
14:47:57	TOKYO	UAL826 TOKYO
	UAL826	GO AHEAD
	TOKYO	ATC CLEARS CLIMB AND MAINTAIN FLIGHT LEVEL 350 REPORT REACHING OVER
	UAL826	LEAVING 330 CLIMBING TO 350 CALL YOU REACHING
14:53:10	TOKYO	(SENT SELCAL SIGNAL)
	UAL826	(NO REPLY HEARD)
14:55:27	UAL826	TOKYO UAL826 YOU'RE CALLING GO AHEAD
	TOKYO	UAL826 TOKYO HOW MANY-PASSENGERS WERE INJURED BY SEVERE TURBULENCE?
	UAL826	O-KAY AT THIS TIME WE HAVE UNKNOWN. WE ARE COUNTING STILL. WE ARE TALKING TO OUR CONTRCL CHICAGO. WE HAVE TO GO CALL YOU BACK
	TOKYO	ROGER
15:36:17	TOKYO	(SENT SELCAL SIGNAL)

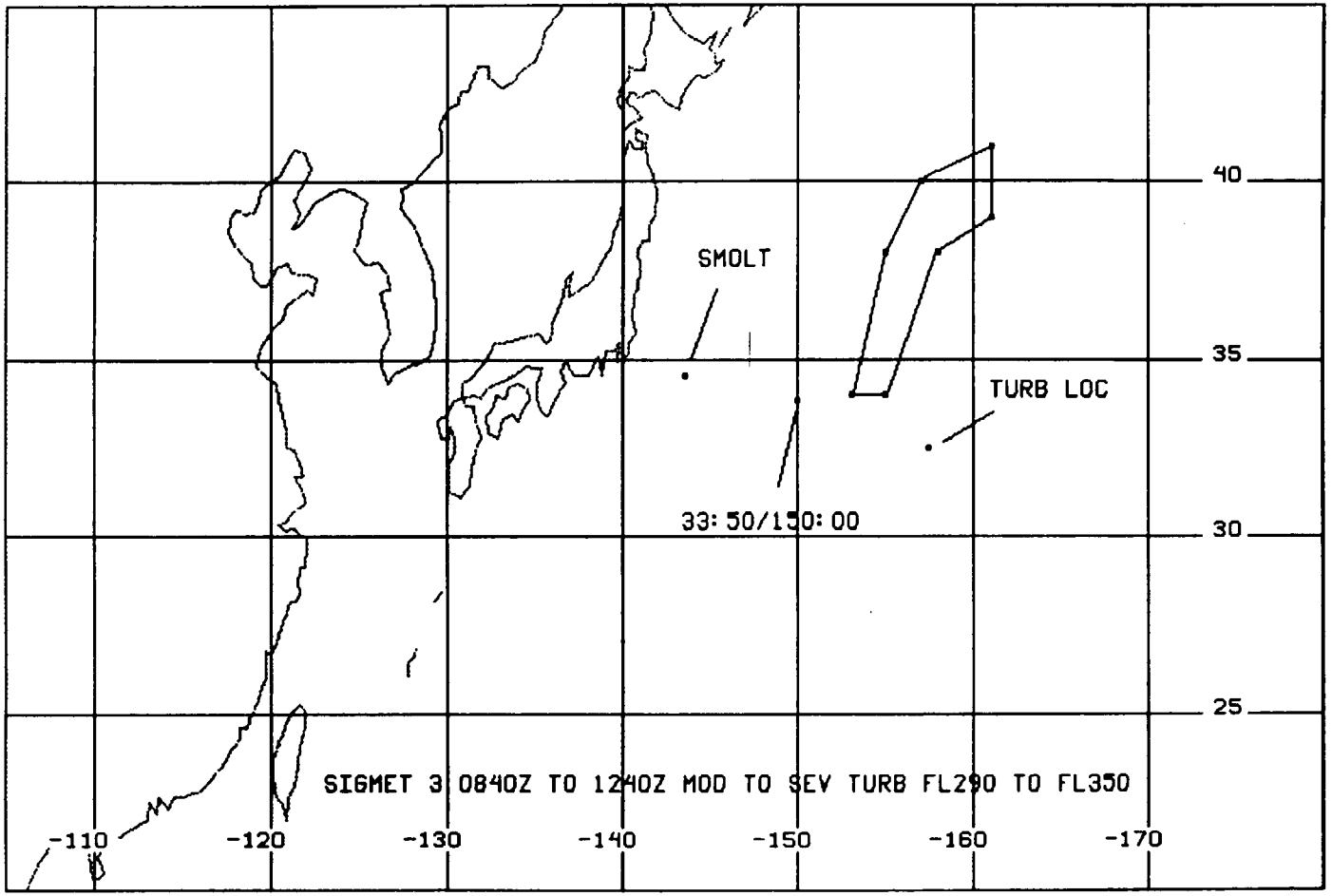
	UAL826	UAL826 ANSWERING SELCAL
	TOKYO	ROGER WE ARE STANDING BY POSITION REPORT 33 NORTH 160 EAST
	UAL826	ROGER STAND BY ONE
	TOKYO	STANDING BY
15:38:05	UAL826	TOKYO UAL826
	TOKYO	UAL826 GO AHEAD
	UAL826	33 NORTH 160 EAST 1431 FLIGHT LEVEL 350 MASON 1557 SMOLT NEXT
	TOKYO	SAY AGAIN MASON ESTIMATE
	UAL826	MASON 1557
	TOKYO	ESTIMATE MASON WILL BE 1657?
	UAL826	STAND BY ONE NEGATIVE 15...1557 IS THE CORRECT TIME FOR MASON
	TOKYO	PLEASE VERIFY MASON ESTIMATE 1557
	UAL826	WE ESTIMATE FROM MASON. ESTIMATING 20 ... 18 MINUTES FROM MASON CORRECT 1557
	TOKYO	ROGER HOW ABOUT TIME OVER 160 EAST 1431
	UAL826	1431—1431
	TOKYO	ROGER IF YOU KNOW LET ME KNOW HOW MANY INJURED PASSENGERS ON BOARD
	UAL826	WE HAVE MANY MANY INJURED PASSENGERS AND WE'RE STILL COUNTING
	TOKYO	ROGER
16:02:35	UAL826	TOKYO UAL826
	TOKYO	UAL826 TOKYO
	UAL826	MASON 1557 FLIGHT LEVEL 350 ESTIMATING SMOLT 1653 AND FUEL FUEL IS 80.5 MINUS 48 275 DIAGONAL 155 OVER
	TOKYO	ROGER 826 ESTIMATE SMOLT 1653 AND REQUEST REQUEST ETA NARITA
	UAL826	O-KAY STAND BY
16:03:45	UAL826	UAL826 IS ESTIMATING NARITA 1725 OVER
	TOKYO	ETA NARITA 1725 AND ESTIMATE SMOLT 1653. IS THAT CORRECT?
	UAL826	THAT'S CORRECT
	TOKYO	ROGER TOKYO. CONTACT TOKYO CONTROL 133.6 AT 146 EAST
	UAL826	133.6 AT 146 EAST AND WE HAVE A NUMBER OF INJURIES

		FOR YOU
	TOKYO	UAL826 GO AHEAD
	UAL826	O-KAY PASSENGERS WHO NEED TO SEE DOCTOR IS 37 37 AND FLIGHT ATTENDANTS ER 9 OVER
	TOKYO	ROGER 826 INJURED PASSENGERS 37 AND FLIGHT ATTENDANTS 9?
	UAL826	THAT IS ER ... THAT'S AFFIRMATIVE THAT IS A CURRENT ESTIMATE, REMAINDERS MORE
	TOKYO	SAY AGAIN
	UAL826	WE ANTICIPATE ADDITIONAL INJURIES
	TOKYO	ROGER COPY
16:20:02	TOKYO	(SENT SELCAL SIGNAL)
	UAL826	TOKYO UAL826 GO AHEAD
	TOKYO	UAL826 ATC REQUESTS UAL826 NUMBER OF PASSENGERS AND CREWS REQUEST SOULS ON BOARD
	UAL826	ROGER THAT NUMBER IS 388 388 IS ON BOARD
	TOKYO	ROGER COPY THANK YOU ADDITIONAL REQUEST TO YOU I'VE GOT YOUR SOULS ON BOARD 388 HOW ABOUT CREW NUMBER?
	UAL826	STAND BY ONE NUMBER OF CREWS 19 NINETEEN
	TOKYO	SOULS ON BOARD 388 INCLUDING CREW 19. IS THAT CORRECT?
	UAL826	THAT'S AFFIRMATIVE
	TOKYO	ROGER THANK YOU
	UAL826	ROGER

16:40:55	UAL826	Tokyo, UAL826, how do you read?
	ACC	UAL826, Tokyo, loud and clear, squawk ··· , correction, verify at FL350.
	UAL826	Affirmative, maintain 350.
16:41:41	ACC	UAL826, squawk 2506.
	UAL826	2506, thank you, 826.
16:42:30	ACC	UAL826, ah, request estimate time arrival at Narita airport.
	UAL826	Stand by.
16:42:52	UAL826	Ah, UAL826 ··· , stand by.
16:42:58	UAL826	UAL826, estimating Narita at ah, 1 ··· , 7 ··· ah, 26, over.
	ACC	UAL826, roger.
16:43:43	ACC	UAL826, ident.
	UAL826	Roger.
16:44:01	ACC	UAL826, radar contact 225 miles southeast of NRE.
	UAL826	Understand, UAL826, and ah, say it just ah, requesting fastest possible route to the airport, over.
	ACC	Ah, UAL826, would you say again, please?
	UAL826	Affirmative, sir. We ex ··· , request expedite arrival, because we have numerous injuries on board.
	ACC	UAL826, understand, we'll advise Narita approach.
16:45:09	ACC	UAL826, cleared via present position direct, ah, november, NRE.
	UAL826	Present position direct Narita, UAL826, thank you.
16:46:45	ACC	UAL826, Tokyo.
	UAL826	Go ahead.
	ACC	Ah, 826, Narita approach wants to know, ah, wants to confirm the number of person, I mean, ah, injured person, forty-six?
	UAL826	Affirmative, sir, we have, ah, we have 46 that need, ah, immediate medical attention. We have other that

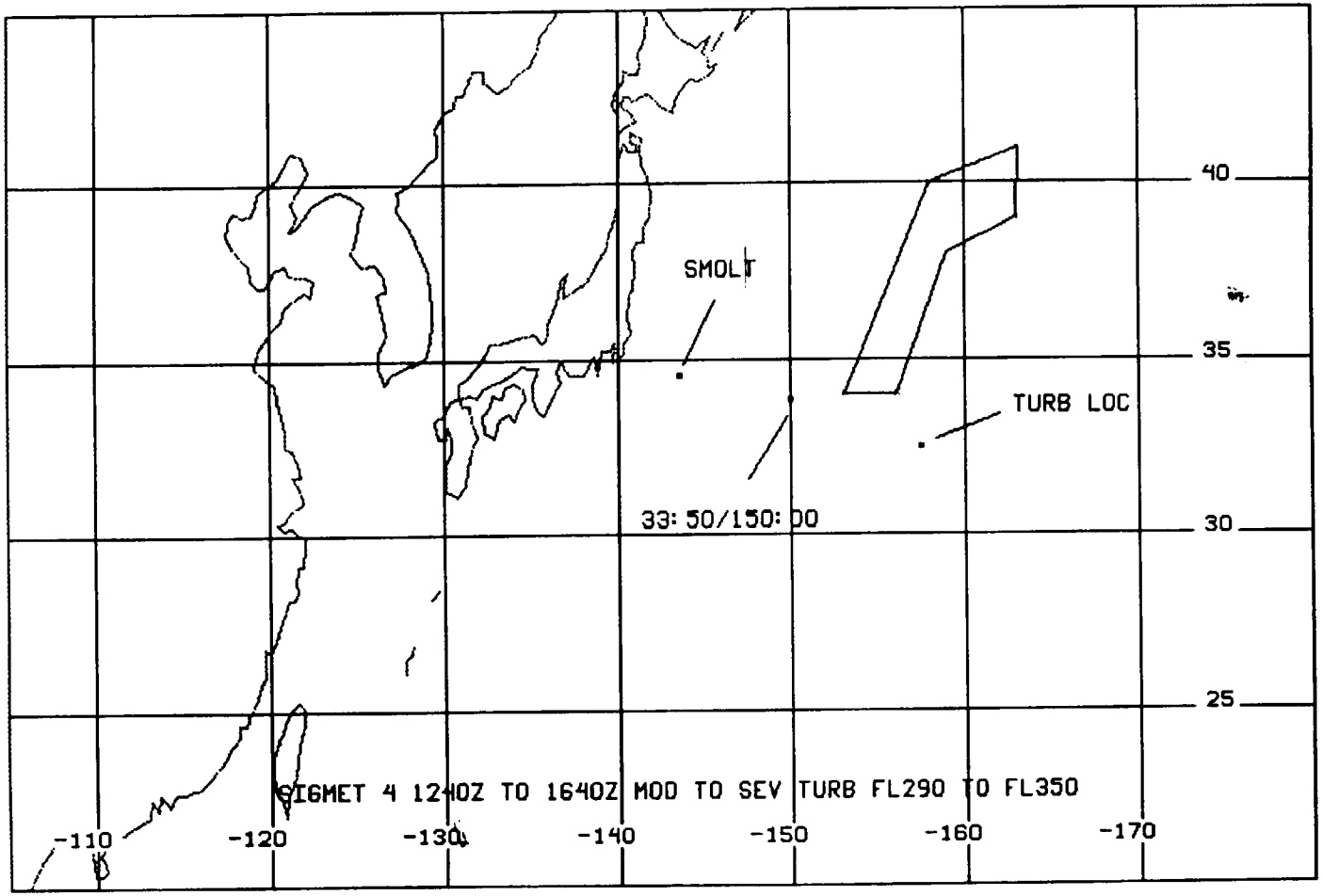
		ah, have minor injuries.
	ACC	826, roger.
16:55:00	ACC	UAL826, at your discretion, descend and maintain 10000, QNH 3019.
	UAL826	Pilot discretion, 10000, 3019, roger.
17:00:32	ACC	UAL826, latest QNH 3020.
	UAL826	Roger, 826.
17:12:02	ACC	UAL826, now contact Narita approach on 125.8, good day.
	UAL826	1258, good day.

17:12:10	UAL826	Narita approach, UAL826, 135 for 10000.
	APC	UAL826, Narita approach, fly heading 280 for vecter to final approach course, runway 34 ILS final approach course, descend and maintain 4000.
	UAL826	280 for vectors and descend to 4000, UAL826.
	APC	UAL826, high speed descent is approved, speed at pilot's discretion. Narita weather at 1700, wind 020 degrees at 8 knots, visibility 25 km, cloud broken 4500, temperature 4, dew point minus 2, QNH 3020.
	UAL826	Copied weather, 3020, 826.
17:13:10	APC	UAL826, We are preparing ambulances for you, and do you need any assistance except ambulance?
	UAL826	Negative, copied about ambulances, negative fire trucks.
17:15:00	APC	UAL826, turn left heading 270.
	UAL826	270, UAL826.
17:20:34	UAL826	Request right turn, UAL826.
	APC	UAL826, turn right heading 310, descend and maintain 3000, 8 miles from outer marker, cleared for ILS runway 34 approach.
17:20:50	UAL826	Cleared ILS 34, 3000, 826.
17:21:35	APC	UAL826, contact tower 118.2.
	UAL826	Good day.
17:21:48	UAL826	UAL826, 8 miles ILS 34.
	TWR	UAL826, Narita tower, cleared to land runway 34, wind 020 degrees at 8 knots.
	UAL826	Cleared to land.
17:26:02	TWR	UAL826, turn right to alfa then taxi to papa 6.
	UAL826	Alfa, papa 6.
17:27:00	TWR	UAL826, contact ramp control 121.75.
	UAL826	Roger, good day.


SMOLT
TURB LOC
33:50/150:00
SIGMET 3 0840Z TO 1240Z MOD TO SEV TURB FL290 TO FL350
40
35
30
25
-110
-120
-130
-140
-150
-160
-170

33

2


SMOLT
TURB LOC
33:50/150:00
SIGMET 4 1240Z TO 1640Z MOD TO SEV TURB FL290 TO FL350
40
35
30
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-110
-120
-130
-140
-150
-160
-170

34

CHAPTER 7. SIGMET AND AIRMET INFORMATION, AERODROME WARNINGS AND WIND SHEAR WARNINGS

7.1 SIGMET information — general provisions

7.1.1 SIGMET information shall be issued by a meteorological watch office and shall give a concise description in abbreviated plain language concerning the occurrence and/or expected occurrence of specified en-route weather phenomena, which may affect the safety of aircraft operations, and of the development of those phenomena in time and space. The information shall be indicated using one of the following as appropriate:

a) at subsonic cruising levels:

thunderstorm	
— obscured	OBSC TS
— embedded	EMBD TS
— frequent	FRQ TS
— squall line	SQL TS
— obscured with heavy hail	OBSC TS HVYGR
— embedded with heavy hail	EMBD TS HVYGR
— frequent, with heavy hail	FRQ TS HVYGR
— squall line with heavy hail	SQL TS HVYGR
tropical cyclone	
— tropical cyclone with 10-minute mean surface wind speed of 63 km/h (34 kt) or more	TC (+ cyclone name)
turbulence	
— severe turbulence	SEV TURB
icing	
— severe icing	SEV ICE
— severe icing due to freezing rain	SEV ICE (FZRA)
mountain wave	
— severe mountain wave	SEV MTW
duststorm	
— heavy duststorm	HVY DS
sandstorm	
— heavy sandstorm	HVY SS
volcanic ash	
— volcanic ash	VA (+ volcano name, if known)

b) at transonic levels and supersonic cruising levels:

turbulence	
— moderate turbulence	MOD TURB
— severe turbulence	SEV TURB
cumulonimbus	
— isolated cumulonimbus	ISOL CB
— occasional cumulonimbus	OCNL CB
— frequent cumulonimbus	FRQ CB
hail	
— hail	GR
volcanic ash	
— volcanic ash	VA (+ volcano nam if known)

Note.— Guidance on the preparation of SIGMET messag is given in Attachment F.

7.1.2 SIGMET information shall not contain unnecessa descriptive material. In describing the weather phenomena which the SIGMET is issued, no descriptive mater additional to that given in 7.1.1 shall be included. SIGMI information concerning thunderstorms or a tropical cyclo shall not include references to associated turbulence and icii However, the occurrence of heavy hail with thunderstorm sh be indicated.

7.1.3 SIGMET information shall be cancelled when t phenomena are no longer occurring or are no longer expect to occur in the area.

7.2 Format and exchange of SIGMET messages

7.2.1 A SIGMET message shall contain the followi information as necessary and in the order indicated:

a) location indicator of the air traffic services unit servi the flight information region or control area to which t SIGMET message refers; for example, "YUCC

Note.— In cases where the airspace is divided into flight information region (FIR) and an upper flig information region (UIR), the SIGMET is identified the location indicator of the air traffic services u serving the FIR; nevertheless, the SIGMET messa applies to the whole airspace within the lateral limits

CHAPTER 5. AIRCRAFT OBSERVATIONS AND REPORTS

5.1 Obligations of States

Each Contracting State shall arrange, according to the provisions of this chapter, for observations to be made by aircraft of its registry operating on international air routes and for the recording and reporting of these observations.

5.2 Aircraft observations

The following aircraft observations shall be made:

a) routine aircraft observations during en-route and climb-out phases of the flight; and

b) special and other non-routine aircraft observations during any phase of the flight.

5.3 Reporting of aircraft observations during flight

5.3.1 Aircraft observations shall be reported by air-ground data link. Where air-ground data link is not available or appropriate, aircraft observations shall be reported by voice communications.

5.3.2 Aircraft observations shall be reported during flight at the time the observation is made or as soon thereafter as is practicable.

5.4 Routine aircraft observations

5.4.1 **Recommendation.**— *When air-ground data link is used and automatic dependent surveillance (ADS) is being applied, automated routine observations should be made every 15 minutes during the en-route phase and every 30 seconds during the climb-out phase for the first 10 minutes of the flight.*

5.4.2 When voice communications are used, routine observations shall be made during the en-route phase in relation to those air traffic services reporting points or intervals:

a) at which the applicable air traffic services procedures require routine position reports; and

b) which are those separated by distances corresponding most closely to intervals of one hour of flying time.

5.4.3 **Recommendation.**— *For helicopter operations to and from aerodromes on off-shore structures, routine observations should be made from helicopters at points and times as agreed between the meteorological authorities and the helicopter operators concerned.*

5.4.4 In the case of air routes with high-density air traffic (e.g. organized tracks), an aircraft from among the aircraft operating at each flight level shall be designated, at approximately hourly intervals, to make routine observations in accordance with 5.4.1 or 5.4.2, as appropriate. The designation procedures shall be subject to regional air navigation agreement.

5.4.5 In the case of the requirement to report during the climb-out phase, an aircraft shall be designated, at approximately hourly intervals, at each aerodrome to make routine observations in accordance with 5.4.1.

5.4.6 When voice communications are used, an aircraft shall be exempted from making the routine observation specified in 5.4.2 when:

a) the aircraft is not equipped with RNAV equipment; or

b) the flight duration is 2 hours or less; or

c) the aircraft is at a distance equivalent to less than one hour of flying time from the next intended point of landing; or

d) the altitude of the flight path is below 1 500 m (5 000 ft).

5.4.7 **Recommendation.**— *When voice communications are used, additional exemptions may be prescribed by regional air navigation agreement for flights over routes and areas with high density air traffic and/or with adequate synoptic networks. Such procedures should take the form of exemption or designation procedures and should:*

a) make it possible for the minimum requirements for aircraft observations of all meteorological offices concerned to be met; and

b) be as simple as possible to implement and preferably not involving consideration of individual cases.

5.5 Special and other non-routine aircraft observations

5.5.1 Special observations shall be made by all aircraft whenever the following conditions are encountered or observed:

a) severe turbulence; or

b) severe icing; or

c) severe mountain wave; or

d) thunderstorms, without hail, that are obscured, embedded, widespread or in squall lines; or

e) thunderstorms, with hail, that are obscured, embedded, widespread or in squall lines; or

f) heavy duststorm or heavy sandstorm; or

g) volcanic ash cloud; or

h) pre-eruption volcanic activity or a volcanic eruption.

Note.— Pre-eruption volcanic activity in this context means unusual and/or increasing volcanic activity which could presage a volcanic eruption.

In addition, in the case of transonic and supersonic flights:

i) moderate turbulence; or

j) hail; or

k) cumulonimbus clouds.

5.5.2 When other meteorological conditions not listed under 5.5.1, e.g. wind shear, are encountered and which, in the opinion of the pilot-in-command, may affect the safety or markedly affect the efficiency of other aircraft operations, the pilot-in-command shall advise the appropriate air traffic services unit as soon as practicable.

Note.— According to Chapter 4, 4.12.1 and Chapter 7, 7.6.2, icing, turbulence and, to a large extent, wind shear, are elements which, for the time being, cannot be satisfactorily observed from the ground and for which in most cases aircraft observations represent the only available evidence.

5.5.3 **Recommendation.**— *When reporting aircraft observations of wind shear encountered during the climb-out and approach phases of flight, the aircraft type should be included.*

5.5.4 **Recommendation.**— *Where wind shear conditions in the climb-out or approach phases of flight were reported or forecast but not encountered, the pilot-in-command should advise the appropriate air traffic services unit as soon as practicable unless the pilot-in-command is aware that the appropriate air traffic services unit has already been so advised by a preceding aircraft.*

5.6 Content of air-reports

5.6.1 When voice communications are used, the elements contained in routine and special air-reports shall be:

Routine air-reports

Message type designator
Section 1
(Position information)
Aircraft identification
Position or latitude and longitude
Time
Flight level or altitude
Next position and time over
Ensuing significant point
Section 2
(Operational information)
Estimated time of arrival
Endurance
Section 3
(Meteorological information)
Air temperature
Wind direction
Wind speed
Turbulence
Aircraft icing
Humidity (if available)

Special air-reports

Message type designator
Section 1
(Position information)
Aircraft identification
Position or latitude and longitude
Time
Flight level or altitude
Section 3
(Meteorological information)
Condition prompting the issuance of a special air-report, to be selected from the list presented under 5.5.1

Note 1.— Air-reports are considered routine by default. The message type designator for special air-reports is specified in the Procedures for Air Navigation Services — Rules of the Air and Air Traffic Services *(PANS-RAC, Doc 4444)*

37

UNITED AIRLINES

World Headquarters

January 14, 1998

Mr. Bob Benzon
National Transportation Safety Board
490 L'Enfant Plaza, S.W.
Washington, D.C. 20594-2000

Subject: Meteorology Report and Meteorologist Statement, Flight 826, December 28, 1997
DCA98MA015

Dear Mr. Benzon:

Enclosed you will find our meteorological report. Also enclosed is a statement from one of the meteorologists on duty at the time of the incident. In the case of the report and statement, I have not sent Mr. Wataki of the JAAIC a copy. If you wish this to be done, let me know, and I will send immediately.

Sincerely,

[redacted]

Jeff Plantz
Flight Safety

38

Box 66100, Chicago, Illinois 60666, • Location: 1200 East Algonquin Road, Elk Grove Township, Illinois 60007

To: NTSB

From: OPBWX- Allen Motew

January 8, 1998

STATEMENT FROM ALLEN MOTEW

NTSB:

I was requested by my manager, Carl Knable (United Airlines Meteorology Department) to supply a written statement regarding any discussions/actions that took place prior to the accident of Flight 826 on December 28, 1997.

I was one of three meteorologists working the midnight shift (2315CST-0745CST) on December 27-28, 1997 and to the best of my knowledge, had no discussions concerning and made no actions during my shift, that specifically related to Flight 826.

I first became aware of the accident by hearing about it on the television news that following evening (December 28, 1997).

Allen Motew

Allen Motew
Meteorologist
United Airlines

39

UNITED AIRLINES

To: WHQFS - Jeff Plantz

FROM: OPBWX - Carl Knable

January 7, 1998

METEOROLOGICAL REPORT, FLIGHT 826-28 DECEMBER 1997, NRT-HNL

INCIDENT

Severe turbulence encounter, FL310, at 32.5N 158.9E, with numerous injuries and one fatality.

GENERAL CONDITIONS

A strong cold front extended from 45N162E southwest to 34N150E, and then to the west into southern Japan. Ahead of this front, a large area of showers and thunderstorms had developed. The southern end of this thunderstorm area intersected the track of Flt. 826 (see attachment 1). Based on GMS IR satellite images, thunderstorms were building rapidly in the vicinity of the incident, with tops estimated to range from FL290 to FL390 (see attachments 6, 7 and 8).

Aloft, a wide band of strong winds, with maximum wind speeds of 140-150 knots, extended from central Japan into the central Pacific (see attachment 2). This area of strong winds appears to consist of a branch of the subtropical jet and a parallel branch of the polar jet. In the vicinity of incident, the jet stream branches appear to diverge.

There were approximately 23 AIREPS available over checkpoint 32N160E between 28/1149Z and 28/1502Z (see attachment 4). The AIREPS show wind speeds between 55 and 135 knots, with significant shears (14 knots per thousand feet) between FL290 and FL330 (see attachment 5). In addition, an analysis of the reported temperatures suggests a strong inversion, with a base near FL310. None of the 23 reports indicated the presence of turbulence.

FORECASTS

The high level significant weather chart valid at 28/1200Z indicated the presence of the polar and subtropical jet cores, the cold front, and an area of frequent CB's near the incident site (see attachment 3). Clear air turbulence was not forecast.

Tokyo had issued a series of sigmets, calling for turbulence in advance of the cold front. In the series, sigmet 4 was valid for the time of the incident, and called for moderate to severe turbulence from FL290 to FL350. The area covered by this sigmet did not cover the incident site or any part of the flight track.

40

SUMMARY

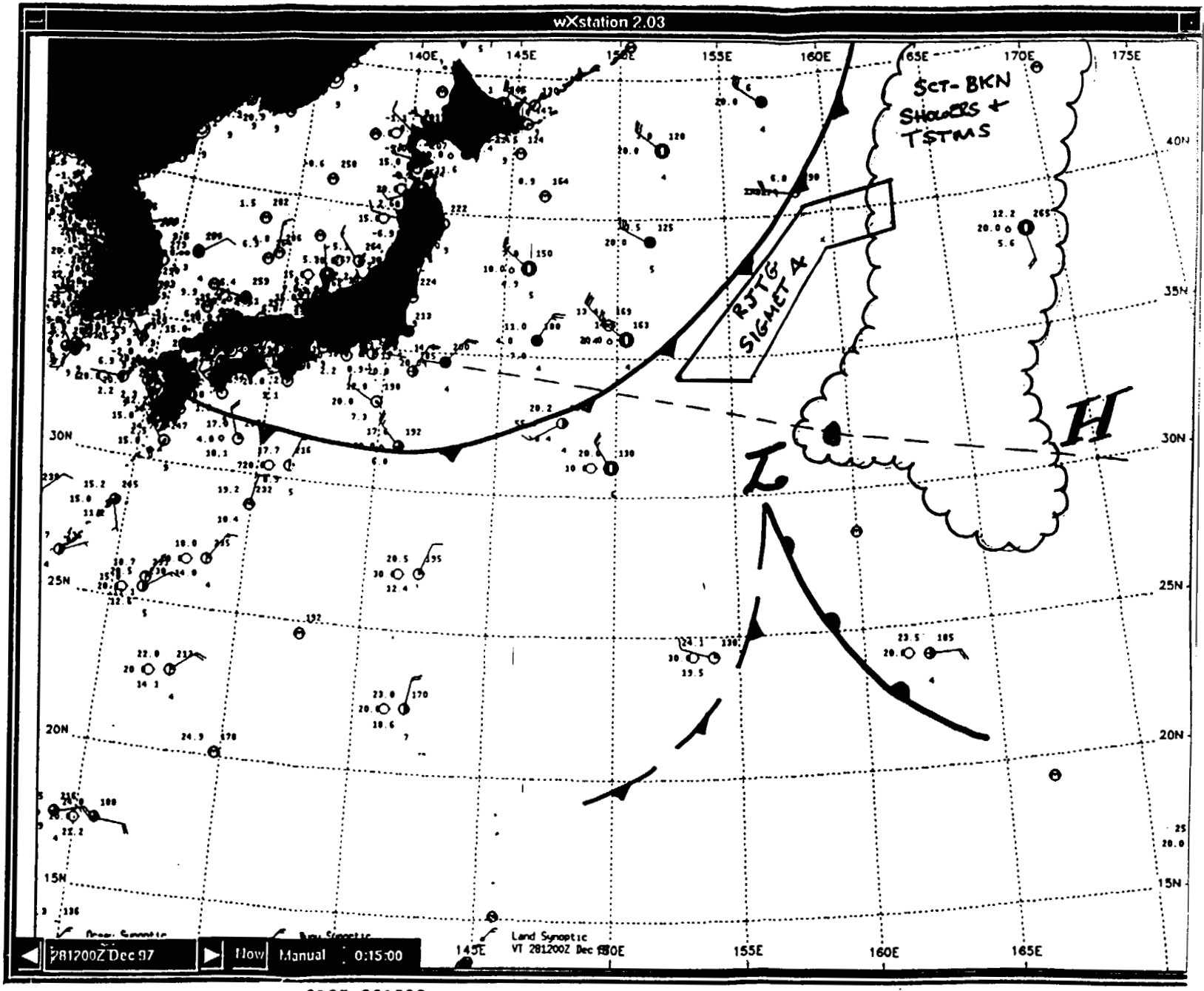
Based on information available, four significant features associated with turbulence appear to be present at or near the incident site: thunderstorms with tops at cruise levels, significant vertical wind shears, an inversion, and the difluence (splitting) of the jet core. As such, the turbulence could have been caused by: 1) flight through or near a thunderstorm top, 2) strong vertical wind shear independent of the thunderstorm environment, or 3) the interaction of the thunderstorms with the existing wind field causing downstream turbulence. Information available at the time of this report suggests either cause 2 or 3, as listed above.

ATTACHMENTS

- 1: Surface chart/sigmet plot - 28/1200Z
- 2: Airep plot - 28/0200Z to 28/1500Z
- 3: High level significant weather chart - 28/1200Z
- 4: AIREP summary - 28/1149Z to 28/1502Z
- 5: AIREP wind/temperature plot - 28/1200Z
- 6: GMS IR image - 28/1334Z
- 7: GMS IR image - 28/1435Z
- 8: Combined IR/AIREP analysis - 28/1334Z

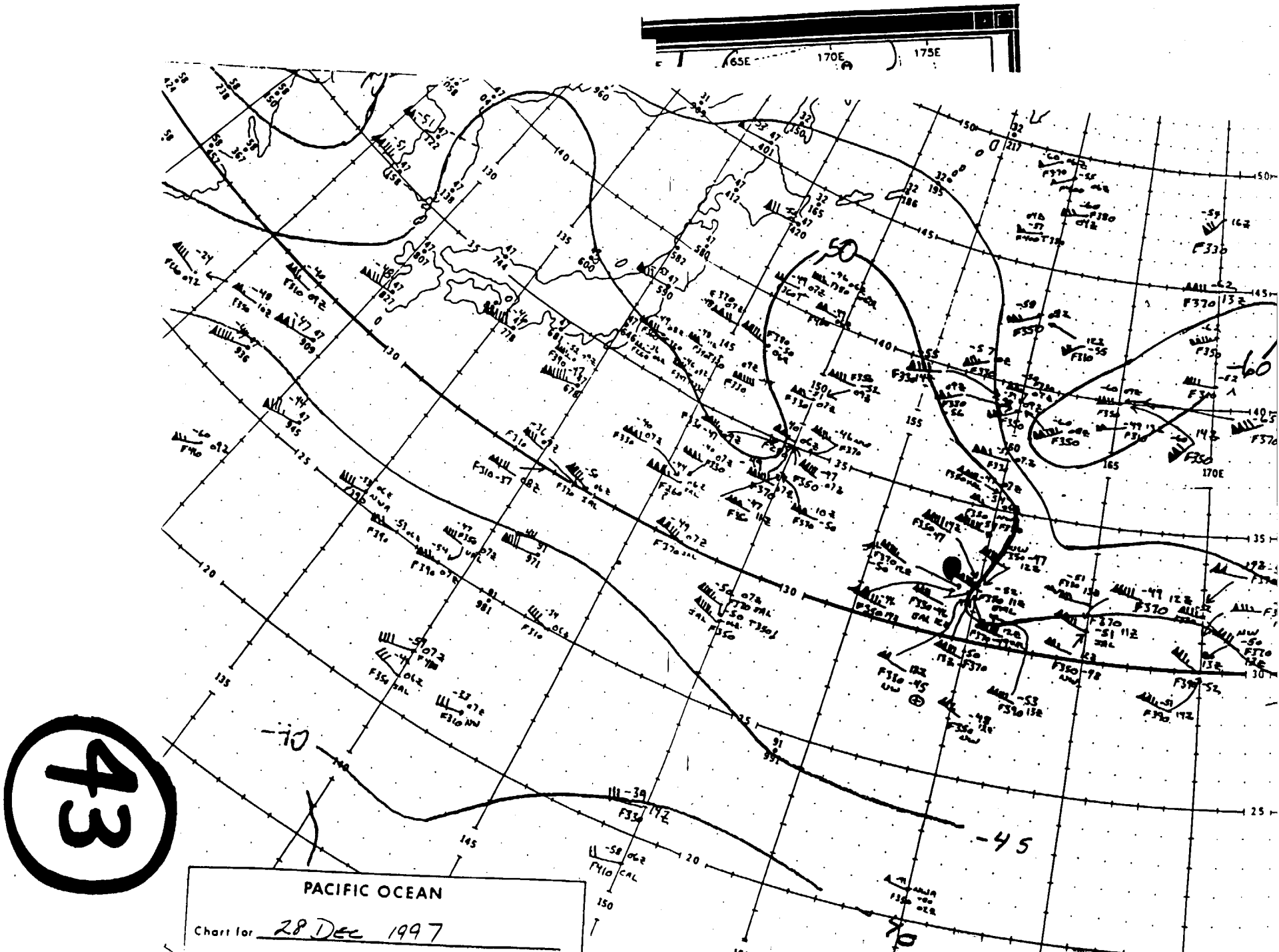
C.R.K.

41



42

.0185 281239
WSJP31 RJAA 281238
RJTG SIGMET 4 VALID 281240/281640 RJAA-
TOKYO FIR MOD TO SEV TURB FCST IN AREA BOUNDED BY 34N153E 34N156E
38N159E 39N163E 41N163E 40N158E AND 34N153E BTN FL290 AND FL350 MOV
ENE 15KT NC=
;12281239 108715 0217



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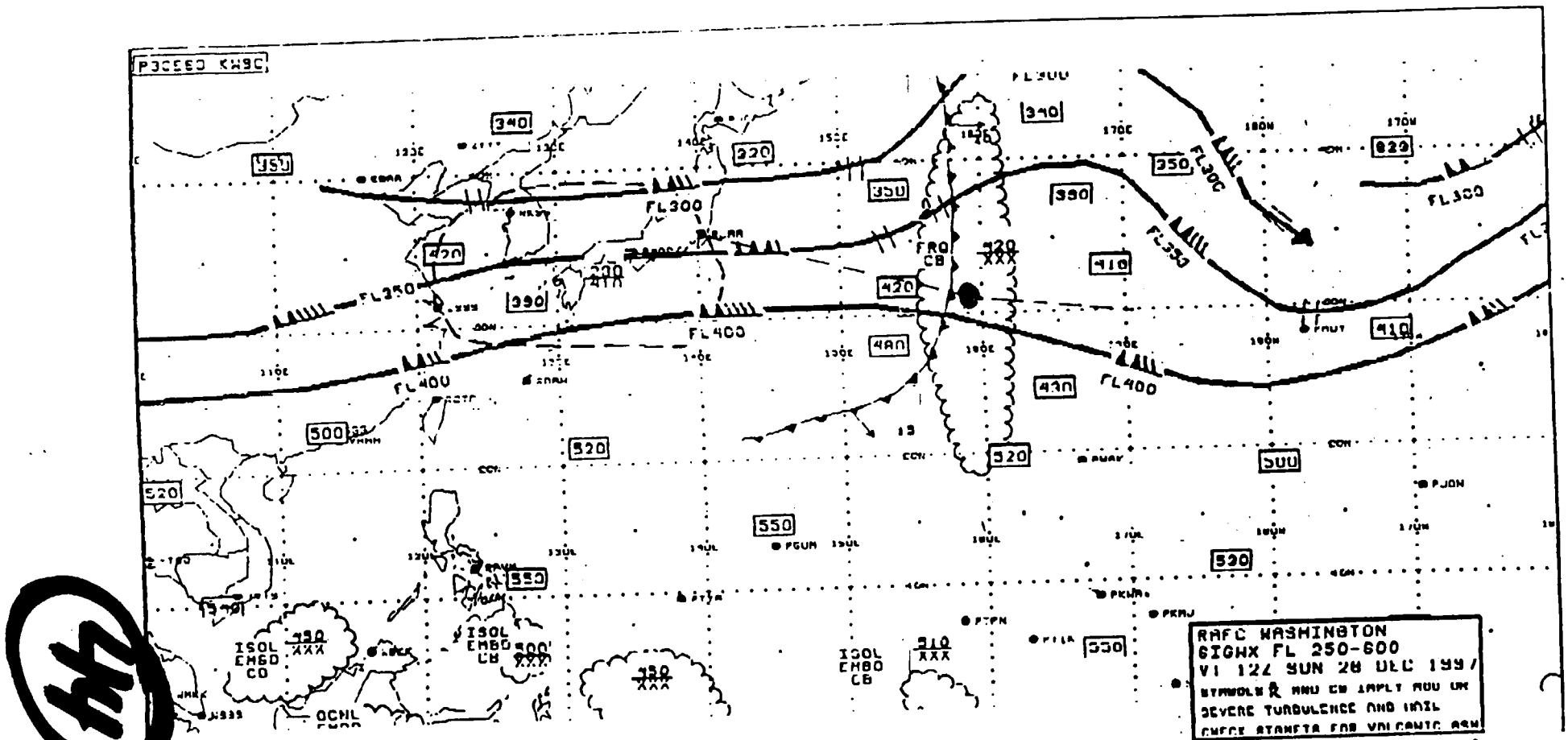

RAFC WASHINGTON
SIGWX FL 250-600
VI 127 SUN 28 DEC 199/
SYMBOLS & ANU CB IMPLY MOD OR
SEVERE TURBULENCE AND MAIL
CHECK STAMETS FOR VOLCANIC ASH
FL300
FL350
FL400
ISOL EMBD CB
ISOL EMBD CB
ISOL EMBD CB
OCNL

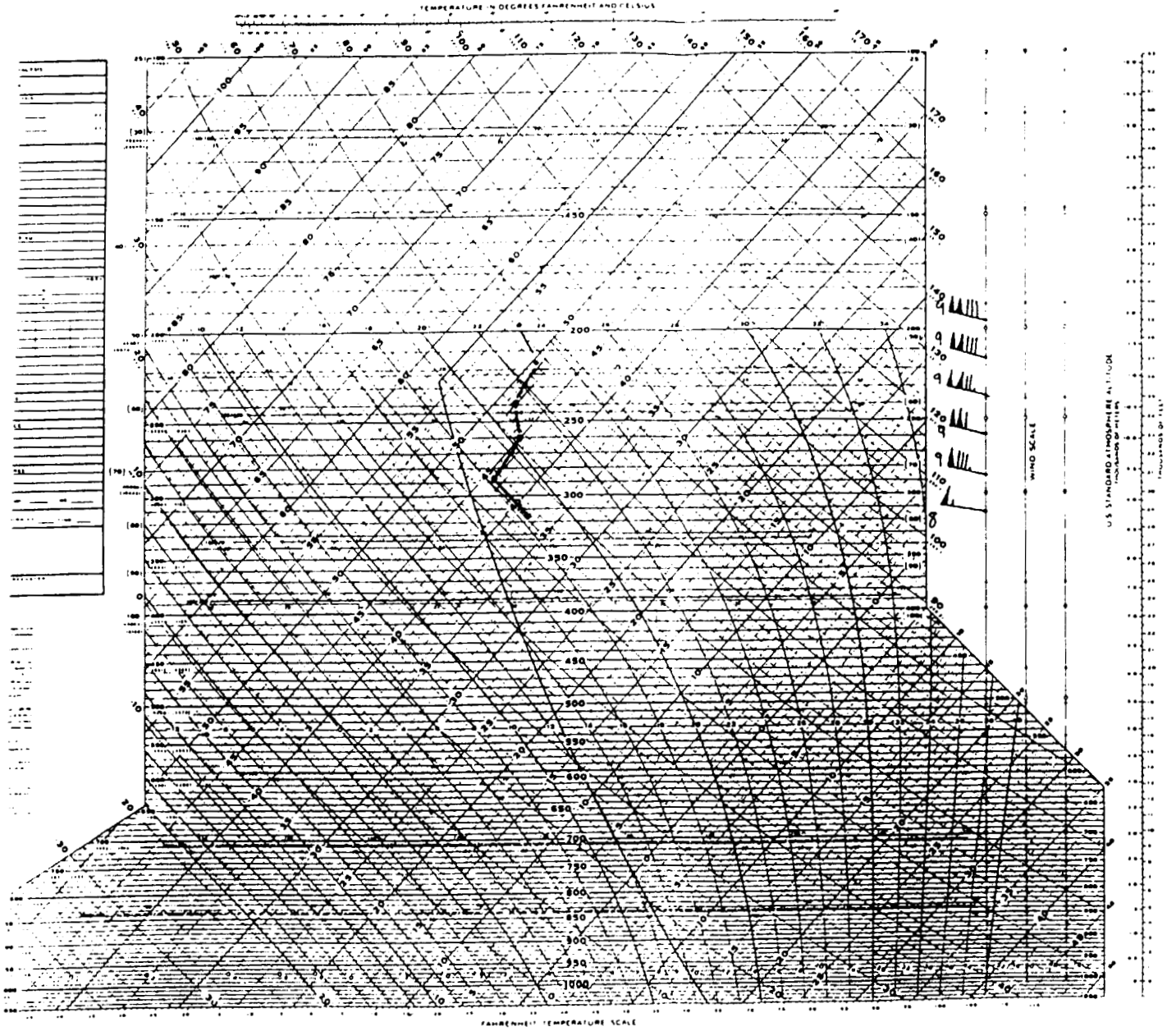
AIRCRAFT WEATHER REPORTS AT 32N 160E FOR THE TIME PERIOD 28/1149Z TO 28/1502Z

WIND	ALTITUDE	TEMP	FLIGHT #	TIME UTC	AVG WIND SPEED	AVG TEMP	VERTICAL SHEAR KNTS/1000FT
290135	390	-54	J208	1305	130 KTS	-54	
290125	390	-54	J74	1442			
							1KT
290140	370	-49	J58	1206	132 KTS	-49.5	
290135	370	-50	J308	1150			
290130	370	-50	J108	1231			
280130	370	-50	J72	1502			
290130	370	-49	AAR232	1450			
280130	370	-49	J109	1433			
							3KTS
290135	350	-52	J208	1056	124 KTS	-48	
280120	350	-46	J56	1205			
290120	350	-47	N92	1149			
290115	350	-48	N816	1226			
290115	350	-48	N16	1226			
290130	350	-47	N22	1351			
290125	350	-46	N90	1339			
280130	350	-49	J88	1423			
							6.5KTS
290100	330	-45	N80	1229	111 KTS	-45	
290130	330	-43	J70	1332			
280105	330	-45	CMI908	1251			
290110	330	-44	U826	1352			
							14KTS
290080	310	-45	J76	1334	83KTS	-44	
290085	310	-43	ANA105	1241			
							14KTS
280055	290	-38	N76	1240	55 KTS	-38	

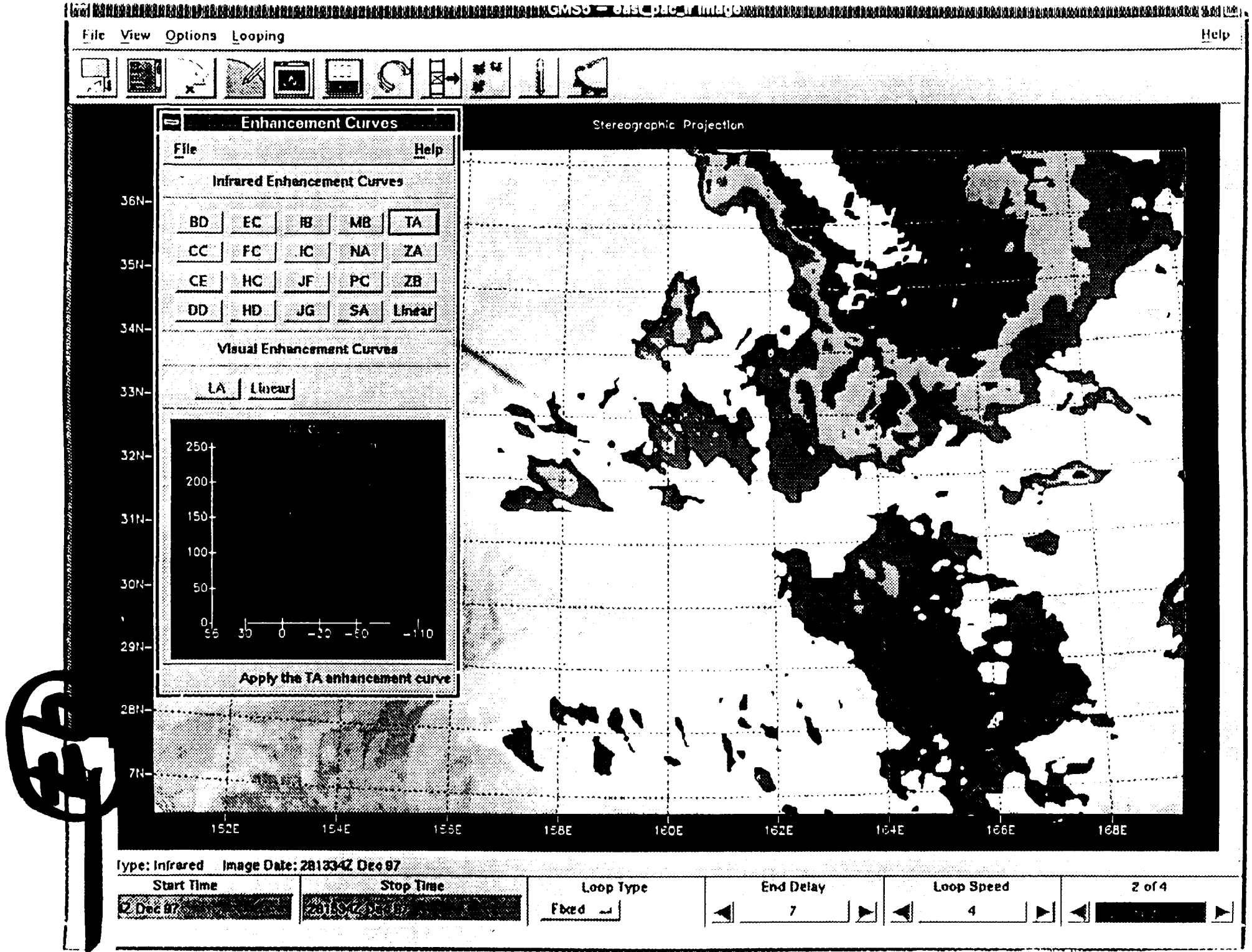
45

DEPARTMENT OF DEFENSE

USAF SKEW T, log p DIAGRAM



Form DOD-WPC 9-161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Enhancement Curves
File Help
Infrared Enhancement Curves
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CC FC IC NA ZA
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DD HD JG SA Linear
Visual Enhancement Curves
LA Linear
Apply the TA enhancement curve
Stereographic Projection
36N
35N
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33N
32N
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29N
28N
7N
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154E
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162E
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Loop Type
Fixed
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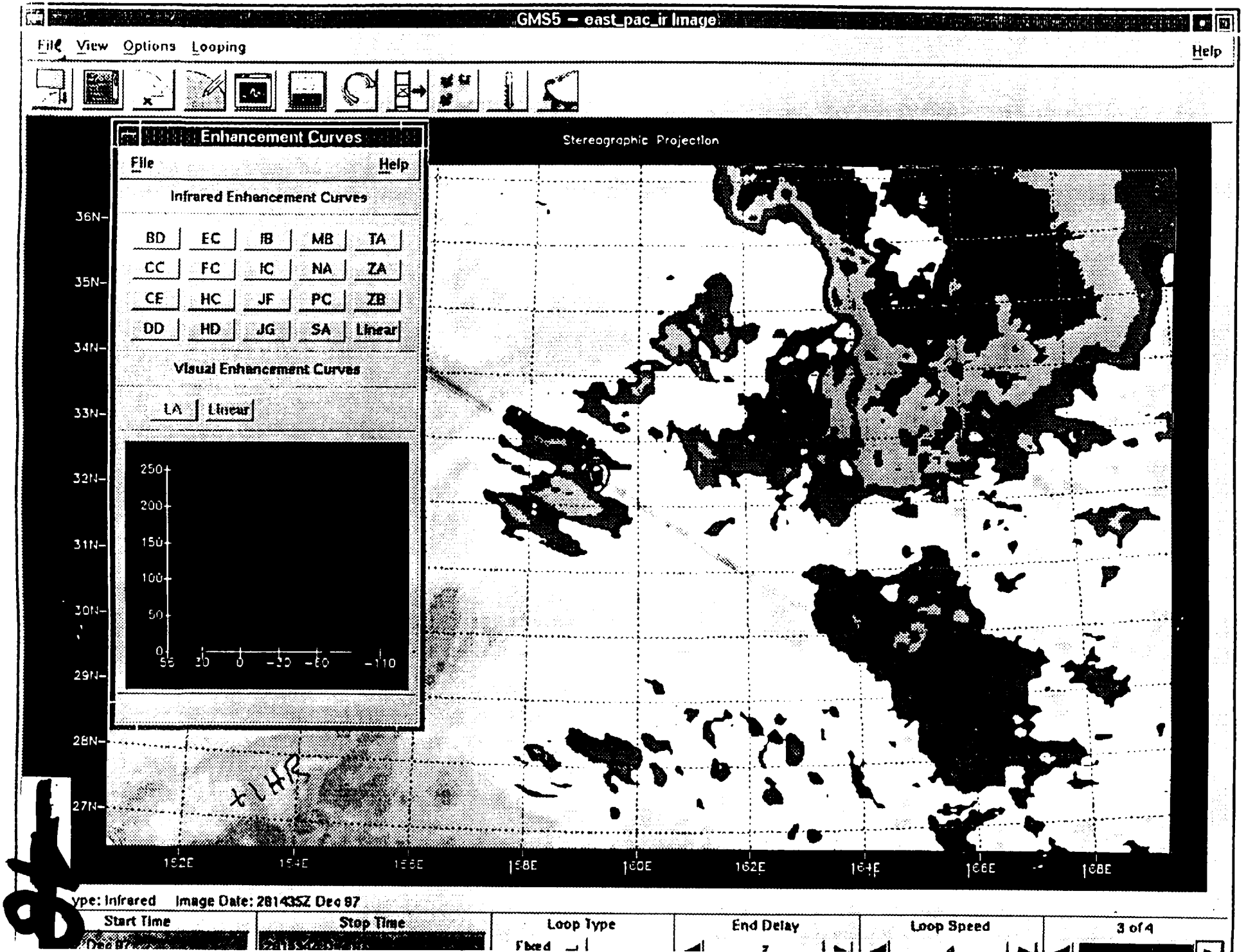
Loop Speed
4
2 of 4


GMS5 – east_pac_ir Image
File View Options Looping
Help
Enhancement Curves
File
Help
Infrared Enhancement Curves
BD EC IB MB TA
CC FC IC NA ZA
CE HC JF PC ZB
DD HD JG SA Linear
Visual Enhancement Curves
LA Linear
250
200
150
100
50
0
55 35 0 -35 -80 -110
Stereographic Projection
36N
35N
34N
33N
32N
31N
30N
29N
28N
27N
152E
154E
156E
158E
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Start Time
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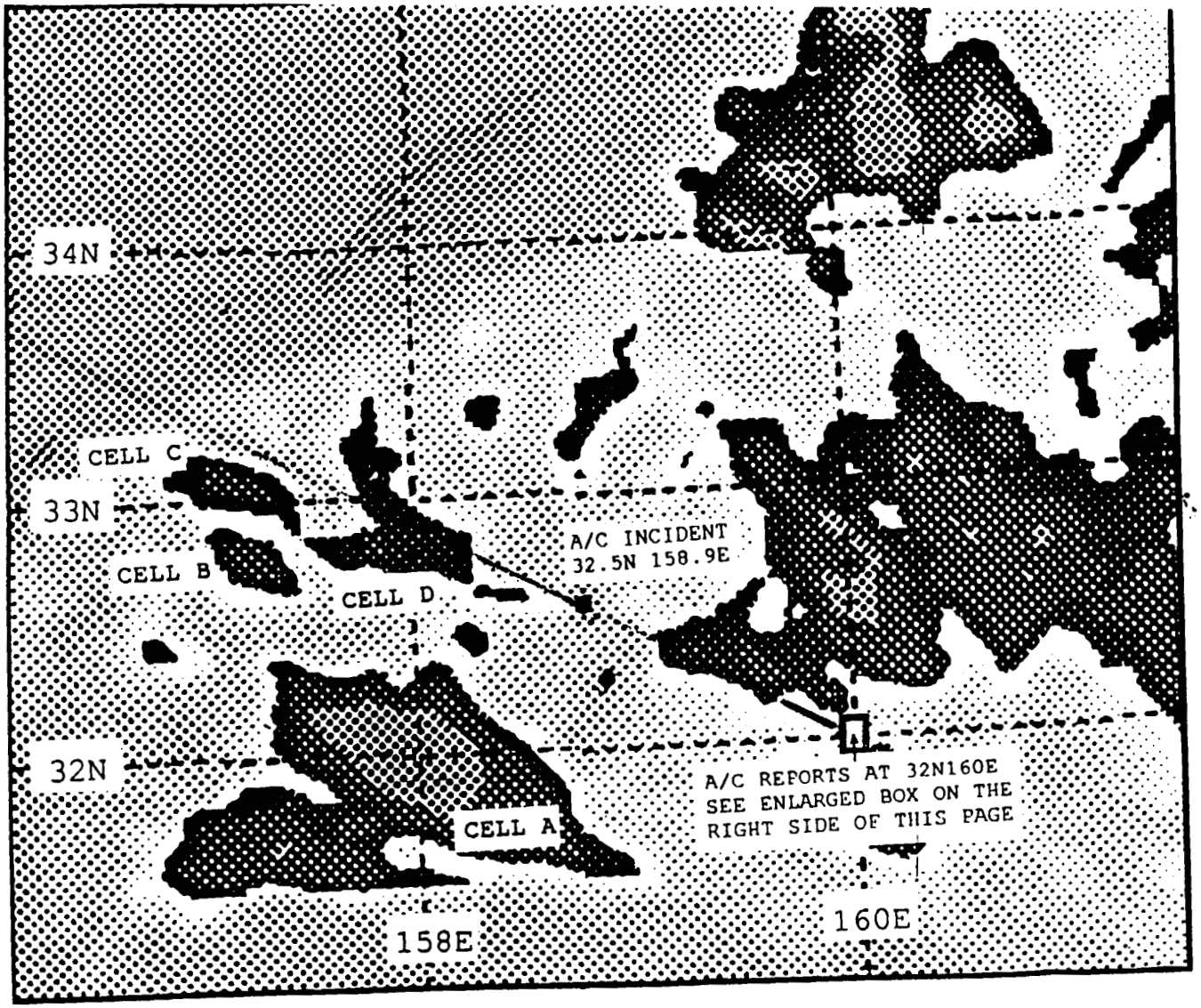
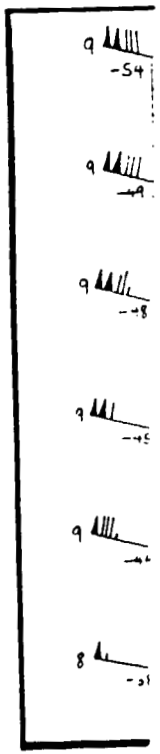
Loop Speed
3 of 4





FLIGHT LELVEL V
BASED ON AIRCR
TIME PERIOD 28

ESTIMATED CLOUD TOPS BASED ON DEC. 28 1334Z GMS IR SATELLITE TEMPERATURES AND 28/1149Z TO 28/1502Z AIRCRAFT REPORTED FLIGHT LEVELS/TEMPERATURES 32N 160E

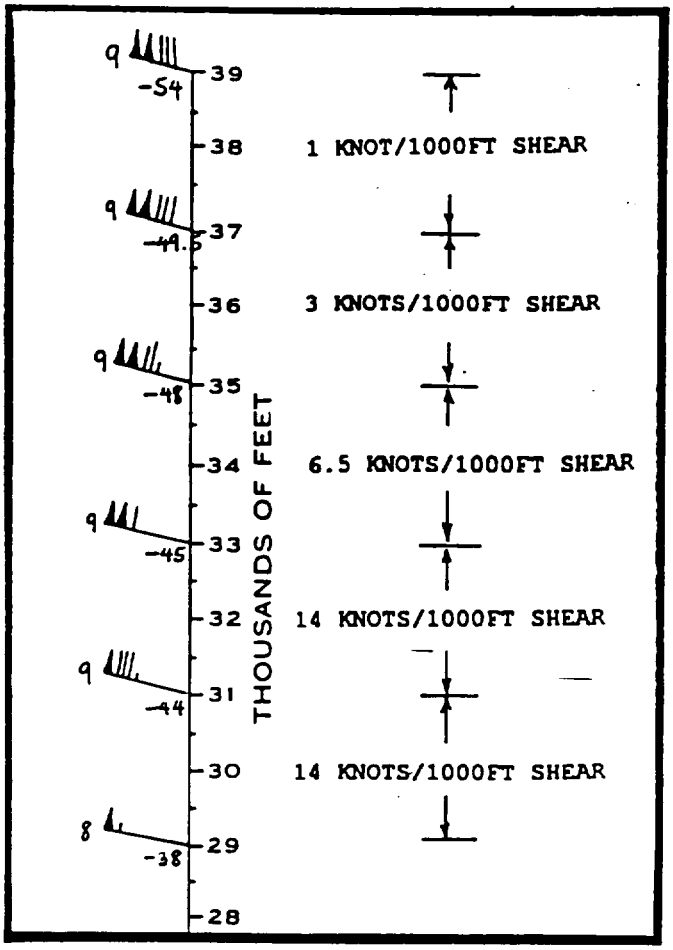
CELL A - FL390

CELL B - FL370

CELL C - FL370

CELL D - FL290

TELLITE
D FLIGHT



FLIGHT LELVEL WIND SPEEDS/TEMPERATURES/SHEARS BASED ON AIRCRAFT REPORTS AT 32N160E FOR THE TIME PERIOD 28/1149Z TO 28/1502Z

UNITED AIRLINES

World Headquarters

January 12, 1998

Mr. Bob Benzon
National Transportation Safety Board
490 L'Enfant Plaza, S.W.
Washington, D.C. 20594-2000

Subject: Flight Papers, Flight 826, December 28, 1997
DCA98MA015

Dear Mr. Benzon:

Enclosed you will find the flight papers for the subject flight. The contents include:
Signed Release
Flight Plan Forcast
Section of the Plotting Chart Pertaining to the Flight
Weather Briefing Message
Weather package obtained locally (Narita)

I am also sending, via company mail, a copy to Mr. Jun Oka, United Airlines, Nartita station operations for delivery to Mr. Atuhiko Wataki, Accident Investigation Commission of Japan. I will also fax Mr. Wataki and Mr. Oka a copy of this coverletter in advance. The material was not fax transmitted as I felt it would loose clarity in the process.

Sincerely,

[redacted]

Jeff Plantz
Flight Safety

cc: Mr. Jun Oka, United Airlines for Mr. Wataki - JAAIC

Encl.

51

Box 66100, Chicago, Illinois 60666, • Location: 1200 East Algonquin Road, Elk Grove Township, Illinois 60007

;12280946 105422 0402

NRTDD CHI17D
.CHIVQUA 280945 /DAV
UAL826-28 NRT HNL PART 1 OF 1 PARTS *** [redacted] ***

RLSD IFR PER RLS 01 CHI17 -DND- DAVE DUSEL 700-3317

CAPT (PRINT)-----S. A. WELLS-----MIN CODE-----C2-----DOM-HM

CAPT SIGNATURE-----[redacted]-----

EMERG: 1340Z
FROM: TOKYO ATC - CRRD TO
N33-00.0 E160-00.0
DIRECT MASON OTRIS SMOLT DIR

POSBD:655-97 QUICK REF CHECKLIST•649-97 IN-TRAIL DESCENT•
644-97 FLAP OVERSPEED(REPLACES 643-97)•
640-97 LAX AND CURFEW(REPLACES 615-97)

CLB +01.1 CRZ +01.1 DSC +00.0 PERCENT BURNOUT FROM BOOK

***

SEND MRMS ON HF
RLSD IFR NRT TO HNL (NON-REDISPATCH) TRACK 12.
PSBL MDT TURBC VCNTY 145E FL280-380. AND 160E-170E FL310-400.
ISOL CB'S PSBL VCNTY 155E-160E TOPS FL380.

---------- SPECIAL ROUTE INFO ----------
(JAPAN-HAWAII TRACK EFF 28DEC/1000Z TO 28DEC/2100Z) (COMPLETE
PACOTS MESSAGE SHOULD BE PART OF CREWS PAPERWORK)

UAL826-28 RJAA/NRT PHNL/HNL [redacted]/N4723U R17J///

	FUEL	TIME	DIST	W/C		TOGWT	LDGWT	ZFWT
BURN	149200	0605	3386			[redacted]	[redacted]	4745
10 PCT	013100	0036				AVG/WC	P104/P083	
FAR	010000	0030						
ALTN PHNA	008800	0018	0057	M004				
NAX				FL060				
HOLD	005100	0015						
EXTRA	000000	0000						
TOTAL	186200	0744			SCHD DEP-ARR 1215Z/2115L-1840Z/0840L			

1 ENG OUT PET RJAA/NRT - PHNL/HNL 02:29/1444NM FROM T/O

ALL ENG OPTG DECOMPRESSION: PET AWK-HNL 03:51 N27 21.0 W177 34.6
PWAK/AWK 0994NM PHNL/HNL 1133NM
FOB 807 /FRQ 674 HOLD INC 000
GWT 5552

52

ALTD	TOGW	TIME	BURN	
FL33	6657	0606	1542	M84
FL29	6788	0616	1673	M82
FL27	6850	0629	1735	M79

IDENT/POS/TIME/FL/NEXT POS/ETA/NEXT POS//FUEL//TEMP/WIND/SIG WX

CKPT LAT	LONG	DRIFT	ZNT TTL	FL TRP	ZBO FUEL	TMP WIND A/W	T/C GS	M/C TAS	M/H MCH	ZND TTL
			1204							
CYF		011	007	CLB	050	M02 27049	099	105	106	050

BURN 149200 0605 3386 5607/7132 5115/5640 7451
10 PCT 013100 0036 AVG/WC P104/P083
FAR 010000 0030
ALTN PHNA 008800 0018 0057 M004
NAX FL060
HOLD 005100 0015
EXTRA 000000 0000
TOTAL 186200 0744 SCHD DEP-ARR 1215Z/2115L-1840Z/0840L
1 ENG OUT PET RJAA/NRT - PHNL/HNL 02:29/1444NM FROM T/O

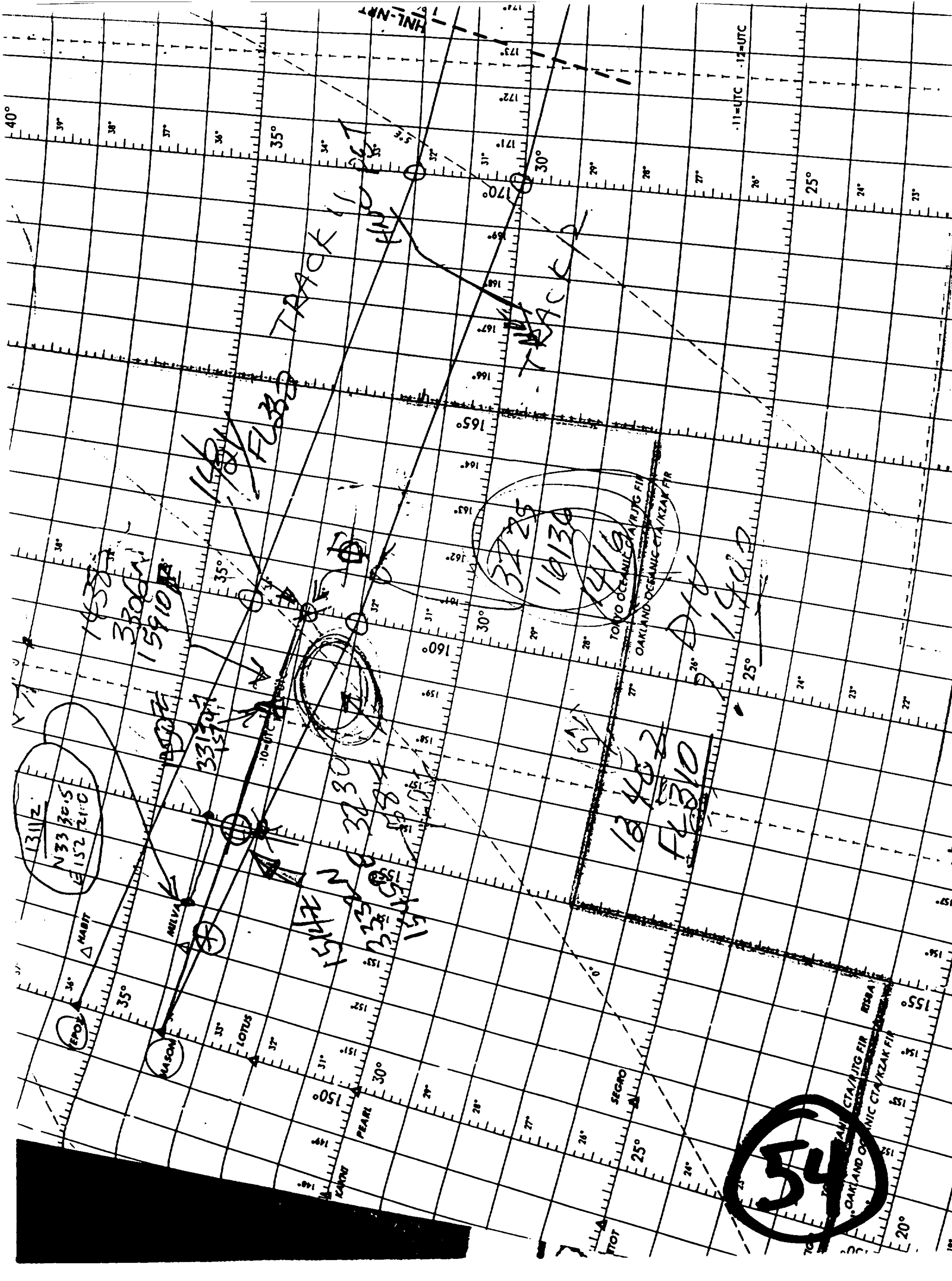
ALL ENG OPTG DECOMPRESSION: PET AWK-HNL 03:51 N27 21.0 W177 34.6
PWAK/AWK 0994NM PHNL/HNL 1133NM
FOB 807 /FRQ 674 HOLD INC 000
GWT 5552

ALTD TOGW TIME BURN
FL33 6657 0606 1542 M84
FL29 6788 0616 1673 M82
FL27 6850 0629 1735 M79

IDENT/POS/TIME/FL/NEXT POS/ETA/NEXT POS//FUEL//TEMP/WIND/SIG WX

	CKPT DRIFT LAT LONG	ZNT TTL	FL TRP	ZBO FUEL	TMP WIND T/C M/C M/H ZND A/W GS TAS MCH TTL
		1204			P34 546
	CVE 01L N3544.2 E14044.3	007 0007	CLB 46	050 1812	M02 27049 099 105 106 050 CLB 3336 N3
		121(			169 E1
1	SHOLT 04L N3434.6 E14331.2	021 0028	CLB 43	151 1661	P02 27143 117 123 127 150 OTR15 CLB 3186
	N3435.0 E143-32	31 1232/30		—	— —
	RCA 05L . .	001 0029	330 44	010 1651	P03 27152 098 103 108 010 OTR15 640 492 840 3176
					124/124
2	MURAY 02L N3417.6 E14600.0	010 0039	330 44	047 1604	P04 27153 098 103 105 114 OTR15 644 493 840 3062
	N3418 E146-02	41 1243/42	310	—	— —
3	MASON 00 N3350.0 E15000.0	019 0058	310 52	085 1519	P06 27152 098 102 102 201 OTR15 641 491 840 2861
	3350.8 14956.0	00/1302/00	310	163.4 42.5	-40 270/30
4	32160 00 N3200.0 E16000.0	050 0148	350 51	213 1306	P07 29118 102 103 103 517 608 492 840 2344
	N3201 E159-56	1348/1352/52	330	131.9	-44 270/10
	FIR 01R N3408.0 165-00.0	027 0215	350 51	110 1196	P03 28099 102 101 100 262 586 488 840 2082
		1419			529/528
5	30170 00 N3000.0 E17000.0	027 0242	350 51	111 1085	P05 29099 104 101 101 267 586 489 840 1815
		46/1446			
6	28N180 00 N2800.0 E18000.0	056 0338	370 50	224 0861	P03 29083 103 096 096 539 567 [illegible] 1276
		1542			
7	25170 03L N2500.0 W17000.0	100 0438	370 53	227 0634	P07 25110 10 096 10 67 57 [illegible] 09

53


HNL-NRT
TOKYO OCEANIC CTA/RJTG FIR
OAKLAND OCEANIC CTA/KZAK FIR
NABIT
MILVA
LOTUS
PEARL
SEGRO
54

***** LOCAL PRINT *****
RQM/SIGMET RJTG =
.RPM=
RJAA 280833 WS
RJTG SIGMET 3 VALID 280840/281240 RJAA-
TOKYO FIR MOD TO SEV TURB FCST IN AREA BOUNDED BY 34N153E 34N155E
38N158E 39N161E 41N161E 40N157E 38N155E AND 34N153E BTN FL290 AND
FL350 MOV ENE 15KT INTSF=

PART 1 LAST

******** END PRINT *****

NRTDD
.CHIVQUA 280945 /DAV
UAL826-28 NRT HNL PART 1 OF 1 PARTS *** RLS 01 ***

WIND MATRIX

FL	MORAY	MASON	32N160E	FIR
430	27149+147+00	27147+145-02	29132+131-03	29128+126-03
410	27153+151+02	27150+148+01	29133+132+00	29127+126-01
390	27157+154+04	27153+151+03	29134+132+03	29125+124+01
370	27157+154+06	27153+151+06	29126+124+06	28112+111+03
350	27157+154+05	27152+150+06	29118+116+07	28099+098+03
330	27153+151+04	27148+146+05	29106+105+06	28088+087+02
310	27144+142+03	27140+139+04	29089+088+06	27078+076+02
290	27134+132+02	28130+129+03	28078+077+06	27070+068+02
270	27122+120+03	28117+116+04	28074+073+06	28063+062+04

FL	30N170E	28N180	25N170W	CANON
430	29100+098-02	28095+094-04	26110+097-04	27068+061-05
410	30105+101+01	28090+089-02	26112+091+00	26070+062+00
390	30110+104+04	28085+084+00	25116+086+04	26071+061+04
370	30104+101+06	29083+082+03	25110+081+07	26068+058+08
350	29099+097+05	29081+079+04	25104+077+08	26065+055+10
330	29091+090+03	30077+073+03	25098+073+07	26062+052+10
310	29082+081+03	31069+062+03	25093+069+07	25057+046+10
290	29070+069+03	31061+054+03	25085+064+07	25053+041+11
270	29057+056+04	30055+051+04	25075+056+08	25048+036+12

UAL826-28 END OF PART 1

*** END PART 01 OF 05 ***

EIDR 280945 PIREP ***<

DENWBUA
•NRTDBUA 280945/KUR
AWR
NRT98

WBM 826-28 NRT-HNL (1838Z) RT: 17/12/3 ALTNT NAX

*** PART 02 OF 05 PARTS ***

AWK TAF28 0540 280528Z 280606 NIL
AWK NC 14/1 AIRPORT IS UNDER CARETAKER STATUS,
EMERGENCY USE 24HRS, SEVEN DAYS A WEEK. NRML OPS HRS
2000-0500UTC MON-SAT. APPROACH CLRNC FROM OAK ARTCC THRU
HNL RADIO (HF). WAKE OPS CTC 128.0. VOR OR GPS APPROACHES
AVAILABLE.(9/22/97 GC WHQDD UPDATE)
CDB TAF28 0540 280535Z 290606 35025G35KT P6SM OVC020
TEMPO 0618 -SHSN BKN015
FM1500 31017KT P6SM -SHSN BKN035
FM2200 31020KT P6SM BKN045
TEMPO 0206 4SM -SHSN BKN030
CDB NC 12/119 14/32 PTCHY THN IR WEF 9712271730
CDB NC 13/120 8/26 PTCHY THN IR WEF 9712271730
CDB NC 13/1 NC TOWER

ADK NC 12/6 AP CLSD
ADK NC 12/7 TOWER 704 (300 AGL) 1 3/4 NNW UNLSTD TIL
9801101845
ADK NC 12/8 ? IN LSR BA NIL WEF 9712261845

SYA TAF28 0817 280803 VRB05KT 9999 SCT025 SCT045 BKN090
QNH3008INS
BECMG 1011 19014KT 9999 VCSN SCT025 BKN045 BKN080 OVC200
620454 QNH3000INS
BECMG 1718 16020G25KT 5000 -SN SCT010 BKN020 OVC040 620208
QNH2985INS
BECMG 2122 15025G35KT 3200 -RASN BR SCT006 OVC012 620128
510000 QNH2976INS
BECMG 0001 15030G40KT 1200 -RA BR BKN005 OVC010 620158
520003 QNH2964INS WND 15038G52KT AFT 04 TO2/06Z TMO4/10Z
LIMITED METWATCH AMENDED ONLY FOR WARNING CRITERIA
ENXXT/CCYY
SYA NO 8/1 10 MLS DCMSND
SYA NC 13/1 SKED MAINT NDB (1900Z-2000Z WHEN ITS ST)
(1900Z-1900Z WHEN ITS DT) THU, VOR (1800Z-2000Z WHEN ITS
ST) (1700Z-1900Z WHEN ITS DT) FRI, ILS (1800Z-2000Z WHEN
ITS ST) (1700Z-1900Z WHEN ITS DT) TUE, WX MIN FOR ILS, VOR

AND NDB ARE 400 FT CEILING AND 1 1/2 MI VIS

56

UA@9C /OV 39N150E 0909 FL350/T8 OCNL LGT CHOP 158E TO 162E

---------- PIREPS ----------

---------- SIGMETS ----------

[illegible] VALID [illegible] IN AREA BOUNDED BY [illegible]

•NRTDNA 280947/RUP
AWD
NRT

WDM 826-28 NRT-HNL (1838Z) RT: 17/12/? ALTNT NAX

*** PART 01 OF 02 PARTS ***

---------- ORIG-DEST-ALTNT-WEATHER ----------
NRT 0941 0930Z 03006KT 360V060 9999 FEW030 BKN043 10/04 Q1020
NOSIG
NRT 0941 0930Z 03006KT 360V060 9999 FEW030 BKN043 10/04 Q1020
NOSIG RMK 1SC030 7SC043 A3012
NRT 0939 0930Z 03006KT 360V060 9999 FEW030 BKN043 10/04 Q1020
NOSIG RMK 1SC030 7SC043 A3012
NRT TAF28 0526 280606 36006KT 9999 FEW030 SCT050
NRT NO 14/1 NRT AREA MAP, JEP 10-1 PAGE HAS 3 WAYPOINT ERRORS - MAMAS,VENUS, AND ARIES COORDINATES ARE IN ERROR. COORDINATES ON SID PAGES ARE CORRECT (09/24/97 JR WHQDD)
NRT NO 14/2 ********** VORTAC (CVC) OTS FROM 10SEP97/1500Z TO 28JAN98/1500Z. TEMPORARY ROUTES AND WAYPOINTS ESTABLISHED FOR USE DURING OUTAGE. (CHART NOTAMS P-339 * CHART IS IN FDM UNDER RCUTES CHAPTER PAGE P305) ********** (GC 9/24/97 WHQDD) T
NRT NO 20/85 EFF 20NOV97/1500 UNTIL 31DEC97/1500 - - - INSTR APCH PROC AT NEW TOKYO INTL APT TEMPO CHG AS FOLWS: DUE TO CBST 1. ADF RWY34 IS UNUSABLE. 2. FOR VOR/DME NR1 RWY34 4 AND VOR/DME NR3 RWY34 (1) VCP NOT APPLICABLE, (2) CROSS NRE 3.4DME AT OR ABOVE 1060FT, (3) CHANGE OF MINIMA STA TO RWY 34,ALS AVBL, ALS OUT, MDA-VIS, C RVR1200M/VIS1200M, VIS1700M, 740-2400M, D RVR1400M/VIS1400M, VIS2300M, 740-3200M.
NRT NO 20/86 A7098/97 EFF 01DEC97/1430 UNTIL 30DEC97/2020 RWY 16/34 CLOSED RMK/EXC EMERG AIRCRAFT 2HR P 1430/2020 EXC 07 14 21 28
NRT NO 20/87 A7741/97 EFF 18DEC97/0000 REF AIP SUP NR.097/97 ITEM 1 APRON TWY (CONST AREA A) AND SPOT NR.27,3 AND 32 CLSD.
NRT NO 20/88 A7802/97 EFF 05JAN98/1430 UNTIL 31JAN98/2020 RWY 16/34 CLOSED RMK/EXC EMERG AIRCRAFT 1HR P 1430/2020 EXC 11 18 25

HNL 0904 280850Z 02008KT 12SM FEW029 21/16 A3009 RMK SLP192 8/
TOC TO2140162 50000
HNL 0852 280950Z 03008KT 12SM FEW029 21/16 A3009 RMK SLP192 8/
TOC TO2140162 50000
HNL 0904 280750Z 06008KT 12SM FEW029 22/17 A3009 RMK SLP192
98610 TO2220165
HNL TAF28 0540 280520Z 280606 07010KT P6SM SCT025 SCT043
TEMPO 0606 -SHRA SCT025 BKN040
HNL NO 11/61 VOR VOICE OTS
HNL NO 12/53 R31C9A ACT 1700-0300 DLY WEF 971229171700-971229080300
HNL NO 12/55 HNL HDH TOWER 293 (190 AGL) 5.5 W UNLGTD WIE TIL 980110180
HNL NO 12/56 FDC 6/3055 IFR TKOF MNMS AND DEP PROC, CHG TKOF MNMS FOR RWY 8R TO READ SCO-2 OR STD WITH A MNM CLB OF 250 FT PER NM TO 1000
HNL NO 12/57 FDC 7/7534 ILS RWY 4R VOR OR TACAN OR GPS RWY 4R. VOR OR TACAN OR GPS-A.DME OR RDR RDR

57

AND NDB ARE 600 FT CEILING AND 1 1/2 MI VIS

---------- PIREPS ----------

UA89C /CV 39N160E 0909 FL350/TB OCNL LGT CHOP 158E TO 162E

---------- SIGMETS ----------

SIGMET RJAA 3 VALID 280837-281334
TOKYO FIR MOD TO SEV TURB FCST IN AREA BOUNDED BY 34N153E
34N155E 30N158E 39N161E 41N161E 40N157E 38N155E AND 34N153E BTN
FL290 AND FL350 MOV ENE 15KT IN ... S

---------- ENROUTE NOTAMS ----------

ENROUTE NOTAM 702 EFF 5DEC97 TO 28JAN98
CHOSHI VORTAC (CVC) OTS UNTIL 28JAN9871500Z TEMPORARY ROUTES
AND WAYPOINTS ESTABLISHED FOR USE DURING OUTAGE. (CHART IS IN
FDM UNDER ROUTES CHAPTER PAGE P-305) (CHART NOTAMS 25SEP97)
(GRID:TYO FDS SJH/12-19-97)

ENROUTE NOTAM 695 EFF - TO 31DEC/2359Z
NAGA VOR/DME (NG) OTS. (WW NOTAM 030CT97)

ENROUTE NOTAM 644 EFF - TO
PEACH INT COORDS N34 09.6E134 51.2 (10-1 CHART RJOO)(07AUG97)

*** END PART 03 OF 05 ***

EISDR 280945 P1929 ***"<

DENWBUA
.NRTDDUA 280945/KUR
AWB
NRT93

WBM 826-28 NRT-HNL (1938Z) RT: 17/12/3 ALTNT NAX

*** PART 04 OF 05 PARTS ***

ENROUTE NOTAM 667 EFF 5DEC97 TO 28JAN98
CTR 18 AND CTR 20 AWYS RENAU WAYPOINT COORDINATES N34-30-54/
E141-41-50 UNTIL 28 JAN 98. REFER TO CHART NOTAMS P-305,
TEMPORARY SHUTDOWN OF CHOSHI VORTAC (CVC). (SJH NAVDATA NOTAM
5DEC97)

ENROUTE NOTAM 668 EFF 5DEC97 TO 28JAN98
A1 AND G597 AWYS MAMAS WAYPOINT COORDINATES N34-58-53/
E140-36-22 UNTIL 28 JAN 98. REFER TO CHART NOTAMS P-305,
TEMPORARY SHUTDOWN OF CHOSHI VORTAC (CVC). (SJH NAVDATA NOTAM
5DEC97)

58

AERODROME FORECASTS FOR HNL BOUND
ISSUED BY METEOROLOGICAL OFFICE AT NEW TOKYO INTERNATIONAL AIRPORT
28,0700UTC DEC 1997

SELECTED WEATHER ABBREVIATIONS

BCFG	FOG PATCHES	FC	FUNNEL CLOUD	PO	DUST DEVILS	SG	SNOWGRAINS
BLSN	BLOWING SNOW	FU	SMOKE	RA	RAIN	SQ	SQUALL
BR	MIST	FZ	FREEZING	RE	RECENT	SN	SNOW
DRSN	LOW DRIFTING SNOW	GR	HAIL	SA	DUSTSTORM SAND-STORM RIZING	TS	THUNDERSTORM
		HZ	DUSTHAZE			+	HEAVY
DZ	DRIZZLE	MI	SHALLOW		DUST OR SAND	-	LIGHT
FG	FOG	PE	ICEPELLETS	SH	SHOWERS		

SELECTED ICAO LOCATION INDICATORS

RJAA NEW TOKYO	RJCC NEW CHITOSE	RJCH HAKODATE
RJSS SENDAI	RJNN NAGOYA	RJBB KANSAI/INTL
RJTT TOKYO INTL	PHNA BARBERS POINT	PWAK WAKE
PHNL HONOLULU	PHOG KAULUI	PHTO HILO

RJAA 280606 36006KT 9999 FEW030 SCT050

RJCC 280606 30015KT 9999 BKN030 TEMPO 1521 2000 -SHSN

RJSS 280024 29012KT 9999 SCT030 TEMPO 0109 29020G30KT

RJNN 280606 30008KT 9999 FEW030

RJBB 280606 35008KT 9999 FEW030

RJTT 280606 34012KT 9999 FEW030 BKN050 BKN200 BECMG 0911
05010KT

PHNA 272121 12010G15KT 9999 SCT030 SCT050 QNH3002INS T28/00Z
TEMPO 2121 -SHRA S CT025 BKN045 BECMG 0507 04006KT 9999
FEW030 SCT050 QNH3005INS T16/15Z NO AMDS AFT 2223 NEXT
2821 LAST

PHNL 280520Z 280606 07010KT P6SM SCT025 SCT045 TEMPO 0606
-SHRA SCT025 BKN040

PHOG 280520Z 280606 06010KT P6SM SCT025 SCT045 TEMPO 0620
-SHRA SCT020 BKN030 FM2000 07015G25KT P6SM SCT025 SCT045
TEMPO 2006 -SHRA SCT025 BKN040 AMD NOT SKED TIL 18Z

PHTO 280520Z 280606 VRB03KT P6SM SCT02● I
SHRA BKN018 OVC040 FM2100 13008KT P
TEMPO 2106 -SHRA BKN025 OVC040

RJCH PWAK NIL=

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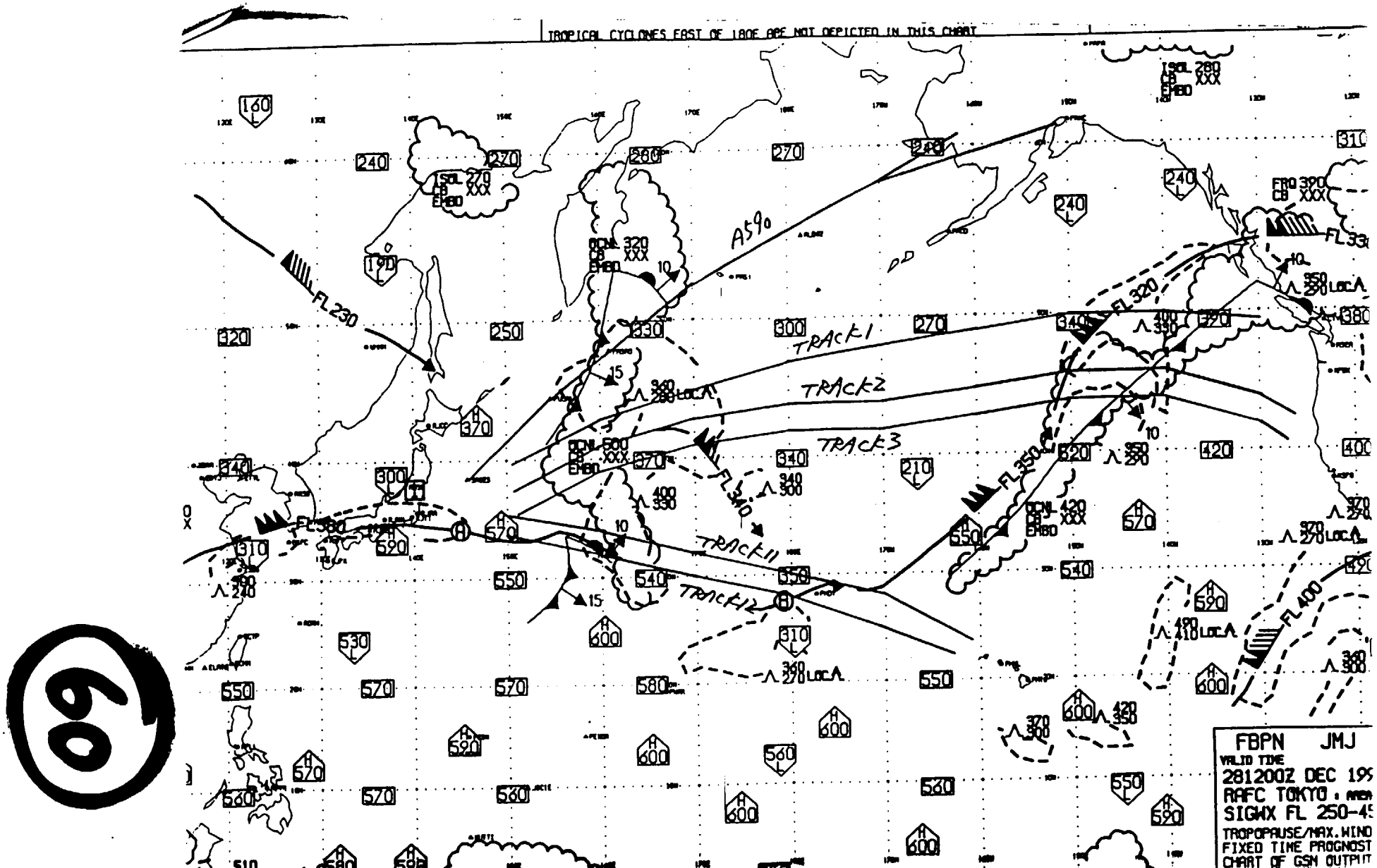
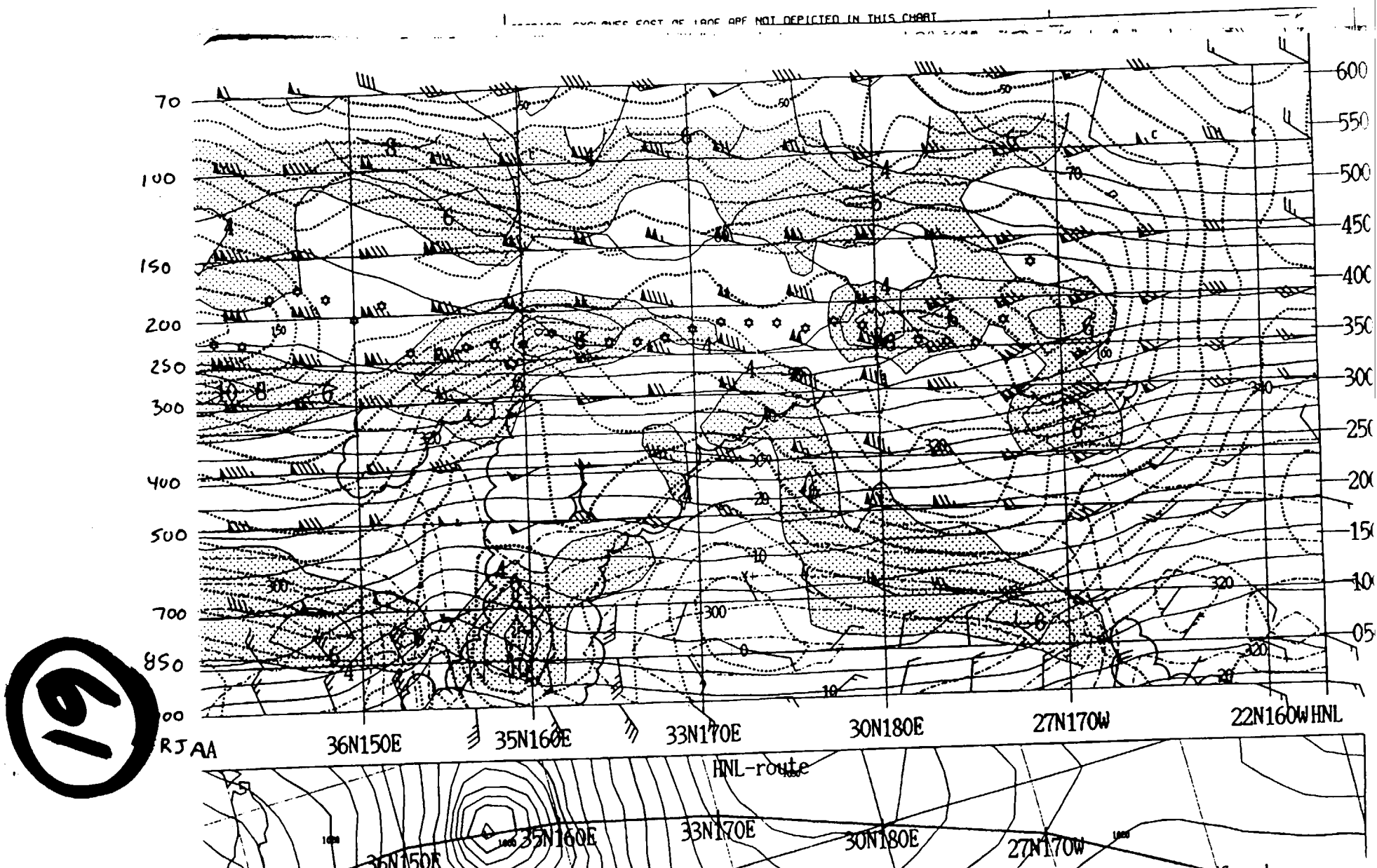

TROPICAL CYCLONES EAST OF 180E ARE NOT DEPICTED IN THIS CHART
TRACK1
TRACK2
TRACK3
TRACK11
TRACK12
FL230
FL310
FL350
FL400
FL320
FBPN JMJ
VALID TIME
281200Z DEC 19
RAFC TOKYO
SIGWX FL 250-4
TROPOPAUSE/MAX.WIND
FIXED TIME PROGNOST
CHART OF GSM OUTPUT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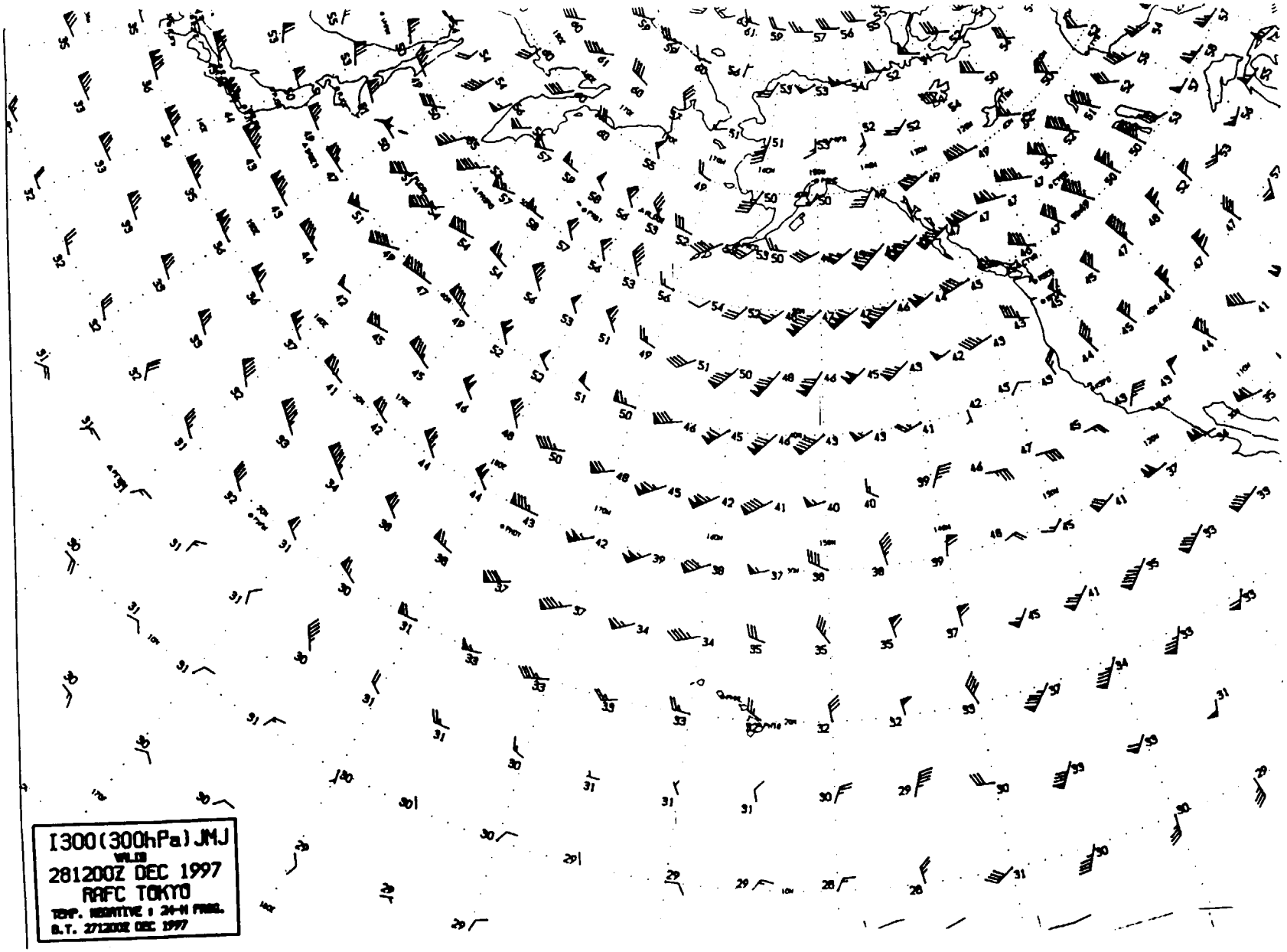
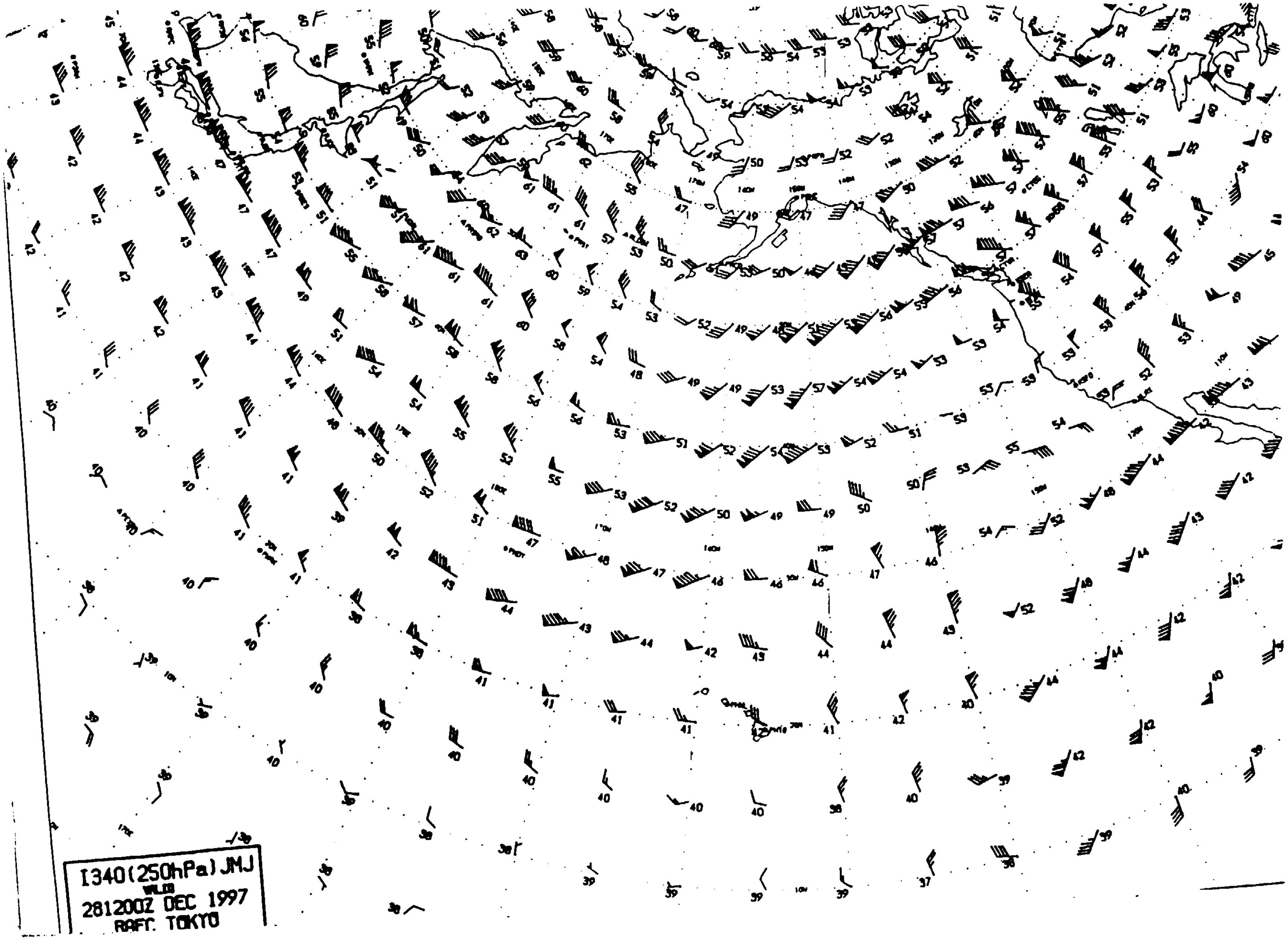
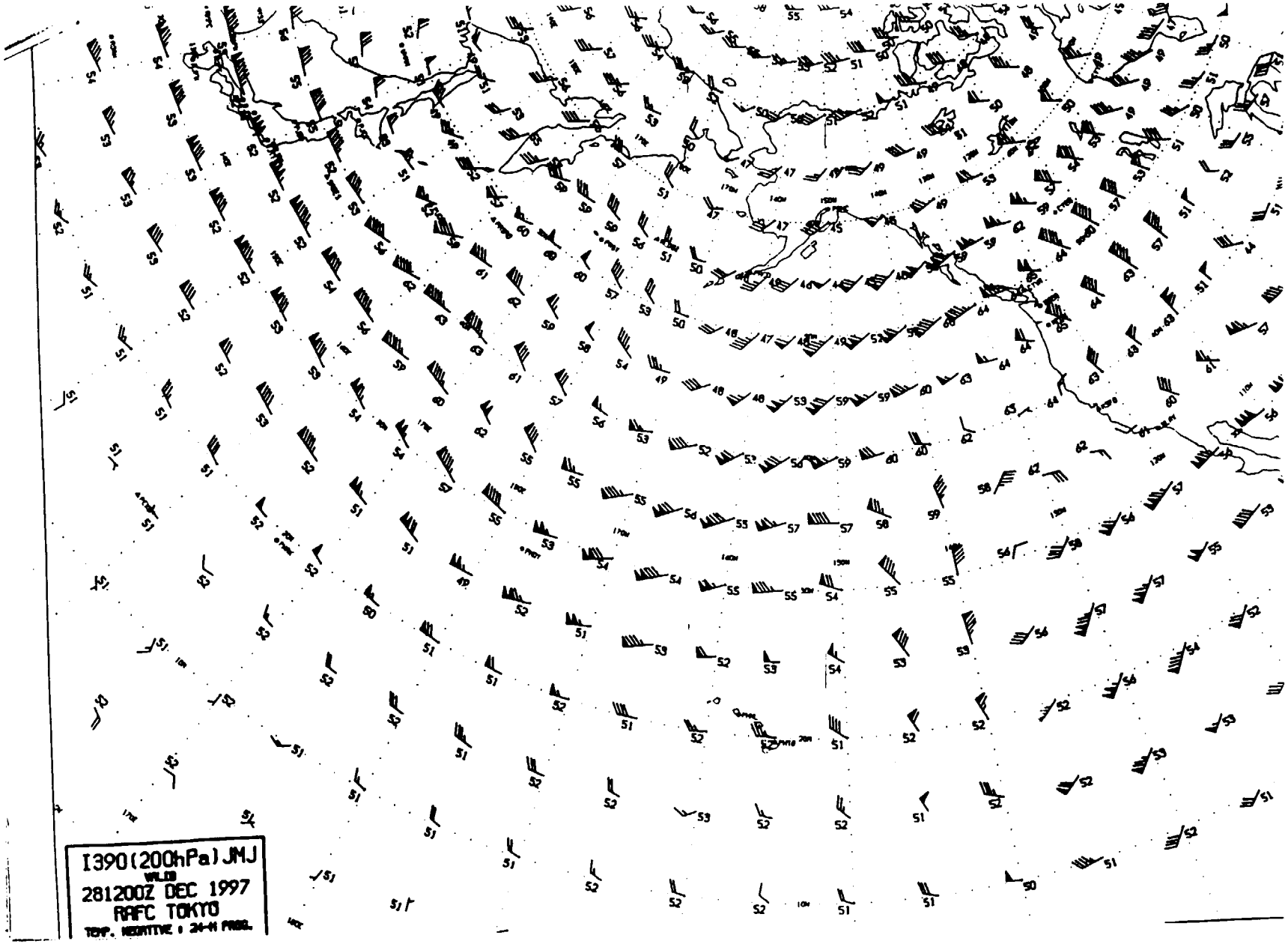
36N150E
35N160E
33N170E
30N180E
27N170W
22N160W HNL
RJAA
HNL-route
35N160E
33N170E
30N180E
27N170W

19


I300(300hPa)JMJ
VALID
281200Z DEC 1997
RAFC TOKYO
TEMP. NEGATIVE : 24-H FCST.
B.T. 271200Z DEC 1997



63


I390(200hPa)JMJ
WMLOB
281200Z DEC 1997
RAFC TOKYO
TEMP. NEGATIVE : 24-H PROG.

MEMO

NORTHWEST AIRLINES

TO: Bob Benzon - NTSB
Date: Tuesday, January 06, 1998

From: Larry Ganse
5101 Northwest Drive
Department N7180
St. Paul MN 55111-3034
[redacted] Phone
Fax
OVID LRGANSE

Subj: NWA pilot reports & meteorological information for Dec 28, 1997, in the vicinity of 32N/160E

Bob,

Here is a quick description of the attached documents.

1. NWA generated upper air depiction for the pacific region applicable to the date/time of the accident. This chart is issued to each departing NW flight.
2. NWA generate surface analysis, also issued to each departing flight.
3. A plot of the NW turbulence plot (TP) applicable at the time of the accident. This was plotted by NWA meteorology in Tokyo after the accident.
4. The text copy of the NW TP message plotted in (3) above.
5. The statement of the Captain of NW flt 22. This flight was in the same area as UA 826. The information is self explanatory.
6. The statement of the Captain of NW flt 80. This flight transited the area approx. 90 minutes ahead of UA 826 at FL 330.
7. The statement of the Captain of NW 10 which was the flight 30 minutes ahead of UA 826 and transited the area at FL 330.
8. The statement of the Captain of NW 76 which transited the area approx. 80 minutes ahead of UA 826 at FL 290.

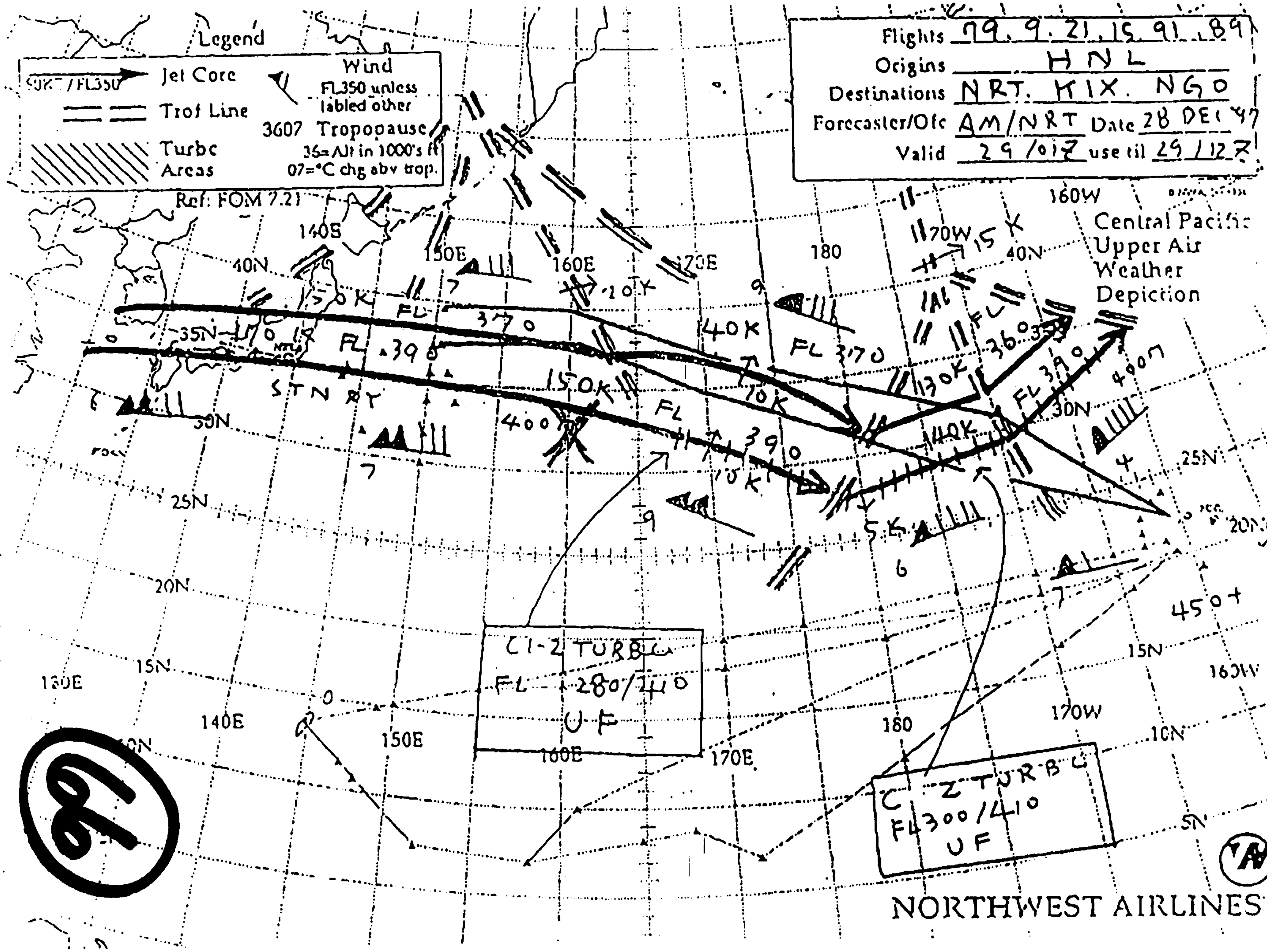
If there is anything else we can do to be of assistance, please feel free to call. I will get back to you on the plan to brief FAA on our TP program.

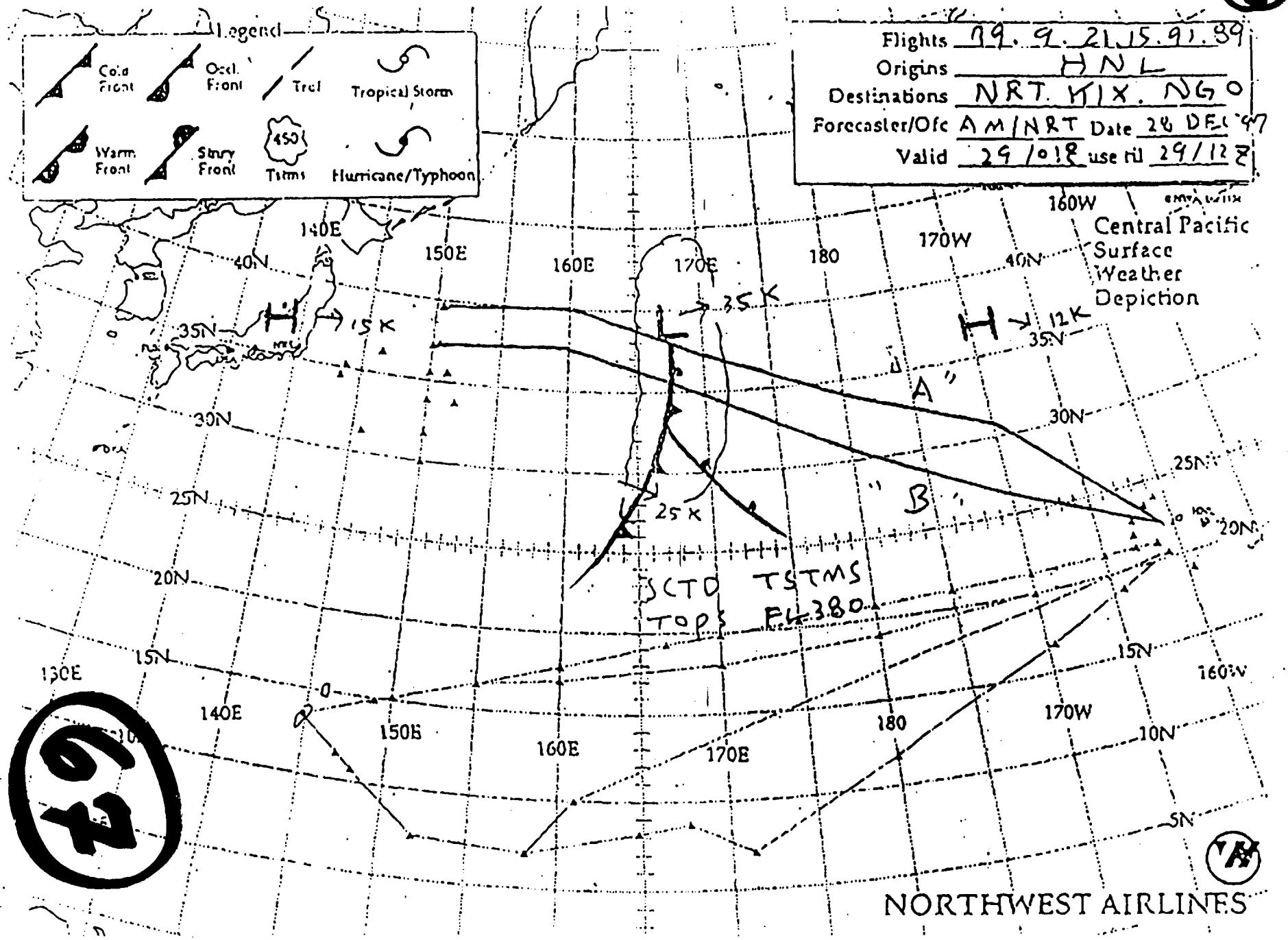
Regards,

[redacted]

65

(1)


Legend
Jet Core
Trof Line
Turbc Areas
Wind
FL350 unless labled other
3607 Tropopause
36=Alt in 1000's ft
07=°C chg abv trop.
Ref: FOM 7.21
Flights 79. 9. 21. 15. 91. 89
Origins HNL
Destinations NRT. KIX. NGO
Forecaster/Ofc AM/NRT
Date 28 DEC 97
Valid 29/01Z
use til 29/12Z
Central Pacific Upper Air Weather Depiction
FL 370
FL 390
FL 370
FL 360
FL 390
STN RY
C1-2 TURBC
FL 280/410
UF
C1-2 TURBC
FL300/410
UF
NORTHWEST AIRLINES


Legend
Cold Front
Occl. Front
Trof
Tropical Storm
Warm Front
Stnry Front
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Tstms
Hurricane/Typhoon
Flights 29.9.21.15.91.89
Origins HNL
Destinations NRT. HIX. NGO
Forecaster/Ofc AM/NRT Date 28 DEC 97
Valid 29/018 use til 29/12Z
Central Pacific
Surface
Weather
Depiction
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170E
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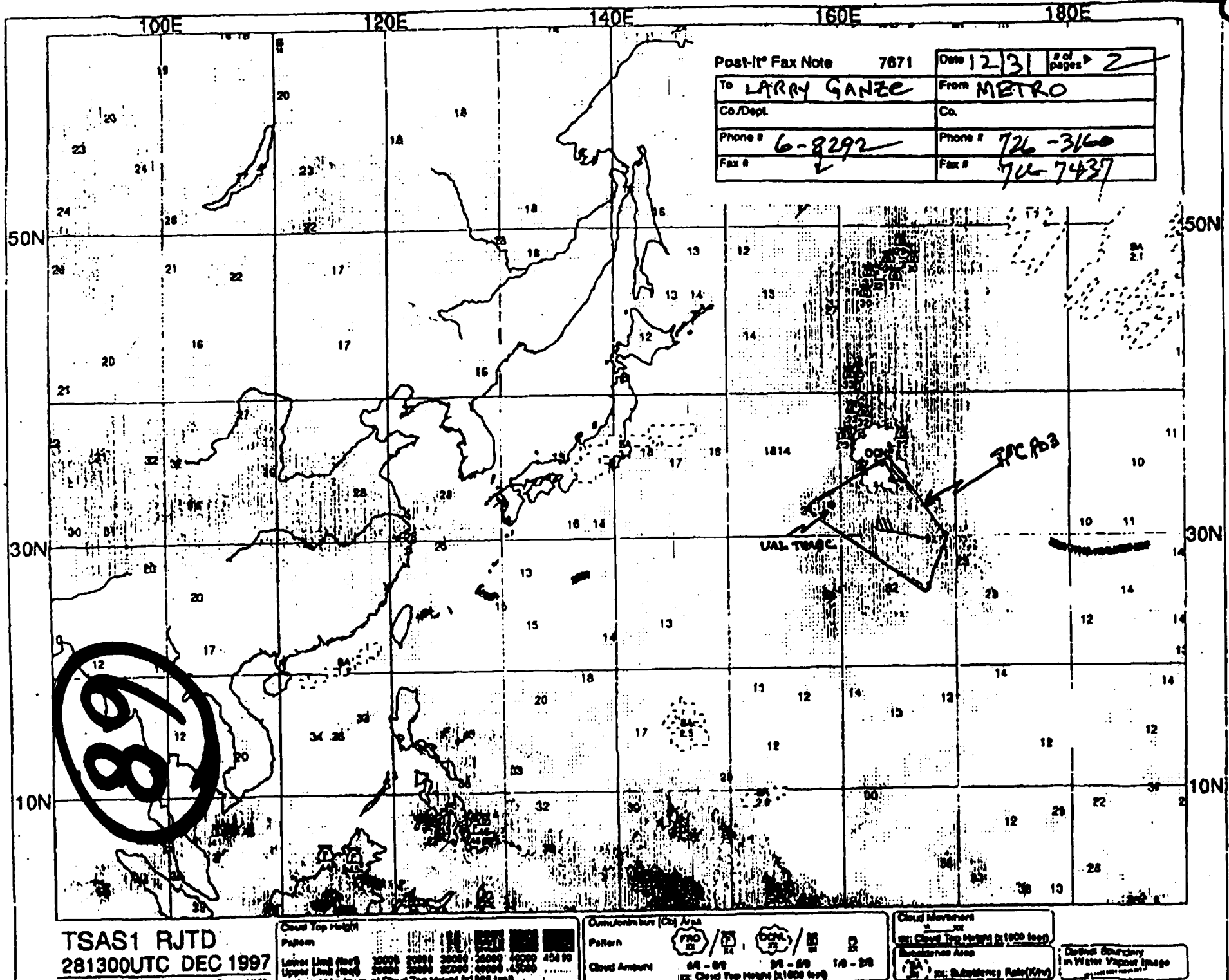
TOPS FL380
NORTHWEST AIRLINES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To LARRY GANZE
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Co.
Phone # 6-8292
Phone # 726-3160
Fax #
Fax # 726-7437
TPC PD3
UAL 1814
TSAS1 RJTD
281300UTC DEC 1997
Cloud Top Height
Pattern
Cumulonimbus (Cb) Area
Cloud Movement
Tropical Storm Area
Dashed Boundary in Water Vapor Image
DEC-31-1997 15:01 Northwest Airlines MSP 612 726 7437 P.01

URTW[illegible] UBTOUNW 0C341NW NFTOHNN MODOWNN

[illegible] 280938 TS

19 [illegible] 280936L

1,E46 E35

2,AREA SCT TSTM

OBSERVED B SATELLITE

35N164E 30N163E

27N168E 33N157E

[illegible]

[illegible] FL240

[illegible]

[illegible]

3,NC

4,CANCEL CH9[illegible]

5,COMMENT NONE

122609361229093B 485 P1U4363Y

69

TOTAL P.02

4

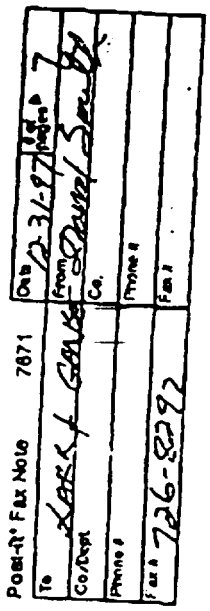
(5)

30 DEC 97

THE FOLLOWING ARE EVENTS RELATING TO OBSERVATION ON NORTHWEST FLT 22 / DEC 26 NRT HNL.

THIS IS WHAT I REMEMBER AS CAPT OF THAT FLT.

WE (CO-PILOT SCOTT WILSON AND I) ARR BETWEEN 8:25 + 8:30 PM (IN THE COCKPIT). SCHD DEPT IS 8:55 PM.



I BELIEVE "FATE" INTERVENED WHEN THE INTERPHONE WAS ACTIVATED BY THE GROUND PERSONNEL TO INFORM US "5 MIN" BEFORE DEPT. THAT WAS ABOUT 8:35 - 8:40. I TOLD HIM WE WEREN'T READY - STAND BY. SCOTT CALLED FOR 350 - 330 SECONDARY. BY FATE, I MEAN THE NORMAL CALL FOR CLEARANCE + ALT REQ WOULD HAVE BEEN AT 8:50. THIS HAS NOTHING TO DO WITH THE INCIDENT ITSELF. BUT I'M CONVINCED WE (NW 22) WOULD HAVE BEEN THE "INCIDENT AIRCRAFT" AT 310 IF WE HADN'T BEEN ALREADY DAILY.

UNITED 826 GOT 310 YET TOOK OFF AHEAD OF US.

(70)

IT WAS MY LEG AND EVERYTHING WAS ROUTINE. TURBULENCE (PIREP) WAS LIGHT TURB BETWEEN 10,000 + 14,000. WE BROKE INO THE CLOUDS AROUND 18 TO 20,000 FT.

WE COULD SEE 826 AHEAD OFF US. SCOTT KEPT TRACK OF HIS ETA'S SO WE COULD MAINTAIN SITUATIONAL AWARENESS ON OUR TRACK. EVERYONE WANTS TO CLIMB EN ROUTE + IT HELPS TO KNOW WHOS HOLDING YOU DOWN + VICE VERSA.

N.W FLT 10 LEAVES NRT 30 MIN AHEAD OF 22 + I KNOW HE'D BE IN RANGE ON VHF (128.95). FLT 80 WAS AN HOUR + 1/2 AHEAD OF US, AT THOSE GROUND SPEEDS HE WAS 900 NM AHEAD OF US + I NEVER HEARD HIM.

WE WERE 1/2 WAY THROUGH THE CHOSI DEPARTURE - NOT TO CHIBA, AND WERE GIVEN RADAR VECTORS, THEN DIRECT TO OUR FIRST FIX. (CAN'T REMEMBER) SMOLT PROBABLY.

THAT TRACK WAS ROUGLY 120°

WE OBSERVED RADAR RETURNS, VERY DISTINCT.

IT WAS OBVIOUS THAT ONCE ON TRACK 12 WE'D GO 093° (ABOUT) + PUT THOSE RETURNS OFF TO OUR RIGHT AND A SAFE DISTANCE.

WE NEVER SAW ANY RADAR RETURNS FOR THE REST OF THE FLIGHT.

71

AFTER LEVELING AT 330, I CALLED NW 10 FOR A PIREP. HE SAID "SMOOTH SO FAR, I'LL GIVE YOU A CALL IF IT GETS BAD" I THINK HE WAS AT 330, AT THAT TIME. WE WERE LIGHT ENOUGH FOR 350 AND PUT IN A REQUEST FOR HIGHER.

WE COULD SEE THE LIGHTS OF UA 826 ABOUT 20/30 MI AHEAD.

AT ABOUT 1340Z, [redacted], 1549E I GOT THIS RADIO CALL ON 128.45. "NW 22 THIS IS UNITED 826" HE WAS CALM + MATTER OF FACT. I RESPONDED + HE SAID. "I'VE JUST EXPERIENCED THE WORST TURBULENCE OF MY CAREER, NUMEROUS INJURIES, POSSIBLE AIRCRAFT DAMAGE, WE MAY GO BACK TO NAT"

I TURNED ON THE SEAT BELT SIGN + MADE A P.A. TELLING ALL F/A + PASSENGERS TO RETURN TO THEIR SEATS + STRAP IN. A/C IN THE AREA HAVE EXPERIENCED STRONG TURBULENCE. WE (NW 22) DID NOT GET A BUMP. DURING THOSE FEW MINUTES WE RECEIVED A SEL/CAL + CLEARANCE TO ESO.

72

THE WIND WAS ALMOST EXACTLY AS FORCAST 270/160. RIGHT ON THE TAIL.

AS WE LEVELED OFF AT 350 WE SAW UA 826 COME ON THE TCAS. I LOOKED OUT MY LEFT WINDOW + HE WAS JUST BELOW US AT 330. THE INCIDENT MUST HAVE SLOWED HIM + BROUGHT HIM BACK TO US.

I DON'T KNOW IF HE WAS CLEARED TO 330 OR USED HIS EMERGENCY AUTHORITY. I WOULD HAVE CLIMBED TO 530 KNOWING NW 22 HAD GONE TO 350. THE HAWAIIAN CONTROLLERS ARE VERY SLOW TO CO-ORDINATE.

ONCE AGAIN — NO TURB ON NW 22. NO RADAR RETURNS. NO LIGHTNING

ON A PERSONAL NOTE THE TRACKS WERE PLANNED THROUGH AREAS OF KNOWN + FORCAST TURB. THE ONLY THOUGHTS WERE MINIMUM TIME TRACKS.

IN THE WINTER IN THE N. PACIFIC WINDS OF 170 KTS ARE NORMAL. NOT EVERY FLIGHT CAN BE IN THE CORE OF THE JET. NOBEL (PHYSICS) PRIZE WINNER RICHARD FEYNMAN WAS QUOTED IN TODAYS (30 DEC) HONOLULU ADVERTISER

73

AS SAYING " THE MOST IMPORTANT UNSOLVED PROBLEM OF CLASSICAL PHYSICS" RELATING TO TURBULENCE IN JET STREAMS.

WE AS AN AIRLINE AND AN INDUSTRY ARE NOT GOING TO STOP FLYING IN STRONG JET STREAM WINDS. BUT TO ME TWO ISSUES MUST BE ADDRESSED.

1. MINIMUM TIME (WE WERE 20 MN EARLY) VERSUS TURB AVOIDANCE. WE'RE DEALING WITH THE ENTIRE N. PACIFIC.
2. ENFORCEMENT OF THE SEAT BELT SIGN. IT IS UNIFORMLY DISREGARDED & PUTS ENFORCEMENT IN THE HANDS OF FLIGHT ATTENDANTS.

I FEEL FOR THE CAPT, CREW & PAX OF UA 826. IT COULD HAVE BE ME, US, NORTHWEST.

IF YOU, NW, THE FEDS ETC NEED ME I'M ON SCHD # 24 AND WILL BE ON THE MAINLAND FROM 20TH TO END OF JAN

DENNIS C. KEATENS
OBIITT / HNL
[redacted]

74

Air Safety Report

4V

Captain: NATE COBB Employee No: 093823

First Officer: STEVE SEKTNAN Employee No: 125260

Second Officer: BRUCE LAMPERT DEC 1997 Employee No: 227668

Lead F/A: MIKE ? Employee No:

Dispatcher: Employee No:

Other Crew:

Date: ~~DEC~~ 28 Da 12 Mo 97 Yr Time 1220 (UTC)

Flight No.: 80 From: NRT To: HNL Divert To: —

Location/Fix: APPROX 160E / 31 N NASA ASRS Filed? Y or (N) (Circle)

A/C Type: B747 A/C No.: 6634 Logbook Ref: —

Emergency Declared? Y or (N) (Circle)

Flight Phase: (Circle One) Parked/Pushback/Powerback/Taxi-Out/Takeoff/Initial Climb/Climb/(Cruise)/Descent/Approach/Landing/Taxi-In/Towing

Altitude/Flt Level: FL 330 ft Runway No.: 34

IAS/Mach: M 84 kts Runway Condition: Dry/Wet/Ice/Snow/Slush

Fuel Jettisoned: — lbs.

Configuration: ON / ON / UP / UP / UP
Auto Pilot / Auto Thrust / Gear / Flap / Slat

Significant Wx: / / / CODE 4
Rain / Snow / Icing / Turbulence

Actual Wx: 270 / 150 / UNL / CLEAR / -44 /
Wind / Vis / Ceiling / Temp / QNH

Description Of Incident: CLEAR AIR TURBULENCE PRIOR TO UA 826/28 DEC

1.) IN VICINITY OF 160E WE ENCOUNTERED MODERATE/SEVERE TURBULENCE (CODE 3/4 REPORTED) @ 330, WHICH LASTED 2-3 MINUTES, FOLLOWED BY 10-12 MINUTES OF LIGHT/MODERATE.

2.) AIRCRAFT WAS CONTROLLABLE THROUGHOUT, AS WE REDUCED TO M 81/82 DURING THIS TIME.

3) Other Information: AFTER PASSING THROUGH TURBULENT AREA, WHILE IN SMOOTH AIR, AIRCRAFT SUDDENLY SWERVED/LURCHED, AS IF ENCOUNTERING A TROUGH (ROLL CLOUD, JETSTREAM, ETC), FOR A BRIEF DURATION.

4.) PRIOR TO 160E, WE TURNED SEATBELT SIGN ON (A/C IN SMOOTH AIR), BASED ON CODE 2 FORECAST, WHICH WAS ACCURATE.

5.) HAVING DONE THAT, I KNOW AVOIDED INJURIES, AS THIS TURBULENCE ~~SHOULD~~ WAS THE WORST THAT I'VE EVER ENCOUNTED!

6.) AT 164E, WE CHANGED TRACKS, TO FACILITATE FL 370/390.

Pilots, Dispatchers: Fill out report in as much detail as possible and hand to station agent upon completion of flight. Note list of reportable incidents on back of form for reference.

Station Agents: FAX to the Flight Safety Office, at 612-726-8292 and send original through company mail to Department (mail stop) N7180, Minneapolis.

[redacted] (NWA 093023)

LARRY etal - HAPPY NEW YEAR!!

75

Air Safety Report

P&I NORTHWEST AIRLINES cc L. Gonsc

Captain: Ron Meeker Employee No.: 07748

First Officer: Jim Myers Employee No.:

Second Officer: Marty Smith Employee No.:

Lead F/A: Employee No.:

Dispatcher: Employee No.:

Other Crew:

Date: 29 Da Dec Mo 97 Yr Time: (UTC)

Flight No.: 10 From: NRT To: HNL Divert To:

Location/Fix: 2 hrs out of NRT ON TRACK 12 NASA ASRS Filed? Y or N (Circle)

A/C Type: 747 A/C No.: 6601 Logbook Ref:

Emergency Delcared? Y or N (Circle)

Flight Phase: (Circle One) Parked/Pushback/Powerback/Taxi-Out/Takeoff/Initial Climb/Climb/Cruise/Descent/ Approach/Landing/Taxi-In/Towing

Altitude/Flt Level: 330 ft

IAS/Mach: .84 kts

Runway No.:

Runway Condition: Dry/Wet/Ice/Snow/Slush

Fuel Jettisoned: lbs.

Configuration: ✓ / ✓ / / / / (Auto Pilot / Auto Thrust / Gear / Flap / Slat)

Significant Wx: / / / Light (Rain / Snow / Icing / Turbulence)

Actual Wx: / / / / (Wind / Vis / Ceiling / Temp / QNH)

Description Of Incident: FLT 22 departed NRT on Sked 29 Dec on Track 12. FLT was briefed for possible code 1-2 2 hours ATO. No mention was made of last Rpt. To avoid Turb. FLT passed through area of expected turb experiencing Very light Turb (Code 1). There were NO TRW's in area (NO radar returns &

Other Information: NO observed lightning). FLT 10 Transited area approximately 30 min later & experienced NO significant Wx They were at FL 330 & experienced only code 1 Turb. UAL 826 was 2 min ahead of FLT 10 @ FL Level 310 & experienced severe Clear Air Turb.

Signature: [redacted] (over)

Pilots/Dispatchers: Fill out report in as much detail as possible and hand to station agent upon completion of flight. Note list of reportable incidents on back of form for reference.

Station Agents: FAX to the Flight Safety Office, at 612-726-8292 and send original through Department (mail stop) N7180, Minneapolis.

OP-294 FORM NO. 7-A328 7/92

76

Air Safety Report

PSI Con't

Captain: _____ Employee No.: _____

First Officer: _____ Employee No.: _____

Second Officer: _____ Employee No.: _____

Lead F/A: _____ Employee No.: _____

Dispatcher: _____ Employee No.: _____

Other Crew: _____

Date: _____ Da _____ Mo _____ Yr Time: _____ (UTC)

Flight No.: _____ From: _____ To: _____ Divert To: _____

Location/Fix: _____ NASA ASRS Filed? Y or N (Circle)

A/C Type: _____ A/C No.: _____ Logbook Ref: _____

Emergency Delcared? Y or N (Circle)

Flight Phase: (Circle One) Parked/Pushback/Powerback/Taxi-Out/Takeoff/Initial Climb/Climb/Cruise/Descent/ Approach/Landing/Taxi-In/Towing

Altitude/Flt Level: _____ ft Runway No.: _____

IAS/Mach: _____ kts Runway Condition: Dry/Wet/Ice/Snow/Slush

Fuel Jettisoned: _____ lbs.

Configuration: _____ / _____ / _____ / _____ / _____
Auto Pilot / Auto Thrust / Gear / Flap / Slat

Significant Wx: _____ / _____ / _____ / _____
Rain / Snow / Icing / Turbulence

Actual Wx: _____ / _____ / _____ / _____ / _____
Wind / Vis / Ceiling / Temp / QNH

Description Of Incident: There was a TP for Scattered Thunderstorms in Area + Upper Wx depiction chart showed possible code 1-2 in area, There were no transmissions on 125.95 which warned of turbulence in the area. There was nothing in the

Other Information: Briefing or experienced by the earlier crews transiting the area to warn the pilots of UAL #26 of severe turb.

Signature: [redacted]

Pilots/Dispatchers: Fill out report in as much detail as possible and hand to station agent upon completion of flight. Note list of reportable incidents on back of form for reference.

Station Agents: FAX to the Flight Safety Office, at 612-726-8292 and send original through company mail to Department (mail stop) N7180 Minneapolis

77

FORM NO 7-A328 7/92

NORTHWEST AIRLINES

JAN - 2 1998

Air Safety Report

(8)

Captain: E.G. KURDZIENWA HNL FLIGHT OFFICE Base: HNL Employee No.: 051-060

First Officer: BRIAN EWALD Base: HNL Employee No.: 127-591

Second Officer: DOUG JOHNSON Base: HNL Employee No.: 225-872

Lead F/A: _____ Base: HNL Employee No.: _____

Dispatcher: _____ Base: _____ Employee No.: _____

Other Crew: _____

Date: 28 Da DEC Mo 1997 Yr Time: 0800 (UTC)

Flight No.: 76 From: FUK To: HNL Divert To N/A

Location/Fix: 2.5 HRS. OUT OF FUK APROX 30° N 160° E NASA ASRS Filed? Y or (N) (Circle)

A/C Type: DC-10 A/C No.: 1227 Logbook Ref: N/A

Emergency Delcared? Y or (N) (Circle)

Flight Phase: (Circle One) Parked/Pushback/Powerback/Taxi-Out/Takeoff/Initial Climb/Climb/(Cruise)/Holding/ Descent/Approach/Landing/Taxi-In/Towing

Altitude/Flt Level: 23,000 Runway/Taxiway/Gate ID: _____

IAS/Mach: .83 M Runway/Taxiway Condition: Dry/Wet/Ice/Snow/Slush

Fuel Jettisoned: N/A lbs

Configuration:	* /	* /	UP /	UP /	UP
	Auto Pilot	Auto Thrust	Gear	Flap	Slat

Significant Wx:	/	/	/	CODE 3
	Rain	Snow	Icing	Turbulence

Actual Wx:	/	/	/	/
	Wind	Vis	Ceiling	Temp	QNH

Description Of Incident: ON TRANS 12 AIRCRAFT ENCOUNTERED CLEAR AIR (JET STREAM) OR CLOUD TOPS CAUSING MODERATE TURBULENCE LASTING ABOUT 5 MINUTES FLT. ATTENDANT IN TAIL KIT AND MAIN CART (NOT SECURED) IN AISLE. FRANCISCO BATANOW 060 535

Other Information: TP WAS FORECAST FOR SUBJECT AREA FOR CODE 1-2 TURBULENCE. FLIGHT ATTENDANTS WERE BRIEFED TO EXPECT POSSIBLE CODE 2 TURBULENCE FROM 1+40 TO 3+10 HRS. OUT OF FUK IN PREFLT. BRIEFING. THE LEAD FLIGHT ATTENDANT WAS BRIEFED 10 MINS. PRIOR TO ENCOUNTER TO EXPECT TURB. (BASED ON RADAR RETURNS IN 'MAP') FRANK IN BACK RECEIVED WORD

Signature: [redacted]

☐ Check If Flight Safety Response is requested

PILOTS/DISPATCHERS: Fill out report in as much detail as possible. Turn report in at Base Office if at pilot base, or hand to station agent if at outlying station immediately following the flight.

If the event is an urgent safety of flight matter per FOM 15.55.1 contact Flight Safety at 1-800-NWA-SAFE or Dispatch at 1-800-NWA-DISP

STATION AGENTS: FAX to the Flight Safety Office, at 612-726-8992 and send original through company mail to Department (mail stop) N7180, Minneapolis.

— over —

78

UNITED AIRLINES

World Headquarters

February 27, 1998

Mr. Bob Benzon
National Transportation Safety Board
490 L'Enfant Plaza S.W.
Washington, D.C. 20594-2000

Subject: Flight 826, December 28, 1997, NRT-HNL, N4723U, Turbulence Encounter, NTSB DCA98MA015

Dear Mr. Benzon:

This document responds to questions asked by Greg Salottolo and Don Eick in a memo dated January 21, 1998, received by e-mail on January 30. The responses were compiled from discussions with the captain of the incident flight, United's manager of meteorology and United's, ALPA chief investigator.

1) The flight plan indicated a Flight Level of 35,000 feet [FL 350] at MASON. Why was the aircraft not at this Flight Level [ATC or other reasons]?

Answer: NRT clearance delivery did not make FL350 available to the flight at departure time. The incident flight was unable to obtain a higher flight level prior to the event.

2) What type of weather radar was onboard?

Answer: C-band

Was the radar functioning normally?

Answer: Yes

What was seen on the weather radar and what was the location and intensity of the echoes seen?

Answer: 50-60 miles ahead, to the right of course, there were some light green (no amber or red) echoes. There was no visual sightings of lightning.

What tilt and range was the weather radar set on?

79

Box 66100, Chicago, Illinois 60666. • Location: 1200 East Algonquin Road, Elk Grove Township, Illinois 60007

Answer: The radar was set on the 80 mile range with 5 degree tilt down. The crew occasionally scanned at 10-15 degree down for confirmation of surface return (functionality).

Does the radar have a turbulence display?

Answer: The radar has a "Precip Only", "Both" and "Doppler Only" modes. At the time of the incident, the radar was set in the "Both" mode.

3) What weather information was received while enroute? How, from whom, and when was the information received?

Answer: The incident flight received a ride report from an aircraft on the same track approximately 30 miles ahead, at a higher flight level. The ride report was, "occasional ripple, but basically a smooth ride." There were no reports of turbulence received from other flights.

4) What were the cloud tops?

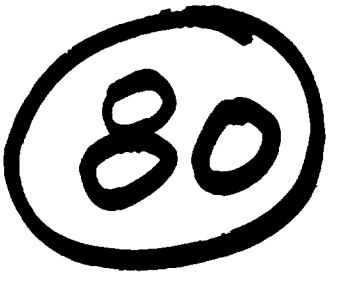
Answer: The pilots reported they were in the clear from level-off at FL310 ("stars above", tops below FL310)

5) What are crew procedures regarding when to turn the fasten seat belt sign on?

Answer: Attached are "OI" and "ALL WX" pages from our Flight Operations Manual.

6) What information is provided by UAL to flight crews regarding turbulence and thunderstorms?

Answer:
Basic weather is provided in the form of the computer generated Weather Briefing Message (WBM). Any text based forecasts of thunderstorms, turbulence (CAT/mountain wave), or tropical storms valid for the route of flight are included. These forecasts can consist of sigmets, convective sigmets, severe weather watch areas, and company issued turbulence forecasts. The WBM also includes all pireps/aireps of turbulence along the route of flight for the past three hours. All crews are also provided with some form of high level significant weather product, either in the form of an ICAO flight weather documentation package, Jeppesen fax product, or via WSI Pilotbrief. In addition, dispatchers append last minute thunderstorm/turbulence data to the flight plan release, as well as providing voice/ACARS uplink of current data to enroute flights.



7) Was the crew aware that isolated cumulonimbus activity was forecast from 155 degrees east longitude to 160 degrees east longitude with tops to FL 380 [noted in the Flight Release]? Was the seat belt sign on at 155 degrees east longitude? If not, why was the seat belt sign not on?

Answer:
As part of the flight planning process, the pilots did in fact review all weather products available to them and briefed both flight attendants and passengers on the possibility of turbulence along their flight path. Momentary light turbulence was encountered at 145E. Because of this light turbulence, the fasten seat belt signs was illuminated for approximately :15 minutes. The seat belt sign was turned off because the turbulence disappeared and conditions smoothed.

8) Was the crew aware that moderate turbulence was forecast beginning at about 158 degrees east longitude from 33,000 feet to 40,000 feet [Significant Weather Prog attached to Flight Release valid 1200Z 12/28]? Was the seat belt sign on at this location? If not, why was the seat belt sign not on?

Answer:
As part of the flight planning process, the pilots did in fact review all weather products available to them and briefed both flight attendants and passengers on the possibility of turbulence along their flight path. The turbulence "event" occurred prior to 158E at 157-27E (agreed to location of the event). The seat belt sign was on for passengers approximately two minutes" prior to the event.

9) Was the crew aware of a forecast for moderate turbulence in the vicinity of 145 degrees east longitude from FL 280 to FL 380 [noted in Flight Release]? Was the seat belt sign on at this location? If the seat belt sign was not on why was it not on?

Answer: As part of the flight planning process, the pilots did in fact, review all weather products available to them and briefed both flight attendants and passengers on the possibility of turbulence along their flight path. Momentary light turbulence was encountered at 145E. Because of this light turbulence, the fasten seat belt signs was illuminated for approximately :15 minutes. The seat belt sign was turned off because the turbulence disappeared and conditions smoothed.

10) What turbulence forecasting techniques do UAL meteorologists use? What weather information do UAL meteorologists use in generating products? Where does the weather information come from? What prompted issuance of the forecast for cumulonimbus activity and turbulence noted in questions 7 and 9? What prompted issuance of the forecast for moderate turbulence in the vicinity of 160 degrees east longitude to 170 degrees east longitude from FL 310 to FL 400 [noted in Flight Release]?

Answer:
- UAL meteorologists use standard turbulence pattern recognition techniques that have been developed over the past 30 years and are used on an industry-wide

basis. This includes in-house developed CAT and mountain wave techniques that have been adopted by many other organizations, including the NWS and USAF.

- UAL meteorologists have at their disposal a full range of meteorological data sets including: All Family of Service alpha-numeric data including HRS, drops on two FAA weather circuits, all NEXRAD data including composites and single site from two sources - UNISYS and WSI, direct readout earth stations for GOES8 and GOES9, a dedicated earth station in Hawaii for direct readout of GMS, vendor provided METEOSAT data, lightning strike data, and all NWS DIFAX products. All of these data sets are integrated on high power UNIX based work stations. In addition, this information is supplemented by UAL automated ACARS weather downlink data. UAL ACARS provides approximately 12,000 daily reports of winds, temperatures, and peak vertical acceleration (turbulence).
- Finally, all meteorologists have INTERNET access at their workstations, thus providing access to all weather related sites.
- Data sources are as indicated above - vendors (UNISYS, WSI, Alden, GAI), government, direct satellite readout, aircraft, and Internet.
- The forecasts referenced in questions 7 and 9 came from the monitoring of real time GMS satellite data, pireps/aireps, and high level significant weather progs.

11) What weather products do UAL meteorologists issue related to turbulence and thunderstorms? How are these products disseminated?

Answer:

- Routine forecasts of CAT/mountain wave are issued for the U.S. and eastern Pacific. Thunderstorm forecasts are provided for the U.S., eastern Pacific, and for all routes affected by thunderstorms generated by organized tropical storms. Verbal briefings regarding turbulence reports, shears, significant thunderstorms, etc., are provided to dispatchers on a routine basis.
- Forecast products are provided in text based format via the WBM and the mainframe data base. The same products are provided in graphic format to all dispatchers and operations control personnel via an operational PC LAN.

Sincerely,

Jeff Plantz
Flight Safety

82

TURBULENCE

Turbulence can be encountered from a variety of sources. Turbulence Intensity Criteria apply to all sources of turbulence.

Turbulence Associated With Thunderstorms Turbulence and windshear within thunderstorms, or in the vicinity of thunderstorm tops and wakes, downbursts, and gust fronts.

Clear Air Turbulence Occurs in the free atmosphere away from visible convective activity. CAT includes high-level frontal and jet stream turbulence and strong vertical windshears.

Mountain Wave Turbulence Produced in connection with mountain lee waves. It may include high amplitude mountain waves, rotors, turbulence in highly sheared layers near the tropopause and near the surface.

SEVERE TURBULENCE Do not intentionally conduct flight through areas of known severe turbulence. If the weather forecast for the route of flight is for "occasionally severe" turbulence, be alert for PIREPs and other indications of the actual level of turbulence present. If informed of the presence of severe turbulence, take the following action:

- In the vicinity of the departure airport, seek departure routing that avoids the turbulent area, if possible, or delay departure until conditions improve.
- En route, change altitude and / or route in order to avoid the reported area.
- In the vicinity of the destination airport, seek descent and approach to avoid the reported area. If avoidance is doubtful, consider holding until the situation improves (PIREPs, LLWAS, TDWR, etc.) or consider diversion.

TURBULENCE ENCOUNTERS A radio report is required by FAR when severe turbulence is encountered. A logbook entry is also required. UA policy requires that turbulence of moderate or greater intensity be reported as soon as possible via Acars or radio (refer to REQUIRED REPORTS in the EMERGENCY / IRREGULAR chapter). When the report is received, CHIDD informs the following:

- Other flights providing information on alternative altitudes and/or routes.
- In the event of severe or greater turbulence, Maintenance at the arrival station. This provides the planner an opportunity to position inspection personnel. The aircraft must be inspected after severe turbulence is encountered.
- In the event of severe or greater turbulence, System Operations Control. This provides the controller an opportunity to adjust aircraft routing regarding inspection requirements.

CABIN NOTIFICATION OF TURBULENCE

Expected Turbulence When turbulence is anticipated, turn on the Fasten Seat Belt sign and make a PA announcement. Give the Flight Attendants an estimate via interphone (such as within two minutes) of when the turbulence will be encountered to permit them to tie down serving carts and stow other loose items before taking their seats.

Unexpected Turbulence If turbulence is encountered unexpectedly, cycle the fasten seat belt sign off and on three or four times and make a PA announcement advising the passengers and flight attendants to be seated immediately. The chime associated with the Fasten Seat Belt sign will provide added emphasis to the passengers and flight attendants. Flight Attendants will advise the flight deck of any injury or damage due to turbulence.

TURBULENCE DURATION CRITERIA

Occasional less than 1/3 of the time.

Intermittent 1/3 to 2/3.

Continuous More than 2/3

Note: Turbulence not associated with convective clouds should be reported as CAT or as turbulence associated with mountain wave.

<table>
<tr><th colspan="4">TURBULENCE INTENSITY CRITERIA</th></tr>
<tr><th>Condition / ACARS Code</th><th>Airplane Reaction</th><th>Cabin Reaction</th><th>Crew Actions</th></tr>
<tr><td>Light Chop
1</td><td>No appreciable changes in altitude or attitude. Slight, rapid and somewhat rhythmic bumpiness occurs.</td><td>Occupants may feel a slight strain against seat belts. Unsecured objects remain stable. Coffee is shaking slightly but not splashing out of cup. No difficulty in walking.</td><td rowspan="2">Captain
• Seat belt signs on at Captain's option.
• PA made instructing passengers to be seated.
Flight Attendants
• Language Qualified Flight Attendant (LQFA), if on board, translates flight deck safety announcement.
• Verify passenger seat belts fastened, bassinets unoccupied, and infant/child secure in approved seat.
• Secure unattended carts on tiedowns; secure loose cabin, galley, and SC items.
• Verify lavatories unoccupied.
• Continue service with caution. Be aware that service may need to be modified or discontinued depending on intensity and duration of turbulence.
• Seat belts may be required for all flight attendants.</td></tr>
<tr><td>Light Turbulence
2</td><td>Momentary, slight, erratic changes in altitude and/or attitude occur.</td><td>Walking and cart maneuvering may be difficult. Coffee is shaking but not splashing out of cup.</td></tr>
</table>

TURBULENCE INTENSITY CRITERIA (Cont.)

Condition / ACARS Code	Airplane Reaction	Cabin Reaction	Crew Actions
Moderate Chop 3	Rapid bumps or jolts without appreciable changes in altitude or attitude.	Occupants feel definite strain against seat belt. Unsecured objects move about. Coffee is splashing out of cup. Very difficult to walk and maneuver carts.	**Captain** • Seat belt signs must be on. • PA made instructing passengers and flight attendants to be seated. **Flight Attendants** • Discontinue service. • Set cart brakes but leave cart in its present location. • Cover coffee pots/wine bottles or place on floor. • Sit down in nearest passenger seat or jumpseat. If seat is unavailable, sit on floor and hold on. • If possible, Language Qualified Flight Attendant translates safety announcement.
Moderate Turbulence 4	Changes in altitude or attitude occur, airspeed fluctuations occur, but the airplane remains in positive control.		
Severe Turbulence 5 Intentional Flight Prohibited	Large, abrupt changes in altitude/attitude occur. Usually large airspeed fluctuations occur. Airplane may be momentarily out of control. Maintenance writeup and airplane inspection required.	Occupants forced violently against seat belts. Unsecured objects tossed about or lifted from the floor. Walking is impossible as is standing without holding on to something for support.	**Captain** • Seat belt signs must be on. • PA made instructing passengers and flight attendants to be seated. • Inspect cabin after experiencing severe or extreme turbulence. **Flight Attendants** • Discontinue service. • Sit down and hold on. If seat is unavailable, sit down on floor. • If flight deck is unable to make PA, command passengers to sit down and fasten seat belts. • If possible, Language Qualified Flight Attendant translates safety announcement.
Extreme Turbulence 6 Intentional Flight Prohibited	Airplane tossed violently about; practically impossible to control. May cause structural damage. Maintenance writeup and airplane inspection required.		

89

PUBLIC ADDRESS ANNOUNCEMENTS

PUBLIC RELATIONS POLICY The degree of customer service we offer adds value to our product, and the more value we offer, the more passengers we will carry. As a pilot, you can use the PA system as a customer service tool to enhance safety and leave positive impressions with our customers. A pleasant, accurate, well-timed PA announcement is an effective and well-received method of communicating to our customers that we care about their safety, comfort and schedule. When making PA announcements to passengers, cockpit crewmembers should identify themselves as Captain, First Officer or Second Officer.

Outside the cockpit, you can also communicate that we care about our customers through face-to-face communication. Greet passengers when passing through the boarding area and stand at the cockpit door while passengers deplane. When in the terminal and time permits, answer questions, give directions, and offer assistance. When possible, greet passengers and introduce yourself. In the eyes of our passengers, you are more than a pilot - you are United Airlines.

There are three types of PA announcements: (1) mandatory, as required by the FAR's, (2) mandatory, as required by United policy, and (3) standard announcements, which are preferred as a matter of United policy. It is also United's policy that at no time should the use of the PA system detract in any way from the safety of the flight or any operational duty. While there is also no requirement that any announcement be made verbatim, the thrust of each announcement and the situation under which it is made should be essentially the same.

DEPARTURE DELAY NOTIFICATION After advising the First Flight Attendant, the Captain is responsible for making timely and appropriate delay announcements to customers onboard the aircraft. The Captain will make initial contact with the CSR working the flight at the podium to determine if there is any known delay. If there is a known delay, the Captain will contact the Zone Controller or Station Agent to determine the details. Both the Captain and the CSR will then coordinate their information so that any delay given to the customers in the boarding area will mirror that of any delay information given to customers onboard the aircraft by the Captain. If there is no known delay, the Captain should proceed onboard the aircraft for normal duties.

Once onboard the aircraft, if the Captain notices any problem or activity which would cause a delay, or if any information (ATC, weather, etc.) is communicated to the flight which could conceivably cause a delay, the Captain should immediately relay that information to the Zone Controller or Station Agent. If a delay of limited and known duration occurs, this will be communicated directly to the Captain via ACARS, e.g., "BAGS 10." If a delay occurs which has the potential to be lengthy or is poorly defined, such as a mechanical problem, a voice contact is essential. The Captain will be contacted via ACARS, e.g., "CALL ZONE", or by VHF radio.

The Captain should then communicate to the passengers the reason for the delay and its duration, as well as when the flight is expected to leave or when to expect further information. If there isn't sufficient information to provide a well-defined explanation, the Captain should tell the passengers what is known at that moment. During irregular operations the Captain should keep passengers informed at least every 10 minutes. Irregular announcements and departure delay notification should be handled by the Captain rather than by the CSR. The Captain may assign these departure delay announcement duties to another cockpit crewmember.

If the pilots are not on board the aircraft, due to irregular operations, the CSR will make the announcements. It is also a United policy that, during the door close-out announcement, the CSR apologize for those things requiring an apology, after which cabin and cockpit crewmembers should not apologize further. While it is appropriate to express empathy, sympathy, regret, etc., it is important to let the passengers know that 1) our number one interest is safety, 2) we care about people, and 3) we will do all we can to get to the destination in the scheduled time or better. The sample announcements are designed to do just that.

SAMPLE PUBLIC ADDRESS ANNOUNCEMENTS Examples of required and other standard announcements are provided below. From time to time, ask Flight Attendants how well the announcements are received. It is easier to improve when you receive feedback on your performance.

ANNOUNCEMENT LIMITATIONS During critical phases of flight, limit announcements to those required only for the safe operation of the airplane. Sterile Cockpit Procedures (refer to STERILE COCKPIT, under FLIGHT OPERATION in this section) outlines these limitations. The announcements appropriate for critical phases of flight are listed under REQUIRED PA ANNOUNCEMENTS, in this section.

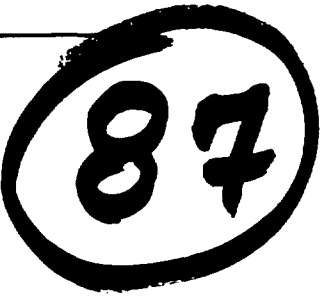
- Avoid airline abbreviations, acronyms, jargon, and detailed explanations of procedures or duties.
- Limit use of PA during periods when passengers are asleep or watching video presentations.
- Exclude the flight attendant rest area in the tail of the 747-400 when making general PA announcements during cruise. Use code #46 on the interphone control panel.
- ATC communications or commercial radio broadcasts may be connected to the appropriate channel of the passenger entertainment system, or, if duties permit, listen to the program and relay pertinent information to passengers using the PA system.

REQUIRED PA ANNOUNCEMENTS

Note: On DC-10-30F freighter, couriers must receive all announcements required for Flight Attendants and passengers.

Prior To Takeoff This announcement must be made at least two minutes prior to takeoff. Flight attendants must notify the cockpit if they are unable to comply. If the flight attendants cannot complete their preparations in the time remaining, the First Flight Attendant will notify the cockpit and the Captain will delay the takeoff until he is assured that all is in readiness for takeoff.

"Flight attendants, prepare for takeoff." - This must be a stand-alone announcement not combined with any other PA announcement. Flight attendants are trained to listen for precisely these words.



Prior To Landing At least five minutes prior to landing:

"Flight Attendants, prepare for landing." - This must be a stand-alone announcement not combined with any other PA announcement. Flight attendants are trained to listen for precisely these words.

On flights of six hours or more, the cockpit will coordinate with the First Flight Attendant / Chief Purser if more than five minutes' notification time is needed.

Fasten Seat Belt Off Make this announcement in conjunction with turning the seat belt sign off the first time after takeoff.

"Ladies and gentlemen, this is Captain (First Officer or Second Officer) _____. We have turned off the seat belt sign; however, we sometimes encounter bumpy air, so for your safety, keep your seat belt fastened at all times while seated." (Optional) "In keeping with our excellent on-time record, we expect an on-time arrival today in _____ (station) at _____ (time)."

Fasten Seat Belt On Any time the fasten seat belt sign is turned on during flight, an announcement will be made. If at all possible, give at least a 10 minute warning.

Anticipated Turbulence "Ladies and gentlemen, this is Captain (First Officer or Second Officer). We have reports from other flights that are experiencing some bumpy air ahead. Because of this, we are turning on the fasten seat belt sign in about _____ minutes. If you need to get up, now would be a good time to do so."

Turbulence "Ladies and gentlemen, this is Captain (First Officer or Second Officer) _____. We have reports from other flights that are experiencing some bumpy air ahead. Because of this, we are turning on the fasten seat belt sign and ask that for your safety everyone return to their seats and fasten their seat belts." If applicable, "This also requires that flight attendants be seated. We will turn the seat belt sign off just as soon as we return to smoother flight conditions, thank you."

Note: Flight Attendants must be given a time element (such as within 2 minutes) via intercom when asking them to be seated under these conditions. Exclude this announcement from the flight attendant rest area in the tail of the B-747-400. Use code #46 on the interphone control panel.

Preparation For Landing "Ladies and Gentlemen, this is Captain (First Officer or Second Officer) _____. In about 10 minutes we will be turning on the fasten seat belt sign for our final descent and landing. If you need to get up, now would be a good time to do so." Then, follow with "Ladies and gentlemen, this is Captain (First Officer or Second Officer) _____ again. In preparation for landing, the fasten seat belt sign has been turned on. We ask that you return to your seats and fasten your seat belts securely. Thank you."

Reinforcing the Seat Belt Sign There are occasions when the seat belt sign is on and passengers ignore it. FAR's require compliance. When a flight attendant informs you that the seat belt sign is being ignored, an announcement form the cockpit should be made to ensure safety.

During Taxi "Ladies and gentlemen, this is Captain (First Officer or Second Officer) _____. The seat belt sign is on, which requires all passengers to be seated with their seat belts fastened. This is an FAA requirement and is for your safety. Anyone moving about the cabin must immediately return to their seats and fasten their seat belts."

Enroute "Ladies and gentlemen, this is Captain (First Officer or Second Officer) _____. The seat belt sign is on, which means all passengers must be seated with their seat belts fastened. We have/expect to encounter(ed) some bumpy air which could increase at any moment and possibly cause people standing or walking to lose their balance. Anyone moving about the cabin must immediately return to their seats and fasten their seat belts. This is an FAA requirement and is for your safety."

88

Unexpected Turbulence In the case of unexpected turbulence encounters, a PA announcement should be made warning the passengers and flight attendants to be seated. The Captain should contact the First Flight Attendant by interphone. After being seated, the First Flight Attendant may reinforce the cockpit call by making a PA announcement to the passengers to be sure their seat belts are fastened.

Smoking and Ventilation Problems "Ladies and gentlemen, this is Captain (First Officer or Second Officer) _____. We are presently experiencing some cabin ventilation problems. Federal Regulations require that we provide a non-smoking environment for non-smokers and it is necessary to turn on the no-smoking sign at this time. For the safety and comfort of everyone, we ask passengers seated in the smoking section to refrain from smoking. As soon as conditions permit, we will turn the no smoking sign off.

STANDARD PA ANNOUNCEMENTS - ROUTINE OPERATIONS This list of announcements represents the type of information Marketing has determined that most passengers would like to hear from the cockpit. On short range, multi-leg flights, these announcements should be shortened (a B-737 Captain's "welcome aboard" announcement when going from CID to OMA would be shorter than a B-747 announcement from JFK to NRT, yet a welcome aboard from the Captain is appropriate for both). On airplanes with no Second Officer, the First Officer may make the announcements.

Welcome Aboard "Good morning (afternoon, evening), ladies and gentlemen, I'm Captain (First Officer or Second Officer) _____ and I would like to welcome you aboard. We are pleased to have you fly with us today, and we'll do everything possible to make this a pleasant flight. We'll be pushing back for an on time departure (if appropriate) in just a few minutes and taxiing to the runway. You can help by taking your seat as soon as possible since we can't move the airplane until all passengers are seated with their seat belts fastened. We will make Air Traffic Control communications available on channel #_____ of the passenger entertainment system (if appropriate). For those of you without headsets at the moment, they will be made available during our climbout. We invite you to enjoy the fine service of our professional flight attendants. We're going to have a great flight."

Welcome Aboard (More Than 15 Minutes Behind Schedule) "Good morning (afternoon, evening), ladies and gentlemen, I'm Captain (First Officer or Second Officer) _____ and I would like to welcome you aboard. We are pleased to have you fly with us today, and we'll do everything possible to make this a pleasant flight. We'll be departing today at _____ (time), and you can help us to depart more quickly by taking your seat as soon as possible since we can't move the airplane until all passengers are seated with their seat belts fastened. I would like to assure you that my entire crew and I will do everything we can to get you to _____ (destination) as soon as possible. We will make Air Traffic Control communications available on channel #_____ of the passenger entertainment system (if appropriate). We will be underway in just a few minutes, and we invite you to enjoy the fine service of our professional flight attendants."

Note: Long range flights having an extra crewmember should add a sentence that says, "Since this is a long range flight, we have an extra crewmember on board. If you see a uniformed cockpit crewmember in the passenger area, don't be concerned. We will have a full crew in the cockpit at all times."

Pre-Takeoff Example listed under REQUIRED PA ANNOUNCEMENTS.

Fasten Seat Belt Example listed under REQUIRED PA ANNOUNCEMENTS.

Flight Information These announcements must comply with Sterile Cockpit procedures. "Ladies and gentlemen, this is Captain (First Officer or Second Officer) _____. Our planned flight time to ____ (station) is _____ (time). We'll be cruising at an altitude of ___ thousand feet and a few points of interest we'll be passing over are _____. We are planning an on-time arrival at _____ (location) at _____ (time). We will do everything possible to make your flight comfortable."

Progress Report

When Delayed and Behind Schedule "Ladies and gentlemen, this is Captain (First Officer or Second Officer) _____ with a progress report. _____ (landmark) is to our right. We are right on our computer flight plan (or ahead of computer plan) and still estimating arrival at _____ (station) at ____ (previously given ETA). We trust you are enjoying the flight."

When Planning On Time Arrival or Within 15 Minutes "Ladies and gentlemen, this is Captain (First Officer or Second Officer) _____ with a progress report. _____ (landmark) is to our right. We are still planning an on-time arrival at _____ and we trust you are enjoying the flight."

Preparation For Descent "Ladies and gentlemen, this is Captain (First Officer or Second Officer) _____. In a few minutes I'll be turning on the Fasten Seat Belt sign, as we will start our descent into _____ (station) (if appropriate). The weather in ____ (station) is _____. We are estimating our arrival (use "on-time," if appropriate) at _____ (time). We hope you have enjoyed the flight as much as we have flying it for you."

Preparation For Descent (When 15 Minutes Or More Behind Scheduled Time) "Ladies and gentlemen, this is Captain (First Officer or Second Officer) _____. We plan to arrive at _____ (location) at _____(time). In a few minutes, I'll be turning on the Fasten Seat Belt sign, as we will start our descent into _____ (station) (if appropriate). The weather in _____ (station) is _____. We hope you have enjoyed the flight as much as we have flying it for you."

Moderate Turbulence Example listed under REQUIRED PA ANNOUNCEMENTS.

Ventilation Problems Example listed under REQUIRED PA ANNOUNCEMENTS.

No Smoking Sign The NO SMOKING sign is to be used only to indicate no smoking. It is not a signal for flight attendants to begin service after takeoff or to take their seats. Leave the NO SMOKING sign ON for the entire flight.

Passengers Up When Seat Belt Sign Is On Example listed under REQUIRED PA ANNOUNCEMENTS.

Parallel Approaches (When landing at CLE, DEN, DFW, LAX, SEA, SFO, etc.). This announcement has been coordinated with United's FAA Principal Operations Inspector and can be given when below 10,000'. "Ladies and gentlemen, this is Captain (First Officer or Second Officer) _____. When we land at _____ (station) we will be making what is known as a parallel approach. This means that you might see another airplane from 400' to 1,000' away which will be landing on a runway parallel to ours. This is a normal landing procedure for landing at _____ (station) and is no need for concern."

Missed Approach (Give as soon as possible after executing the miss, work load permitting. This announcement is not a violation of sterile cockpit procedures and may be made below 10,000 feet.) "Ladies and gentlemen, this is Captain (First Officer or Second Officer) _____. As you can hear and feel, we have added power and elected to discontinue our approach because _____. Everything is normal and under control even though we realize that it may have come as a surprise to you. We will be landing in approximately _____ minutes" OR "We are proceeding to our alternate and we'll give you further details in a few minutes."

PA ANNOUNCEMENTS - IRREGULAR OPERATIONS United's policy is stated under PUBLIC RELATIONS POLICY above. Irregular operations announcements should be made by the Captain. However, the Captain may designate other crewmembers as the situation requires. In order to comply with Sterile Cockpit procedures, Irregular Operations announcements must be made on the ground when the airplane is parked with the parking brake set, or in the air above 10,000'. Those announcements which are made in conjunction with an emergency and which contribute to the safe operation of the airplane may be made at any time regardless of altitude or the airplane being parked.

When at the gate, if the Customer Service Representative is not present, the cockpit crew should be proactive and contact the station control center by radio or telephone, make an inquiry through Acars (refer to ACARS under ESTIMATED DEPARTURE in the ACARS chapter), or investigate using any means available in order to keep passengers updated as to the state of the delay. Passengers will invariably have a more positive state of mind if they receive timely, accurate information from a cockpit crew that seems sincerely concerned about them, their safety, and getting to their destination as rapidly as possible.

Engine Torching During Start "Ladies and Gentlemen, we have just been informed by the ground crew that some fuel which had pooled in the engine torched off during engine start. While engine torching can certainly be spectacular in appearance, it is not dangerous and we ask that you treat the incident calmly.

CABIN SAFETY ANNOUNCEMENTS
On ferry and training flights to which no Flight Attendants are assigned, it is the Second Officer's responsibility (First Officer on two-pilot crews) to make the following announcement:

Prior to Takeoff "Ladies and Gentlemen, this is (First Officer or Second Officer) _____, please direct your attention to the Safety Information card located in the seat pocket in front of you and follow along as I cover the important safety features of this _____ airplane."

Carry-on Baggage "Ensure that all carry-on items are securely stored either under the seat in front of you or in the overhead bins."

Exits "If you are sitting in an exit row, you will be required to assist the crew in an emergency. If you are unable to perform the functions described in the front of the safety Information card, please advise the crew at the end of this announcement."

"Locate the two emergency exits nearest your seat. In some cases they may be behind you. If evacuation is necessary, floor lighting will automatically illuminate to guide you to an exit."

91

Flotation (Overwater Equipped) "This airplane is equipped with life vests which may be found under, between or beside your seat and is identified by a red strap. Follow the instructions shown on the Safety Information card."

Flotation (Domestic) "This airplane is equipped with floatable seat cushions. Follow the instructions shown on the Safety Information card."

Oxygen "If needed, an oxygen mask will drop from the compartment above your seat. (On smoking flights, extinguish your cigarettes when you see the mask.) Place the mask over your nose and mouth and tighten the straps as necessary. The flight crew will advise you when the mask is no longer needed."

Seatbelts, Seatbacks, Tray Tables "For takeoff (landing), fasten you seatbelt tightly across your lap, place your seatback in the full upright position and lock your tray tables in place."

Missed Approach (Give as soon as possible after executing the miss, work load permitting. This announcement is not a violation of sterile cockpit procedures and may be made below 10,000 feet.) "Ladies and gentlemen, this is Captain (First Officer or Second Officer) _____. As you can hear and feel, we have added power and elected to discontinue our approach because _____. Everything is normal and under control even though we realize that it may have come as a surprise to you. We will be landing in approximately _____ minutes" OR "We are proceeding to our alternate and we'll give you further details in a few minutes."

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CABIN SAFETY ANNOUNCEMENTS On ferry and training flights to which no Flight Attendants are assigned, it is the Second Officer's responsibility (First Officer on two-pilot crews) to make the following announcement:

Prior to Takeoff "Ladies and Gentlemen, this is (First Officer or Second Officer) _____, please direct your attention to the Safety Information card located in the seat pocket in front of you and follow along as I cover the important safety features of this _____ airplane."

Carry-on Baggage "Ensure that all carry-on items are securely stored either under the seat in front of you or in the overhead bins."

Exits "If you are sitting in an exit row, you will be required to assist the crew in an emergency. If you are unable to perform the functions described in the front of the safety Information card, please advise the crew at the end of this announcement."

"Locate the two emergency exits nearest your seat. In some cases they may be behind you. If evacuation is necessary, floor lighting will automatically illuminate to guide you to an exit."

93

Flotation (Overwater Equipped) "This airplane is equipped with life vests which may be found under, between or beside your seat and is identified by a red strap. Follow the instructions shown on the Safety Information card."

Flotation (Domestic) "This airplane is equipped with floatable seat cushions. Follow the instructions shown on the Safety Information card."

Oxygen "If needed, an oxygen mask will drop from the compartment above your seat. (On smoking flights, extinguish your cigarettes when you see the mask.) Place the mask over your nose and mouth and tighten the straps as necessary. The flight crew will advise you when the mask is no longer needed."

Seatbelts, Seatbacks, Tray Tables "For takeoff (landing), fasten you seatbelt tightly across your lap, place your seatback in the full upright position and lock your tray tables in place."

ATTACHMENT C-1:

NATIONAL TRANSPORTATION SAFETY BOARD
Office of Aviation Safety
Washington D.C. 20594

In order to assist us in the investigation of the accident involving United Airlines Flight 826, that occurred on December 28, 1997 at about latitude 32:30 north and longitude 159.00 east at about 1410Z, please provide written answers to the following questions:

1) What office or agency issues SIGMETs for the Tokyo FIR?

2) What are the criteria for issuance of SIGMETs?

3) Why were SIGMETs 3 and 4 for moderate to severe turbulence issued? What reports and/or meteorological analyses prompted issuance of these SIGMETs?

4) How were these SIGMETs disseminated?

5) Why were there no SIGMETs in effect for the time and location of the accident?

6) Were turbulence reports received in the area covered by SIGMETs 3 and 4? What and when were these reports received [please provide reports]?

7) Were turbulence reports received in the area of the accident during the time frame 1300Z to 1500Z? What and when were these reports received [please provide reports]?

8) Did you receive a severe turbulence report from UAL 826? When and how did you receive this report? What actions did you take when you received this report?

9) What techniques are used to forecast turbulence in the Tokyo FIR?

Thank you in advance for your reply.

[redacted]

Gregory D. Salottolo
National Resource Specialist
Meteorology
January 6, 1998
Phone: [redacted]
FAX: 202.314.6339
e-mail: [redacted]

95

ATTACHMENT C-2: Meteorological Information (Answers to the Questionnaire from NTSB NRSM)

This papers were prepared by the AAIC of Japan in cooperation with related organizations to answer the questions from above mentioned body on faximile message dated on January 6, 1998 attached from Mr. Robert Benzon NTSB major investigation Div. of the official faximile letter.

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(1) What office or agency issues SIGMETs for the Tokyo FIR?

The New Tokyo Aviation Weather Service Center (New Tokyo AWSC) of the Japan Meteorological Agency (JMA) is responsible to issue SIGMET information for the Tokyo FIR.

(2) What are the criteria for issuance of SIGMETs?

New Tokyo AWSC issues SIGMET information concerning turbulence, thunderstorms, tropical cyclones, icing and volcanic ash for the area above around 8000 m in the Tokyo FIR in the following cases:

(a) SIGMET information for turbulence is issued when
an aircraft observation of severe turbulence is reported and the phenomenon is expected to continue; or
the occurrence of severe turbulence is expected by examining weather charts, Geostationary Meteorological Satellite(GMS) cloud imagery, etc.

(b) SIGMET information for turbulence is issued when a cluster of cumulonimbus clouds covers more than around a square of 100 km × 100 km.

(c) SIGMET information for thunderstorms is issued when a cluster of cumulonimbus clouds covers more than around a square of 200 km × 200 km.
SIGMETs for thunderstorms do not include references to associated turbulence.

(3) Why were SIGMETs 3 and 4 for moderate to severe turbulence issued? What reports and/or meteorological analyses prompted issuance of the SIGMETs?

Messages of SIGMET 3 and 4 were issued since the occurrence of severe turbulence was expected by examining weather charts, GMS cloud imagery, etc. Considering limitation of the forecast techniques on turbulence, these messages were described as moderate to severe

96

turbulence.

In both cases, no observations of severe turbulence were reported from aircraft. Details are as follows:

- *By examining weather charts at 0000UTC on 28 December, a developing low was observed at 33° N, 150° E and moving toward the east–northeast. Numerical Weather Prediction (NWP) guidance for turbulence valid at 1200UTC on 28 December indicated an area of strong vertical wind shear suggesting the occurrence of turbulence over around the developing low.*

- *On GMS cloud imagery, a distinct cirrus streak corresponding to a secondary jet stream was observed in the west edge of a cloud area associated with the developing low at 0000UTC on 28 December and thereafter. Besides, a dark area suggesting the existence of a stable layer was recognized adjacent to the cirrus streak on GMS water vapor imagery.*

- *It is generally known that an area of strong vertical wind shear exists in a stable layer along a jet stream to the north of a developing low, and severe turbulence is expected to occur in such an area. Therefore New Tokyo AWSC judged that severe turbulence was expected around the cirrus streak and issued the messages of SIGMET 3 and 4 concerning moderate to severe turbulence for the area surrounding the cirrus streak.*

(4) How were these SIGMETs disseminated?

The messages of SIGMET 3 and 4 were disseminated :

- *to Meteorological Watch Offices (MWOs) in the ICAO Asia and Pacific Regions, World Area Forecast Center (WAFC) Washington, neighboring Regional Area Forecast Centers (RAFCs) in accordance with the regional Air Navigation Plan;*

- *to Common Aeronautical Data Interchange Network (CADIN) of the Japan Civil Aviation Bureau (JCAB) via the exclusive communication line; and*

- *to some airlines on an on–line basis (see note).*

(5) Why were there no SIGMETs in effect for the time and location of the accident?

By examining weather charts, GMS cloud imagery etc., no occurrence of severe Clear Air Turbulence (CAT) was expected around 32° 30' N, 159° E at nearly 1400UTC on 28 December. Although a cluster of cumulonimbus clouds was observed around [redacted] scale

97

was small and it was not expected to develop into a large–scale cluster of cumulonimbus clouds. No SIGMET information, therefore, was issued.

(6) Were turbulence reports received in the area covered by SIGMETs 3 and 4? What and when were these reports received [please provide reports]?

Following reports for turbulence besides temperature and wind were received by Tokyo Radio as Routine Air–Reports from aircraft's which passed the area of SIGMET 3 and 4.
In each reports, time indicates when the aircraft passed 39° N and 160° E.

(a) 0911UTC NWA26 39N160E F310 CODE 3(LIGHT, OCCASIONAL MODERATE TURBULENCE)

(b) 1109UTC UAL818 39N160E F310 LIGHT TURBULENCE

(7) Were turbulence reports received in the area of the accident during the time frame 1300Z to 1500Z? What and when were these reports received [please provide reports]?

Following reports for turbulence besides temperature and wind were received by Tokyo Radio as Routine Air–Reports at 32° N and 160° E.
In each reports, time indicates when the aircraft passed 32° N and 160° E.

(a) 1312UTC NWA10 F350 CODE 0 (SMOOTH)

(b) 1339UTC NWA90 F350 CODE 1 (OCCASIONAL LIGHT)

(c) 1351UTC NWA22 F350 CODE 0 (SMOOTH)

(d) 1502UTC JAL72 F370 NO TURBULENCE

(8) Did you receive a severe turbulence report from UAL 826? When and how did you receive this report? What actions did you take when you received this report?

When Tokyo Radio has relayed ATC speed instructions to UAL826 at 1336UTC, they requested higher altitude due to encountering severe turbulence at 3231N15727E. Then Tokyo radio has relayed the ATC clearance for FL330 at 1344UTC.
Later at 1410UTC, UAL826 requested ATC clearance for returning to Narita, and UAL826 replied upon question from Tokyo Radio, that they had encountered severe turbulence and (have) numerous injuries on board, numerous passenger injuries.

98

Tokyo Radio asked UAL826 where did they encounter severe turbulence.
At 1434UTC, UAL826 answered that they were FL310 track12, approximetely 3230N158 to 159E. At 1436UTC, Tokyo Radio informed this information to UAL, Tokyo ACC(Area Control Center) and JMA as AIREP special. JMA disseminated this AIREP special to MWOs in the ICAO Asia and Pacific Regions, WAFC Washington, neighboring RAFCs, aviation weather offices of JMA and some airlines(see note) at around 1438 UTC on 28 December.

AIREP special is as follows that reporting by Tokyo Radio.
UAL826 SEV TURB AT F310 TR12 3230N159E

(9) What techniques are used to forecast turbulence in the Tokyo FIR?

Turbulence associated with cumulonimbus clouds and Clear Air Turbulence (CAT) are forecasted in the following manner:

(a) turbulence associated with cumulonimbus clouds is expected around developing cumulonimbus clouds. Forecasters find out an area of unstable atmospheric conditions with weather charts such as upper analysis charts and NWP upper prognostic charts.
Then, they watch GMS cloud imagery paying attention to the unstable area.

(b) CAT is expected in the area of strong vertical wind shear. Accordingly forecasters examine the atomospheric flow (jet stream etc.) and meteorological conditions (temperature distribution etc.) with weather charts, NWP guidance for turbulence, GMS cloud imagery and aircraft reports to estimate the area of strong vertical wind shear.

Note: This is an optional action for the airlines which have the necessary arrangements for the distribution of meteorological information including SIGMET messages and AIREP reports.
United Airlines has not requested to JMA for such arrangements.

99

NATIONAL TRANSPORTATION SAFETY BOARD
Office of Aviation Safety
Washington D.C. 20594

Atsuhiko Wataki (Mr.)
Deputy Chief Investigator
The Aircraft Accident Investigation Commission
Ministry of Transport
Telephone: [redacted]
Fax: +81 -3-3580-7973

Dear Sir:

Please provide the following additional information to assist us in the investigation of the accident involving United Airlines Flight 826, that occurred on December 28, 1997 at about latitude 32:31 north and longitude 157:27 east at about 1336Z.

According to a written statement from the Captain of Northwest Flight 80 [NWA 80], a B-747 enroute from NRT to HNL at FL 330, moderate to severe turbulence was encountered in the vicinity of 160 degrees east at about 1220Z on December 28, 1997. The Captain reported the encounter which lasted 2 to 3 minutes as Code 3 to 4. The captain stated that the turbulence was the "worst that I've ever encountered." This encounter was followed by 10 to 12 minutes of light to moderate turbulence.

Did you receive any reports from NWA 80? Did you receive this report? If you received this report what actions were taken? What actions would normally be taken given a report of moderate to severe turbulence (Code 3 to 4)? Would you expect such a report to be provided to Tokyo Radio?

Thank you in advance for your reply.

99A

Gregory D. Salottolo
National Resource Specialist
Meteorology
April 7, 1998
Phone: [redacted]
FAX: 202.314.6339
e-mail: [redacted]

1 of 1

AIRCRAFT ACCIDENT INVESTIGATION COMMISSION
MINISTRY OF TRANSPORT
2-1-3, Kasumigaseki, Chiyoda-ku
TOKYO 100-8989, JAPAN

[illegible]

[illegible] Division
[illegible] Safety Board
[illegible] Place East, S.W.
[illegible], D.C. 20594-2000
[illegible] +1-202-314-6319

[illegible]: NWA Flight 80 etc. in Relation to [illegible]
(Preliminary Information)

[illegible]

[illegible] received your facsimile [illegible] dated [illegible]
[illegible]aire from Mr. Gregory D. Salottolo was attach[illegible]
[illegible] understood your situation regarding public [illegible]
[illegible]ing NWA Flight 80, I conducted quic[illegible]
[illegible]ing record:

[illegible]WA80 32N160E 1229 F330 32N170E [illegible]
[illegible]E3 FUEL 129.5 REQ CMB F350 [illegible]

[illegible] now vacation season in Japan until [illegible]
[illegible]r answer to the questionnaire from Mr. [illegible]
[illegible] our best to answer that questionnaire [illegible]

[illegible] any [illegible]n or further request[illegible]

COPY

AIRCRAFT ACCIDENT INVESTIGATION COMMISSION
MINISTRY OF TRANSPORT
2-1-3, Kasumigaseki, Chiyoda-ku,
TOKYO 100, JAPAN

August 27, 1998

Mr. Robert Benzon
Investigator in Charge
Major Investigation Division
National Transportation Safety Board
490 L'Enfant Plaza East, S.W.
Washington, D.C. 20594-2000
Facsimile: +1-202-314-6319

Subject: NWA Flight 80 in Relation to the Accident Investigation on UAL 826 and some other information

Dear Sir:

This is in reply to your facsimile letter dated April 23, 1998 to which question from Mr.Gregory D. Salottolo was attached. In this connection, please refer to my letter addressed to you dated May 1, 1998.

As herewith attached, we prepared our answer to the question above. This answer was prepared by the AAIC of Japan based upon the written information from the Civil Aviation Bureau which correspond to the answer but was written mostly in Japanese.
We deeply apologize to you that it took long time until we arrange our answer to the question above.

Meanwhile, Mr. M. Kitazawa, former Investigator-General, moved to the Civil Aviation Bureau and I have succeeded him. I, however, still remain to be the Accredited Representative of the UAL 826 case, though Mr. T. Yabuki, Deputy Chief Investigator, was appointed as the "group chief" of the AAIC investigators engaged in the UAL 826 case.
Mr. T. Yabuki was also appointed as the Investigator- in- Charge of the UAL 801 case in place of me.

We expect that our answer this time will be helpful to you, and if you have further question of request, please feel free to contact us at any time.

Sincerely,

[redacted]

Astuhiko Wataki
Investigator-General
and Accredited Representative
AAIC of Japan

99D

Answer to the questions from the NTSB concerning weather conditions

(The questions were enclosed in the letter of April 23, 1998 which was sent by Mr. Robert Benzon, an investigator-in-charge of the accident involving the United Airlines Flight 826.)

Regarding your questions, the AAIC obtained the following information from Civil Aviation Bureau of Japan (JCAB).

Question 1. Did you receive any reports from NWA 80 ?

Answer : Appended herewith is a report received from NWA 80.

Question 2. Did you receive this report ?

Answer : The JCAB did not receive any of the following information on turbulence, which is referred in the NTSB questions, from NWA 80.

① Report on encountering a "Moderate to Severe Turbulence" at approximately 160 degrees east longitude at around 1220 UTC.

② Report on a subsequent "CODE3 TO 4" turbulence which seemed to have lasted for a couple of minutes.

③ Report on a "Light to Moderate Turbulence" which seemed to have lasted for 10 to 12 minutes.

However, the report on turbulence we received from NWA 80 is, as indicated in the appendix item 3, "encounter CODE 3', i.e. Light, Occasional Moderate Turbulence" with the position report at 32N160E FL330 1229UTC. Tokyo Radio notified Tokyo Area Control Center (ACC), Meteorological Agency and Northwest Airlines of this report.

According to the NWA Flight Operations Manual, "CODE 3" is defined as "Light, Occasional Moderate Turbulence", "CODE 4" is defined as "Moderate Turbulence" and "CODE 5" as "Moderate, Occasional Severe Turbulence".

Question 3. If you received this report what actions were taken ?

Question 4. What actions would normally be taken given a report of moderate to severe turbulence (Code 3 to 4) ?

Answer for Q3 and Q4 : If a report on turbulence categorized as "Light to Moderate Turbulence" is received, Tokyo Radio will notify the report to the related ACCs, Meteorological Agency, and an Airline which operates the aircraft which provided the report (the Airline) or a contracted company which provides operational services (the Contracted Company). If a report on turbulence categorized as "Moderate Turbulence", "Moderate to Severe Turbulence" or more severe level of turbulence, i.e. not less than "Moderate Turbulence", is received, the report will be notified as "AIREP SPECIAL" to the related aircraft following the aircraft which provided the report as well as the related ACCs, Meteorological Agency, and the Airline or the contracted company.

For example, if a report on "CODE 3" turbulence is received from NWA aircraft, Tokyo Radio will notify the related ACCs, Meteorological Agency, and Northwest Airlines of the report. If a report on "CODE 3 to 4", "CODE 4" or more

99E

severe level of turbulence is received, Tokyo Radio will notify the report as "AIREP SPECIAL" to the related aircraft following the NWA aircraft as well as the related ACCs, Meteorological Agency, and Northwest Airlines.

Question 5. Would you expect such a report to be provided to Tokyo Radio ?

Answer : If an aircraft encounters turbulence which is categorized as not less than "Moderate", the aircraft shall notify the related Air Traffic Services Units of the turbulence as "AIREP SPECIAL" in accordance with the ANNEX 3 (Meteorological Service for International Air Navigation) to the ICAO convention and the Procedures for Air Navigation Services / Rules of the Air and Air Traffic Services (PANS-RAC). Based on the above rule, the JCAB should be provided such a report from the aircraft.

99F

U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

Subject: ATMOSPHERIC TURBULENCE AVOIDANCE	Date: 9/9/97	AC No: 00-30B
	Initiated By: AFS-400	Change:

1. **PURPOSE.** This Advisory Circular (AC) describes to pilots, aircrew members, dispatchers, and other operations personnel the various types of clear air turbulence (CAT) and some of the weather patterns associated with it. ***Also included are "Rules of Thumb" for avoiding or minimizing CAT encounters. Appendix 1 provides a sample Atmospheric Hazards Advisory and Avoidance System that air carriers can tailor to their specific needs.***

2. **CANCELLATION.** AC 00-30A, Rules of Thumb for Avoiding or Minimizing Encounters With Clear Air Turbulence, dated November 21, 1988, is cancelled.

3. **RELATED READING MATERIAL.**

   a. AC 00-6A, Aviation Weather.

   b. AC 00-45, Aviation Weather Services (current edition).

   c. AC 61-23, Pilot's Handbook of Aeronautical Knowledge (current edition).

4. **BACKGROUND.**

   a. In 1966, a National Committee for Clear Air Turbulence officially defined CAT as "all turbulence in the free atmosphere of interest in aerospace operations that is not in or adjacent to visible convective activity (this includes turbulence found in cirrus clouds not in or adjacent to visible convective activity)." Over time, less formal definitions of CAT have evolved. The Aeronautical Information Manual expands the basic CAT definition as "turbulence encountered in air where no clouds are present." This term is commonly applied to higher altitude turbulence associated with windshear. Thus, clear air turbulence or CAT has been defined in several ways, but the most comprehensive definition is

100

"turbulence encountered outside of convective clouds." This includes turbulence in cirrus clouds, within and in the vicinity of standing lenticular clouds and, in some cases, in clear air in the vicinity of thunderstorms. Generally, though, CAT definitions exclude turbulence caused by thunderstorms, low-altitude temperature inversions, thermals, or local terrain features.

b. CAT was recognized as a problem with the advent of high altitude jet operations in the 1950's. CAT is especially troublesome because it is often encountered unexpectedly and frequently without visual clues to warn pilots of the hazard.

5. DISCUSSION.

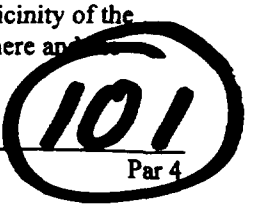
a. One of the principal areas where CAT is found is in the vicinity of the jetstreams. A jetstream is a river-like flow of high-altitude wind following the planetary atmospheric wave pattern, with speeds of 50 knots or greater. There are, in fact, three jetstreams: the polar front jetstream, the subtropical jetstream, and the polar night jetstream.

(1) The polar front jetstream, as it's name implies, is associated with the polar front or the division between the cold polar and warm tropical air masses. The mean latitude of the jetstream core varies from 25° north latitude during the winter months to 42° north latitude during the summer months. It is the center of the planetary wave pattern and as such meanders over a large portion of the hemisphere throughout the year, particularly during the winter months when it is most intense. Although the polar jetstream varies in altitude, the core is most commonly found around 30,000 feet and it is generally best depicted on the 300 millibar constant pressure map.

(2) The subtropical jetstream is a very persistent circumpolar jetstream found on the northern periphery of the tropical latitudes between 20° and 30° north latitude. It normally forms three waves around the globe with crests over the eastern coasts of Asia, North America and the Near East. Like the polar front jetstream, the subtropical jetstream is most active during the winter months and often intrudes well into the southeastern United States. It is generally higher than the polar front jetstream with the core between 35,000 and 45,000 feet.

(3) The polar night jetstream is found in the stratosphere in the vicinity of the Arctic Circle during the winter months and does not have a significant affect on air travel over the United States and southern Canada.

b. CAT associated with a jetstream is most commonly found in the vicinity of the tropopause (a very thin layer marking the boundary between the troposphere an



stratosphere) and upper air fronts. Analyses of the tropopause are issued by the National Weather Service on a scheduled basis. In the absence of other information, the tropopause will generally have a temperature of between -55°C. and -65°C. In some cases, it will be at the top of a cirrus cloud layer. Clouds are very seldom found above the tropopause in the dry stratosphere (a layer typified by relatively small changes in temperature with height except for a warming trend near the top), except in the summertime when occasionally large thunderstorms will poke through the tropopause and spread anvil clouds in the stratosphere. CAT is most frequently found on the poleward side of the jetstream (the left side facing downwind). It is additionally common in the vicinity of a jetstream maxima (an area of stronger winds that moves along the jetstream).

c. There are several patterns of upper-level winds that are associated with CAT. One of these is a deep, upper trough. The CAT is found most frequently at and just upwind of the base of the trough, particularly just downwind of an area of strong temperature advection. Another area of the trough in which to suspect CAT is along the centerline of a trough area where there is a strong horizontal windshear between the northerly and southerly flows. CAT is also found in the back side of a trough in the vicinity of a wind maxima as the maxima passes through.

d. One noteworthy generator of CAT is the confluence of two jetstreams. On occasion, the polar front jetstream will dip south and pass under the subtropical jetstream. The windshear effect of the jetstream between the two jetstreams in the zone of confluence and immediately downstream is often highly turbulent.

e. CAT is very difficult to predict accurately, due in part to the fact that CAT is spotty in both dimensions and time. Common dimensions of a turbulent area associated with a jetstream are on the order of 100 to 300 miles long, elongated in the direction of the wind, 50 to 100 miles wide, and 5,000 feet deep. These areas may persist from 30 minutes to a day. In spite of the difficulty forecasting CAT, there are forecasting rules that have been developed to identify those areas where CAT formation is likely.

f. The threshold windspeed in the jetstream for CAT is generally considered to be 110 knots. Windspeed in jetstreams can be much stronger than 110 knots and the probability of encountering CAT increases proportionally with the windspeed and the windshear it generates. It is not the windspeed itself that causes CAT; it is the windshear or difference in windspeed from one level or point to another that causes the wave motion or overturning in the atmosphere that is turbulence to an aircraft. Windshear occurs in all directions, but for convenience it is measured along vertical and horizontal axes, thus becoming horizontal and vertical windshear. Moderate CAT is considered likely when the vertical windshear is 5 knots per 1,000 feet, or greater, and/or the horizontal windshear is 40 knots per 150 miles or greater.

102

g. Depictions of the upper air structure, discussed in paragraphs 5c-f, are found in AC 00-6A, chapter 13.

h. The majority of the following guidelines were developed initially by the International Civil Aviation Organization's (ICAO) Sixth Air-Navigation Conference of April/May 1969, but have been expanded based on recommendations from the Department of Defense, the National Transportation Safety Board, and the Federal Aviation Administration.

(1) Jetstreams stronger than 110 knots (at the core) have potential for generating significant turbulence near the sloping tropopause above the core, in the jetstream front below the core, and on the low-pressure side of the core.

(2) Windshear and its accompanying CAT in jetstreams is more intense above and to the lee of mountain wave ranges. CAT should be anticipated whenever the flightpath traverses a strong jetstream in the vicinity of mountainous terrain.

(3) Both vertical and horizontal windshear are, of course, greatly intensified in mountain wave conditions. Therefore, when the flightpath traverses a mountain wave type of flow, it is desirable to fly at turbulence-penetration speed and avoid flight over areas where the terrain drops abruptly, even though there may be no lenticular clouds to identify the condition.

(4) On charts for standard isobaric surfaces, such as 300 millibars, if 20-knot isotachs are spaced closer together than 150 nautical miles (2-1/2° latitude), there is sufficient horizontal shear for CAT. This area is normally on the poleward (low-pressure) side of the jetstream axis.

(5) Turbulence is also related to vertical shear. From the tropopause height/vertical windshear chart, determine the vertical shear in knots-per-thousand feet. If it is greater than 5 knots per 1,000 feet, turbulence is likely.

(6) Curving jetstreams are more apt to have turbulent edges than straight ones, especially jetstreams which curve around a deep pressure trough.

(7) Wind-shift areas associated with pressure troughs and ridges are frequently turbulent. The magnitude of the windshear is the important factor.

i. Although CAT is difficult to predict, there are a number of things to look for and to remember that will help reduce the likelihood encountering CAT. In concert with a good tracking system and pilot reports, knowing the characteristics and signs of CAT can

103

prevent an incident from occurring. Until practical airborne detectors are developed, pilots are urged to use the "Rules of Thumb to Assist in Avoiding or Minimizing Encounters With Clear Air Turbulence" in the next paragraph.

6. "RULES OF THUMB" FOR TURBULENCE AVOIDANCE The following "Rules of Thumb" apply primarily to the turbulence associated with the westerly jetstreams.

a. If jetstream turbulence is encountered with direct tailwinds or headwinds, the pilot should consider a change of flight level or course since these turbulent areas are elongated with the wind and are shallow and narrow.

b. If jetstream turbulence is encountered in a crosswind, it is not so important to change course or flight level since the rough areas are narrow across the wind.

c. If turbulence is encountered in an abrupt wind shift associated with a sharp pressure trough line, establish a course across the trough rather than parallel to it.

d. If turbulence is expected because of penetration of a sloping tropopause, watch the temperature gauge. The point of coldest temperature along the flightpath will be the tropopause penetration. Turbulence will be most pronounced in the temperature-change zone on the stratospheric (upper) side of the sloping tropopause.

e. If possible, when crossing the jet, climb with a rising temperature and descend with a dropping temperature.

f. Weather satellite pictures are useful in identifying jetstreams associated with cirrus cloud bands. CAT is normally expected in the vicinity of jetstreams. Satellite imagery showing "wave-like" or "herringbone" cloud patterns are often associated with mountain wave turbulence. Pilots should avail themselves of briefings on satellite data whenever possible. (See AC 00-6A, chapter 13.)

g. Last, but not least, monitor your radio - - pilot reports can be invaluable and if you get caught by "the CAT," file a PIREP!

7. INFLIGHT AVIATION WEATHER ADVISORIES. The primary weather products used to disseminate information on atmospheric turbulence, both convective and CAT are the Inflight Aviation Weather Advisories (WST, WS, and WA). All inflight advisories in the conterminous United States are issued by the Aviation Weather Center (AWC) and disseminated as follows:

104

a. Convective SIGMETS are issued on a scheduled basis at H +55 and are labeled E (eastern third of the continental United States), C (central third of the continental United States) and W (western third of continental United States). They are issued for thunderstorms and related phenomena, when they are present. The Convective SIGMET will state NONE when the required conditions are not present.

b. A SIGMET contains information on specified weather phenomena of an intensity and/or extent that concerns all pilots and operators of all aircraft. The phenomena that require SIGMET issuance are turbulence (including CAT), icing, widespread dust and sand, volcanic eruptions and volcanic ash.

c. AIRMETS are issued to advise of significant weather phenomena at intensities lower than those that trigger SIGMETS.

d. This information is available to pilots through the en route advisory service (flight watch), SIGMET alerts broadcast on air route traffic control center frequencies, and over the hazardous in-flight weather advisory service (HIWAS).

8. RECOMMENDATION. All pilots and other personnel concerned with flight planning should carefully consider the hazards associated with flight through areas where pilot reports or aviation weather forecasts indicate the presence of CAT including mountain wave turbulence.

W. Michael Sacrey
Acting Deputy Director, Flight Standards Service

105

APPENDIX 1. A MODEL FOR A CLEAR AIR TURBULENCE AVOIDANCE SYSTEM

1. BACKGROUND.

a. There are three key elements in an effective Clear Air Turbulence (CAT) avoidance system. These three elements are:

(1) an appropriate initial and recurrent training program,

(2) a dedicated planning/dispatch function, and

(3) a fully supported operational implementation of a pilot reporting (PIREP)/communications system (not ATC-based).

b. There is no mystery or magic involved, only the awareness and involvement of three critical functions that are a part of any safe air operation. A truly effective system is based on training, internal communications, and full operational involvement in the process. The rather simplistic model presented is primarily oriented to air carrier operations and represents a "best practice" as developed by industry.

2. OPERATIONAL CONCEPT. The first step in avoidance of atmospheric hazards, especially turbulence, is to examine available weather information for planning flight operations. Direct access to a meteorological support service (in-house or outside source) by the operator's planning and dispatch function is a major factor in a successful turbulence avoidance system. Forecasting of areas of probable turbulence is essential and the graphic depiction of the impacted airspace on operationally useful plotting charts is highly recommended. Aircrews and dispatch/operational control personnel must be thoroughly trained in the techniques of timely and accurate pilot reports, and the subsequent plotting and relay of those reports throughout the operator's route structure. An efficient communications system must be established and supported to permit quick and easy interchange of flight critical information between the aircraft and the operational control function. However, management philosophy toward the CAT problem is a crucial element in an effective turbulence avoidance system. Management must establish the avoidance of atmospheric hazards as a high organizational priority. Management must be willing to expend resources on the safest operational practices and resist the expedient.

106

3. A MODEL SYSTEM.

a. The philosophy of avoidance and dedicated training are an integral part of an effective system. There can also be adjuncts to a turbulence avoidance system (one airline company has expanded its system to include other atmospheric hazards, such as thunderstorms, icing, ozone, and volcanic ash).

b. Successful turbulence avoidance and tracking is initiated in the planning and preparation phase of operations through the acquisition of applicable weather data and products. A suggested product list includes:

(1) Alphanumeric weather information such as surface observations.

(2) Area and terminal forecasts.

(3) Wind and temperature forecasts.

(4) National Weather Service (NWS) in-flight advisories (SIGMETS, Convective SIGMETS and AIRMETS).

(5) Upper air charts, graphical radar summaries or composites.

(6) Satellite imagery.

c. Incorporating current data processing and computer plotting techniques will facilitate the analysis and plotting of areas of possible adverse atmospheric turbulence. Software routines are available that will provide the analyst convenient means to track areas of interest. An example of this capability is the automated plotting on map overlays of an adverse weather area by using a "mouse" to "click" on the key features of the computer image.

d. Archiving and distributing turbulence information is the next step in the process. The product(s) should be stored in easily-accessed data bases for use by the operational control/dispatch personnel and should be available for periodic review by the generating office. Aircrew dispatch packages should contain not only the current turbulence advisories, but also the latest applicable PIREPS generated by the system. Accurate and timely pilot reporting is also essential to an effective turbulence and tracking system.

e. A basic component in any tracking/avoidance system is the supporting communications system which facilitates the free and easy flow of turbulence information between aircrew, dispatcher, and meteorological support function. Timely operational control advisories, accurate

CAT forecasts, and feedback through conscientious pilot reporting are the heart of effective avoidance of either convective or clear air turbulence. Without efficient air/ground communications, an air carrier can not ensure the timely delivery of this extremely perishable information to the appropriate operational components. Less than efficient communications will result in an ineffective program for the tracking and avoidance of clear air turbulence or any other atmospheric hazards.

f. Finally, the short- and long-term success of a carrier's turbulence avoidance and tracking system requires a dedicated and continuing training program for aircrews, dispatchers, meteorologists and other operational control personnel. Training should begin with a reasonably detailed exposure to the science of the atmosphere and the meteorological techniques/products involved in turbulence forecasting. This should be followed by continuing recurrency classes for all personnel concerned with flight operations and operational control.

4. RECOMMENDED PRACTICES.

a. Comprehensive training for aircrews, dispatchers, and meteorologists.

b. Establishment of a full meteorological support system (either in-house or outside source).

c. Thorough preflight planning including concentrated examination of upper air wind patterns.

d. Accurate tracking of jet streams.

e. Acquisition of satellite imagery for aircrews and operational control centers and dispatchers.

f. Graphical depictions of forecast areas of turbulence on planned routes of flight.

g. Use of appropriate plotting charts for facilitation of pilot reporting.

h. Establishment of an efficient and effective communications system administered by the operator to support the company's pilot reporting system.

i. Promulgating a corporate philosophy of avoidance as the first line of defense.

108

NATIONAL TRANSPORTATION SAFETY BOARD
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Larry Ganse
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Dear Sir:

Please provide the following additional information to assist us in the investigation of the accident involving United Airlines Flight 826, that occurred on December 28, 1997 at about latitude 32:31 north and longitude 157:27 east at about 1336Z.

According to a written statement from the Captain of Northwest Flight 80 [NWA 80], a B-747 enroute from NRT to HNL at FL 330, moderate to severe turbulence was encountered in the vicinity of 160 degrees east at about 1220Z on December 28, 1997. The Captain reported the encounter which lasted 2 to 3 minutes as Code 3 to 4. The captain stated that the turbulence was the "worst that I've ever encountered." This encounter was followed by 10 to 12 minutes of light to moderate turbulence.

Did you receive any reports from NWA 80? Did you receive this report? If you received this report what actions were taken? What actions would normally be taken given a report of moderate to severe turbulence (Code 3 to 4)? Are Northwest pilot reports of significant weather conditions [turbulence, icing, etc] disseminated outside of Northwest Airlines? How is this information disseminated to outside interests? If not disseminated why is this information not disseminated?

Thank you in advance for your reply.

109

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Gregory D. Salottolo
National Resource Specialist
Meteorology
April 8, 1998
Phone: [redacted]
FAX: 202.314.6339
e-mail: [redacted]

110

MEMO

NORTHWEST AIRLINES

Robert Benzon
NTSB
Monday, April 27, 1998

From: Larry Gense
[illegible]
Department NWMSO
St. Paul MN 55111-3034
(612) 726-0916 Phone
(612) 726-8292 Fax
OVID LRGENSE

Subj: Information Request of 4/23/98

cc: Gregory D. Salottolo

This information is in reply to the questions on your letter of inquiry.

NWA 80 did report the turbulence encountered and it was received by our Tokyo dispatch office. Unfortunately, and this is important, the crew classified it as Code 3. By NWA definition, code 3 is light, occasionally moderate turbulence. Therefore, the information transmitted did not accurately reflect the captain's description of "the worst that I've ever encountered" as confirmed by my subsequent discussion with him. He should have assigned it a code 5 or 6. FYI, I have appended a copy of our turbulence definitions.

Since the report was only for code 3 and since a Northwest TP message was already in place for code 2 in the area, no further action was taken by Northwest Dispatch or Meteorology. If, in fact, a code 5 or 6 report comes in, meteorology will immediately re-evaluate the current TP or issue one for NW flights if there is not one [illegible]

[illegible] pilot reports are not disseminated outside of [illegible] mechanism in effect to do so. Those reports given [illegible] reports are accessible to other airlines dispatch [illegible] are not routinely monitored by other airlines [illegible] reports).

[illegible] of information, Northwest has concluded [illegible] our TP messages will be accessible by other [illegible] mation should be available by June 1, 1998. [illegible] reports from Northwest flights but, if the pilot report [illegible] formation would then become available.

Please feel free to give me a call if you have any further questions.

Sincerely,

WEATHER

Intensity	Aircraft Reaction	Reaction Inside Aircraft
Extreme	Turbulence in which the aircraft is violently tossed about and is practically impossible to control. May cause structural damage.	

Turbulence Reporting Codes

The following codes are used for reporting turbulence:

0 - smooth

1 - occasional light turbulence

2 - light turbulence

3 - light, occasional moderate turbulence

4 - moderate turbulence (intermittent)

5 - moderate, occasional severe turbulence

6 - severe turbulence (intermittent)

7 - occasional extreme turbulence

The following definitions, regarding [illegible] international agreement:

occasional: occurring less than 1/3 of the [illegible]

intermittent: occurring 1/3 to 2/3 of the [illegible]

continuous: occurring greater than 2/3 of the [illegible]

Turbulence Reporting [illegible]

[illegible] interrupt is responsible [illegible] performed on an aircraft [illegible]