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SYSTEM DESCRIPTION FOR THE AIRBORNE-OMEGA DATA BANK,(U)
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FAA-CT-80-191

SYSTEM DESCRIPTION FOR THE AIRBORNE-OMEGA DATA BANK

Lorraine Rzonca

FEDERAL AVIATION ADMINISTRATION TECHNICAL CENTER
Atlantic City, N. J. 08405

SYSTEM DESCRIPTION

JULY 1980

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Prepared for

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FEDERAL AVIATION ADMINISTRATION
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Washington, D. C. 20590

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16. Abstract

The Airborne-Omega Data Bank has been established at the Federal Aviation Administration (FAA) Technical Center. Its main objective is to provide a centralized repository for operational airborne-Omega data so that performance which is representative of the majority of production airborne-Omega navigation equipments under various ionospheric conditions (including high solar activity) may be evaluated. Details of the methods developed for data collection, processing, and reporting are documented in this report. Current status and plans for the near future are discussed.

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METRIC CONVERSION FACTORS

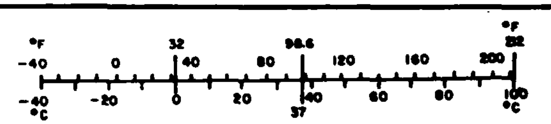
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in ≡ 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10.286.

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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INTRODUCTION

At the present time, Omega is used for oceanic navigation of aircraft, either as a primary means or as a supplement to another system. Commercial air carrier operators from several nations have installed Omega Navigation Systems (ONS) in their aircraft which operate over world-wide oceanic routes. Overall, the ONS have performed well under the flight conditions encountered. However, the characteristics of Omega propagation are strongly dependent upon prevailing ionospheric conditions so that performance recorded at a specific time and date may not adequately reflect the range of conditions which should be considered when evaluating the accuracy and reliability of the Omega System.

Most of the possible sources of anomalous Omega propagation have been identified from years of scientific monitoring of Omega signals by various organizations throughout the world. Current scientific efforts are directed toward providing early notification of solar activity and the predicted effect on Omega signals. In addition, the United States (U.S.) Coast Guard, which maintains the Omega Navigation System transmitters, continues its program of Omega validation in various parts of the world in order to determine the adequacy of its theoretical models (several variations are currently implemented in production ONS software). The need to develop data bases to analyze ground monitor information (especially now, during the peak of the current solar cycle) is being met by the U.S. Coast Guard Omega Navigation System Operations Detail (ONSOD). This data base should provide statistics on effects of solar activity upon the Omega signal.

Although the data collection efforts mentioned here are sufficient for characterizing the Omega signal environment, which is detected by an aircraft Omega antenna, the noise levels associated with a particular aircraft installation, and the characteristics of each ONS manufacturer's software package, may lead to significantly different navigation capabilities. In order to provide a measure of performance which is representative of the majority of production airborne ONS equipments under various ionospheric conditions (including high solar activity), an Airborne-Omega Data Bank has been established at the Federal Aviation Administration (FAA) Technical Center. A meeting was hosted by the FAA in August 1978 (reference 6) at which the proposed operation of the Data Bank was presented. Status reports were given to the International Omega Association at its Third and Fourth Annual Meetings (references 4 and 5).

PURPOSE.

In order that Data Bank contributors, potential contributors, and other interested parties understand the operation of the Airborne-Omega Data Bank and the outputs which are available to them, this report describes the methods which are presently in use to collect, process, and disseminate airborne-Omega information which is currently being fed into the Data Bank. A brief summary of status and future plans are included to acquaint potential contributors with the scope of the Data Bank effort.

DISCUSSION

The Airborne-Omega Data Bank is designed to:

1. Produce empirical signal coverage charts, based upon data obtained from several different airborne ONS over routes of commercial interest.

2. Provide a measure of the range of signal-to-noise levels possible due to

factors which include type of Omega set, aircraft installation configuration, geographic location, seasonal changes, and effects of solar activity.

3. Help define coverage "holes" and marginal areas where certain circumstances may produce a "hole."

4. Examine the role that the "very low frequency (VLF) option" plays in those ONS equipped to receive the U.S. Navy stations as a backup to Omega.

5. Provide "real-world" parameters to enhance theoretical inputs for simulation of proposed new routes.

6. Provide the capability to develop a statistical data base on Omega accuracy along world-wide air routes traveled by those contributors who exercise the option to allow the recording of Inertial Navigation System (INS) for later position comparison with the Omega data.

The immediate objectives of the Data Bank are to:

1. Compile all Omega data acquired during a given 3-month period and produce several types of data listings and the periodic technical report.

2. Compile all Omega data over a 2-year period (during high solar activity) and generate a variety of aggregate statistics at the end of this time period in a final report.

Since the Data Bank is required to handle large quantities of Omega data from various types of aircraft and from several models of Omega navigation systems, standardization of data recording, processing, and reporting procedures is mandatory. To optimize the efficiency of the Bank, engineers at the FAA Technical Center have designed a special airborne interface and recording set for distribution to Data Bank contributors. Base Ten Systems, Incorporated has manufactured and delivered 20 of these cassette recorders to the FAA. Upon installation in a contributor aircraft, data is collected along normal air routes and cassette tapes are mailed to the FAA Technical Center. Here the data is transcribed to 9-track tape, several types of data listings are printed, and the data is entered into the Honeywell 66/60 Omega data base according to procedures developed by the scientists, engineers, and technicians of the Omega project team.

Data collected during each season from all contributors are analyzed with results presented in a periodic technical report. The general scheme for data flow from cassette tape to reports is shown in figure 1.

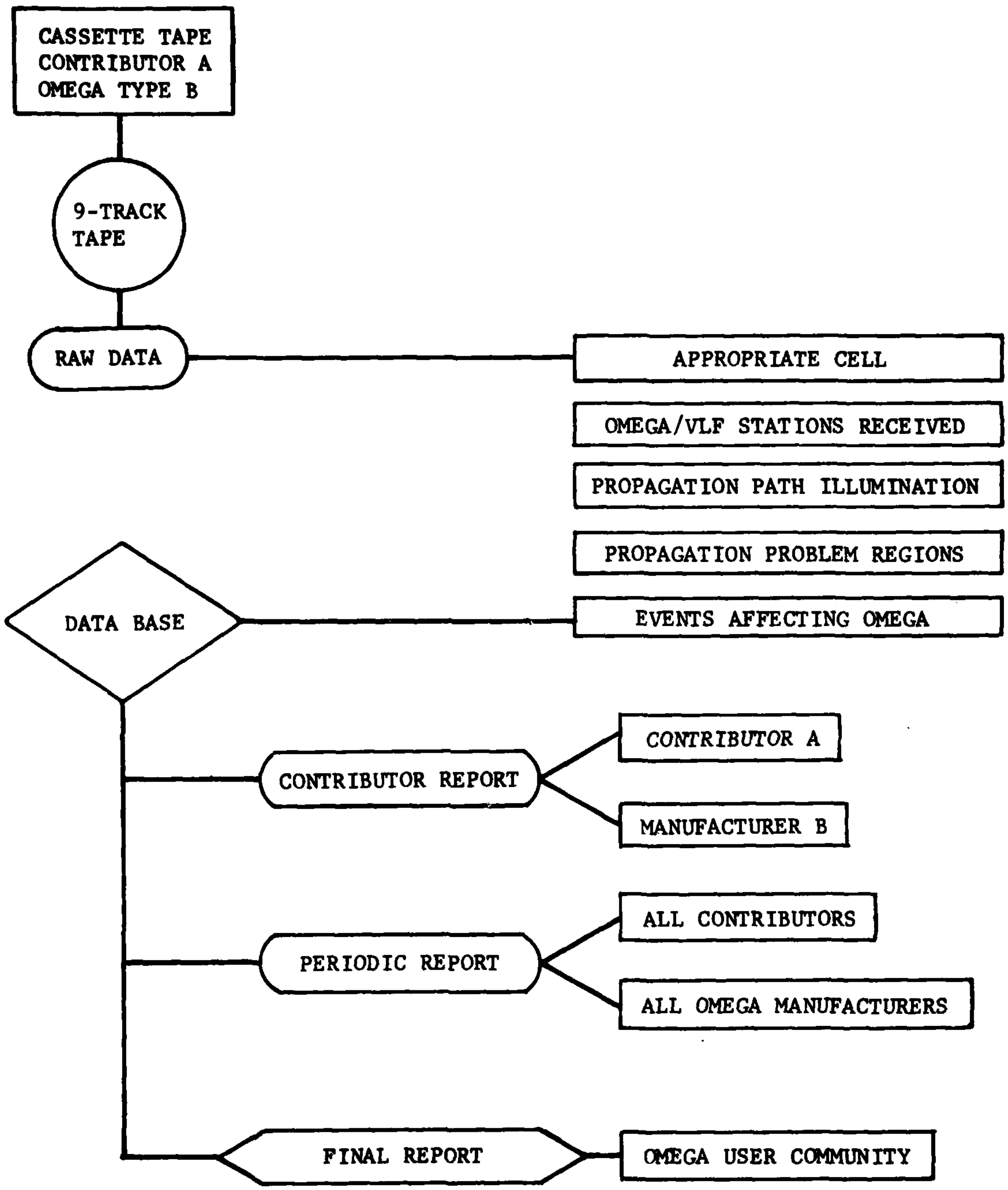
The Data Bank offers several types of flight data listings. Contributors may exercise the option of requesting special data listings which best fit their particular needs. Contributors who wish to extract a specific set of statistical data from the data base should submit their requirements to the Data Bank.

Details of the methods which have been developed for data collection, processing, and dissemination are described below. The current level of participation and expected future efforts are discussed.

EQUIPMENT.

A technical description of the cassette recorder is given, followed by a statement of the responsibilities/costs involved in the installation/engineering of the cassette recorder and interface boards required of FAA/manufacturer/contributor.

TECHNICAL DESCRIPTION. An airborne interface and recording set, which applies the design provided by the principal design engineer of the Omega



80-191-1

FIGURE 1. SCHEME FOR DATA PROCESSING/REPORTING

project team, has been manufactured by Base Ten Systems, Incorporated as the principal instrument for collecting the necessary digital records of Omega performance. The data recording system, Base Ten model 700-546, is housed in a standard 3/4 ATR box (short) 7.6 inches wide, 7.8 inches high, 12.5 inches long, and weighs 14.6 pounds. The package consists of an MFE 250B digital cassette tape recorder, two Lambda power supplies, a control card, a memory buffer card, and wired positions for user Omega interface cards.

The internal power supply provides ±12 and +5 volts. The 5-volt supply delivers 5 amperes (amps): 1.5 amps to the tape recorder and control electronics, 3.5 amps available to the interface cards. The +12 volt supply delivers 400 milliamps to the interface cards; the -12 volt supply contributes 125 milliamps to the recorder system and 272 milliamps to the interface cards.

The system has space for four three-layer, wire wrapped interface cards; however, provisions have been made to include three additional cards, if needed. If interface cards are printed circuit boards, as opposed to wire wrapped, then seven cards may be installed.

The unit has a buffer memory card with capacity for 2048 bits, internally programmable in increments of 512 bits. Memory is a standard RAM, type 21 L02i. To record data on tapes the device requires three input signals: buffer enable, clock, and data. In operation, whenever buffer enable is true (or high), data enters buffer storage on the positive edges of the input clock cycle. When memory has become full, or when a particular block of information is to be recorded (by dropping the enable line through a false zero condition), the unused memory will fill with zeroes and then write the data onto the tape. First, a 90-millisecond high gap is written onto the tape, then a double A hexidecimal preamble, followed by the complete block of data, a cyclical redundancy check character, and a double A hexidecimal postamble. The buffer then begins to load for the next data sample. During the initialize cycle, a 50 kilohertz (kHz) clock writes all zeroes into the RAM to clear the memory of residuals.

The tape in the cassette is 300 feet long, with 282 feet usable for recording. The tape has capacity for recording 2.88 megabits. Normally, recording is done at 800 bits per inch. With a standardized recording rate of one sample (1024 bits) per minute, up to 24 hours of Omega data may be recorded per cassette.

Temperature range of operation is 0 - 55° centigrade. To preclude damage to the tape if temperatures fall outside this range, two thermostats, in series with incoming power, keep the device turned off until operating temperature is reached. Main power also enters through a 2-amp circuit breaker at the "On-Off" switch on the front panel.

When a cassette tape is loaded into the recorder and power is applied, activation of the "Initialize" button causes the tape to rewind and stop on the clear leader portion of the tape (a red light on the right side of the panel signals this status). The tape reverses until it is positioned for data recording (a green light to the left of the power switch indicates the tape is ready to record data).

INSTALLATION/ENGINEERING RESPONSIBILITIES AND COSTS. The recording package, which the FAA supplies to each contributor, includes the Base Ten tape recorder, a shock/vibration mount, a cable connector, and 20 cassette tapes. The contributor installs the recording system together with the required interface boards obtained from the Omega manufacturer. Some models of ONS require internal changes to the receiver processor unit (RPU) before data can be delivered for automatic recording. The nonrecurring engineering costs to design such changes are covered by the FAA under contracts awarded in 1978-1979 to four Omega manufacturers: Bendix Corporation; Canadian Marconi Company, Incorporated; Norden Systems; and Tracor Systems, Incorporated. (Litton ONS equipment does not require software changes in the RPU.) The FAA also released contracts to cover the engineering and fabrication of interface boards required between each of the five types of Omega set and the Base Ten recorder or, alternately, to cover engineering assistance to the FAA for this purpose.

In addition to single ONS recording, several options are available to participants in the Data Bank. Either single or dual ONS installations can be recorded with a single Base Ten recorder. Similarly, for contributors interested in comparison of ONS and INS, an interface board for the INS can be supplied by the FAA for dual ONS/INS data recording on the Base Ten recorder.

PROCEDURES FOR PROCESSING DATA TAPES.

Each cassette tape that a contributor receives from the FAA has an identity label affixed to it so that the operator of the cassette recorder can enter the date that the cassette was inserted/removed, type of Omega set, airline, and aircraft number. At convenient intervals, cassettes containing data are mailed to the Omega Data Bank at the FAA Technical Center. Figure 2 contains a copy of the cassette identity label and the mailing address for the Data Bank.

Upon receipt at the Data Bank, Omega project team technicians transcribe the cassette tapes to 9-track tape. Transcription equipment consists of the Base Ten recorder feeding the Kennedy 9832 9-track recorder. Each contributor's data is entered on separate 9-track tapes with this data further separated into seasons. Each aircraft identifier and Omega type is assigned a fixed code number by which data are identified within Data Bank periodic technical reports. The 9-track tape is then sent to the Honeywell 66/60 computer, data are entered into the data base, and data listings produced. When verification is received that all the data are stored safely within the data base, the original cassette tapes are erased and recycled to contributors.

Since data from each model of ONS differs in content and format as recorded on the cassette tapes, individual computer programs are required to produce the data listings and insert data into the data base. The FAA will develop the required programs for the different Omega sets as sample operational tapes become available.

STRUCTURE OF DATA BASE.

Within the data base, data from each flight are stored according to geographic location (648 cells), date, time of day, season, propagation path illumination, known problem regions, time-correlation with solar-geophysical events, and with transmitter outages. Sources of the information which are included in the data base and techniques devised for data storage and retrieval are discussed below.

SOURCES OF INFORMATION. Data are grouped in geographic areas, or cells, which are 10° latitude by 10° longitude, charted on a Mercator projection of the earth (see figure 3). The date and time of day associated with each data point are those which the Omega operator has entered into the ONS during initialization. The seasons are defined as follows:

Fall = September, October, November

Winter = December, January, February

PROPERTY OF U.S. GOVERNMENT - RETURN TO:

OMEGA DATA BANK, FAA TECHNICAL CENTER, ACT-100B

ATLANTIC CITY, N.J. 08405

SIDE A

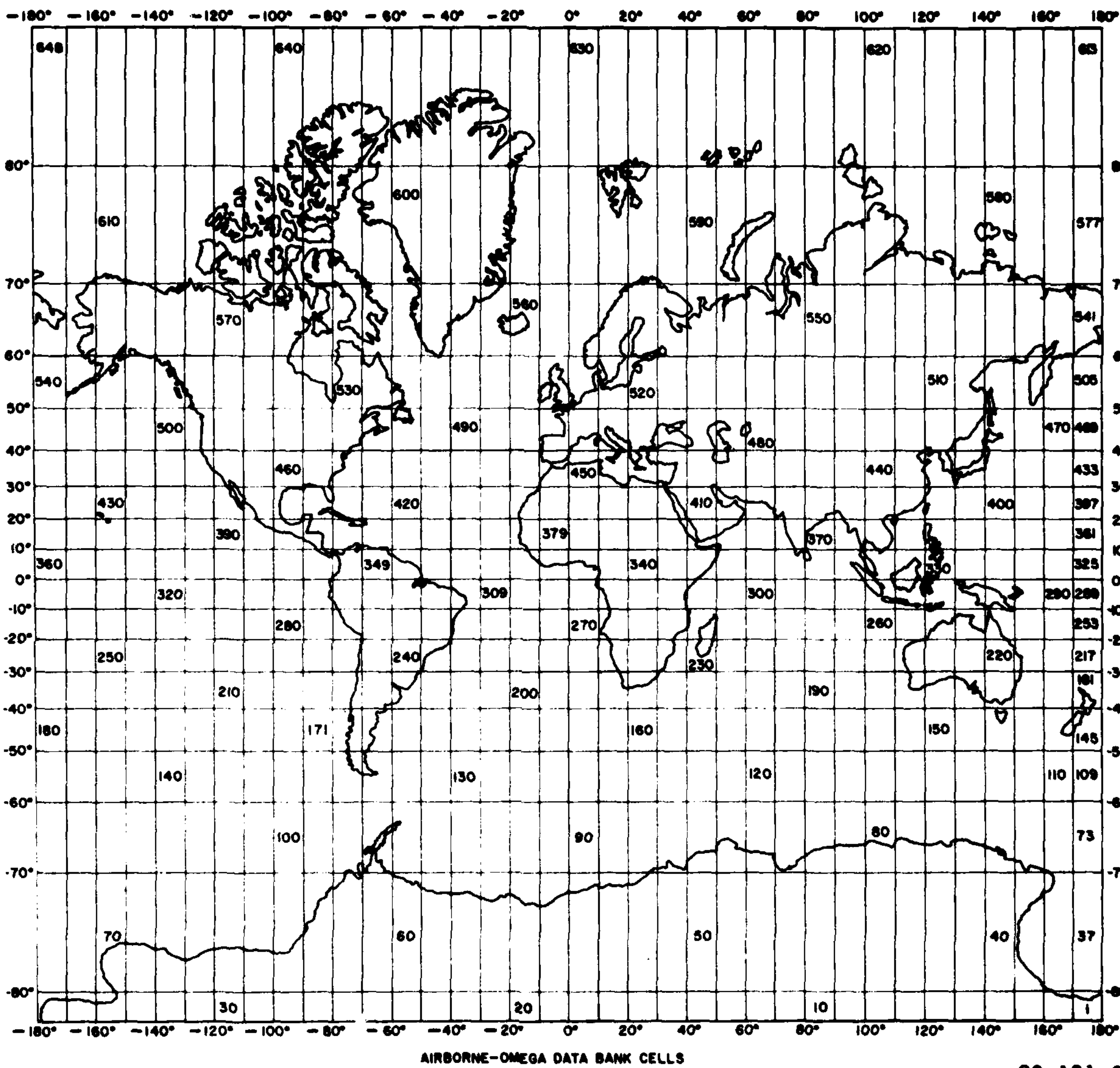
SIDE A

RECORD
THIS
SIDE

DATE INSTALLED	DATE REMOVED	DATE MAILED
AIRLINE	AIRCRAFT NO.	OMEGA TYPE

80-191-2

FIGURE 2. CASSETTE IDENTITY LABEL WITH MAILING ADDRESS



80-191-3

FIGURE 3. AIRBORNE-OMEGA DATA BANK CELLS

Spring = March, April, May

Summer = June, July, August

Propagation path illumination is computed by a subroutine called NITEDAY, which determines whether the propagation path between the data point and the Omega transmitter is fully illuminated, completely dark, or some combination of light and dark.

Problem regions (see table 1) include those cells in which Omega signals are expected to be affected by the Greenland and Antarctica Ice Caps attenuation, nighttime modal interference, solar particle effects in the auroral zones, and high VLF noise areas. The Ice Caps are defined by those areas in which the effective conductivity is less than or equal to $3x10^{-5}$ mho/meter; great circles originating from a given Omega transmitter and bounding the Ice Cap determine which cells are included within the affected region (if more than one-third of the cell is within the great circle boundary, the cell is included within the problem region); the cells included within the Greenland Ice Cap shadow for Norway signals are shown in figure 4. The regions of nighttime modal interference are based upon diagrams for 10.2 kHz signals obtained from ONSOD. If more than one-third of a given cell is within the modal region, it is included in this problem region. Cells expected to contain modal interference from the 10.2 kHz Liberia signal are shown in figure 5. The auroral zones are approximated by those areas of maximum frequency of occurrence of overhead aurora on magnetically disturbed days (boundaries conform to the largest areas depicted in reference 6). Great circles originating from a given transmitter, and bounding the auroral area, determine the cells included in the auroral zone shadows in which signals may have been affected by solar particle and magnetic effects. If more than one-third of the cell falls within the bounding great circle, that cell is included in the region. The high VLF noise areas are those defined in the International Radio Consultative Committee (CCIR) Report 322 for which VLF noise at 10 kHz is greater than or equal to -94 decibels (dB), relative to 1 volt/meter/$\sqrt{c}$/second (c = speed of light); values are provided for each 4-hour (GMT) interval within a day, and are applicable to a 3-month period (September, October, November; December, January, February; March, April, May; and June, July, August).

Solar-geophysical events (see table 1) which are time-correlated with flight data within the data base include solar x-rays, polar cap disturbances (PCD's), magnetic storms, and Omega transmitter power reductions/outages. Information on solar x-rays and magnetic storms is obtained each week from the publication cited in reference 7. Solar x-rays are classified by their peak flux in the 1 to 8 Angstrom wavelength range with "M" events flux between 10^{-5} and 10^{-4} watt/m^2 and "X" events flux greater than 10^{-4} watt/m^2. The data base includes events of M2 and greater, where the digit following the letter acts as a multiplier (e.g., M2 = $2x10^{-5}$ watt/m^2 and X5 = $5x10^{-4}$ watt/m^2).

Major magnetic storms, which result in a 3-hourly K-index, ranging from 6 to 9 at the Anchorage (high latitude) monitor, are included within the data base. Flights which are made during any portion of the 3-hour period when the K-index is 6 or greater are considered to be potentially influenced by the increased magnetic activity. Information on PCD's is obtained from ONSOD teletypes. A record of Omega transmitter outages and power reductions is obtained from weekly ONSOD teletypes. All of the information on events noted above are entered onto computer cards and inserted into the data base at the end of each 3-month period.

DATA STORAGE/RETRIEVAL. The Omega signal data recorded on all of the 9-track tapes generated during a given quarter are transcribed onto a

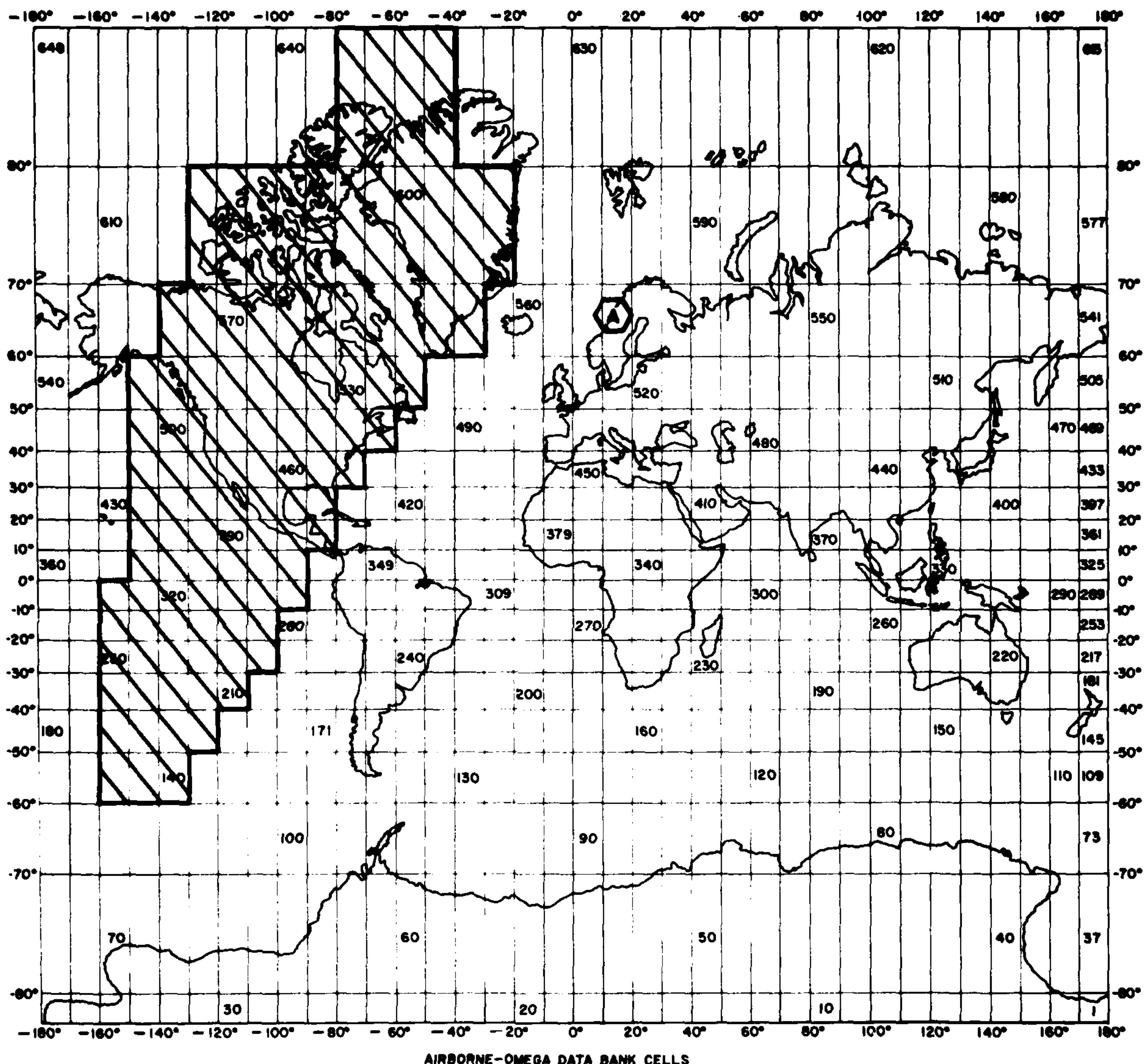
TABLE 1. REGIONS/EVENTS WHICH AFFECT OMEGA PROPAGATION

Propagation Problem Regions	Information Source
1. Greenland Ice Cap Shadow	Westinghouse Conductivity Map
2. Antarctica Ice Cap Shadow	Westinghouse Conductivity Map
3. Nightime Modal Interference (10.2 kHz)	ONSOD
4. North Auroral Zone Shadow	Davies: Ionospheric Radio
5. South Auroral Zone Shadow	Propagation; April 1965, pp. 34-35 (NBS Monograph 80)
6. High VLF-Noise Area	CCIR 322 Publication

Events	Information Source
1. Solar X-Rays	NOAA "Preliminary Report and Forecast of Solar and Geophysical Data" (PRF) (weekly)
2. Polar Cap Disturbance (PCD)	ONSOD Teletypes
3. Magnetic Storm	NOAA "PRF" (weekly)
4. Station Power Reduction/Outage	ONSOD Teletypes (weekly)

Note: ONSOD = Omega Navigation System Operations Detail (U.S. Coast Guard)
NOAA = National Oceanic and Atmospheric Administration
CCIR = International Radio Consultative Committee

AFFECTED CELLS



80-191-4

FIGURE 4. GREENLAND ICE CAP SHADOW FOR NORWAY (A) SIGNALS

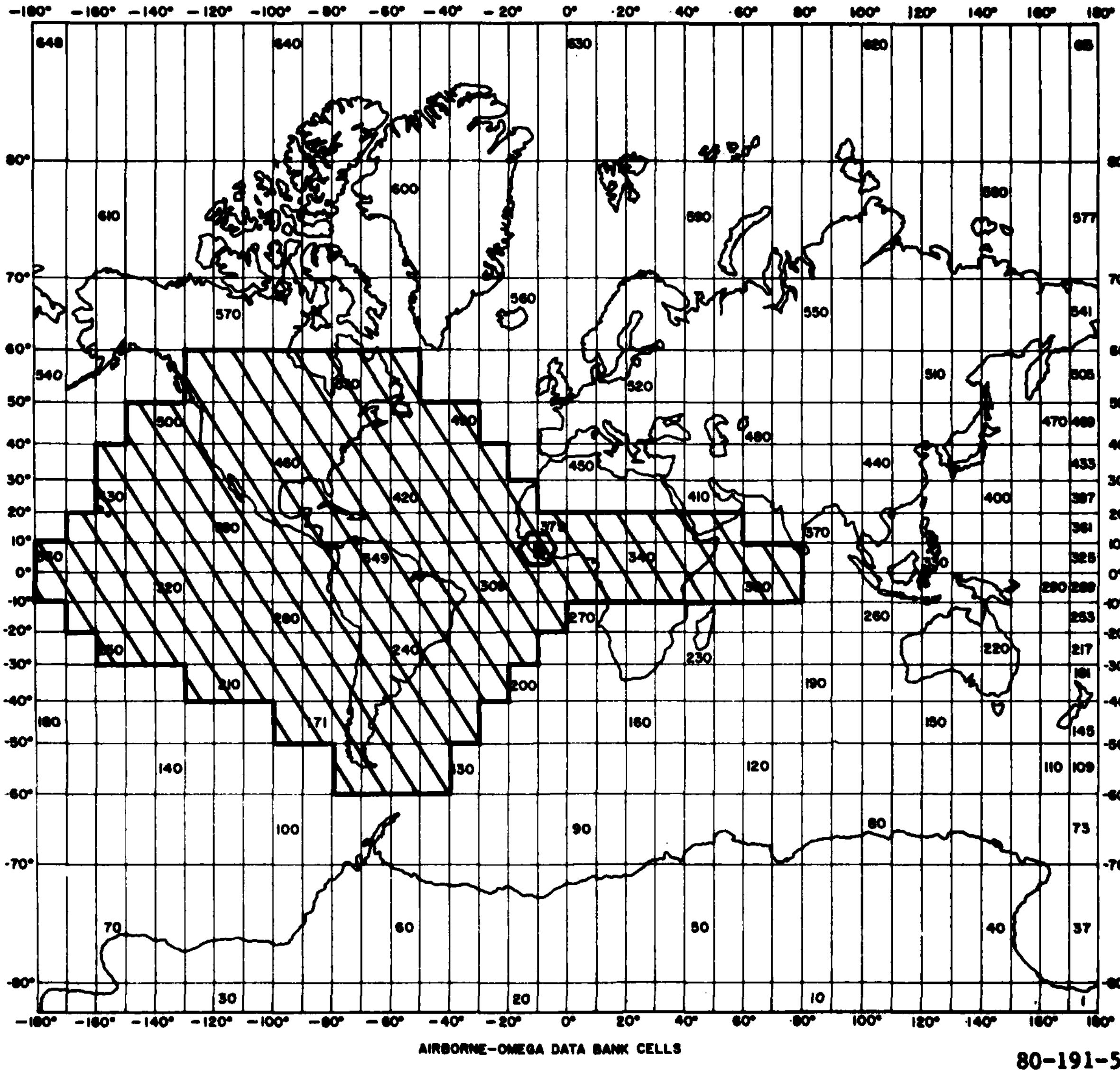


FIGURE 5. NIGHTTIME MODAL INTERFERENCE FOR 10.2 kHz LIBERIA (B) SIGNAL

removeable disk pack file. As the airborne data is processed, the time-position coordinates of each data point are compared to the events/regions of table 1; any associations are noted within each transcribed record. All records which show associations with the same events/regions are back-linked by pointers so that they can easily be removed as a subset and transcribed for further analysis. The process is terminated by writing a directory onto the disk pack. For each identifiable propagation problem, the last data record associated with this problem is noted together with the total number of occurrences of this particular problem. With the system described, any given subset of data may readily be extracted for further processing.

A similar linking structure allows extraction of data with respect to position geometry, with all data divided according to cell.

The directory delimits data records according to contributor, Omega receiver, and single flights; therefore, these data may be extracted from the data base either by individual factors or any desired combinations.

Each disk pack is identified by a catalog name, Q (i) Y (jj), where "i" specifies the given quarter (i=1,2,3,4) and "jj" specifies the year (jj=79). Each catalog contains five files as described in table 2. The directory for the "Data" file (containing quarterly flight data) provides for up to 240 magnetic tape elements with up to 12 flights per element; there is capacity for up to $(2^{18} - 1)$ correlations for a given VLF propagation problem.

DATA BANK OUTPUT/REPORTS.

The Data Bank offers three types of data listings and plots for individual flights of each contributor, publishes periodic technical reports on data accumulated from all contributors within a particular time period (normally 3 months), and will publish a final report at the end of 2 years of operation. The available listings/plots and reports are described below.

FLIGHT DATA LISTINGS/PLOT. Standardized data listings and track plot are described (note that VLF information is included from those ONS equipped with VLF option). Contributors may also request special formats which best fit their needs. Such arrangements may be initiated by a written request sent to the Omega Data Bank mailing address given in figure 2.

1. The "Point-by-Point" data listings are shown and explained in figures 6 through 9. This is a standardized printout based upon the type of information which is usually available from all types of ONS.

2. The "Navigation Highlights" listings are shown and explained in figures 10 through 12. Data are listed according to cell number and only include data points recorded when aircraft indicated speed exceeds 300 knots. Included are the first data point within a given cell and those points which represent a change in usable stations or a significant change in crosstrack error (Omega-indicated or based on INS, if available).

3. The "Received-Signal Quality" listing is shown in figure 13. Signal quality is indicated by the median signal quality number (S/N) within each cell during the flight; in addition, factors which may affect the S/N level are included.

4. The basic "Track Plot" is shown in figure 14. This depicts Omega indicated track on a latitude versus longitude grid made up of cells (10° x 10°), with the corner cells numbered. In addition to this basic plot, several options are possible:

TABLE 2. DATA BASE FILES FOR DISK PACK

File Name	Description	Record Size (words)	File Size (recs/sector)
SOLARX	Solar X-ray Events	8	512/64
POLARCAP	Polar Cap Disturbance	8	512/64
STORMS	Magnetic Storms	8	512/64
OUTAGES	Omega Transmitter Power Reductions/Outages	8	512/64
DATA	Quarterly Flight Data	128	300,000/600,000

Note: One disk pack has 616,360 sectors.

Expected usage is 600,256 sectors, with expansion capability of 16,000 sectors.

a. Latitude versus time and longitude versus time.

b. Superposition of track plots for specified flights (e.g., all eastbound flights along the same route, all daytime flights, etc.).

c. Superposition of ONS track and INS track from dual ONS/INS installation.

d. Other combinations as required by contributors.

PERIODIC TECHNICAL REPORTS. Data Bank reports, with contributors and ONS types identified by assigned code number only, are mailed to all contributors and Omega manufacturers concerned. Each report contains: (1) a summary of air routes flown, number of contributors, types of ONS providing data, and total number of flight data hours; (2) table of solar-geophysical events coincident with flight times of each contributor; (3) geographic charts depicting operationally usable signals within each cell for each contributor; (4) listing of Omega crosstrack and along track differences computed with reference to INS in a dual ONS/INS installation; and (5) highlights of problem areas or events which warrant special consideration. Details of the various data presentations are given below.

1. Summary of Flight Activity. The number of contributors, the types of Omega sets (in alphabetical order) operated by the contributors, and the total number of flight data hours with each type of Omega set are listed for the reporting period. Track plots representing the typical air routes which were flown by contributors are included (see figure 15).

2. Solar-Geophysical Events Coincident with Flights. A list of solar-geophysical events (1=solar x-ray, 2=PCD, 3=magnetic storms, 4=transmitter outages of duration greater than 5 minutes) which are coincident with flight times (see table 3) is provided for each contributor. The date and

3 14 1980 Contributor NO. 02 TRACOR 7640

GMT H	GMT M	LAT D	LAT M	LONG D	LONG M
23	0	48	1	-61	32
23	44	47	58	-61	38
23	45	47	55	-61	46
23	46	47	52	-61	52
23	47	47	48	-61	59
23	48	47	45	-62	5
23	49	47	42	-62	11
23	50	47	38	-62	18
23	50	47	35	-62	24
23	52	47	32	-62	31
23	52	47	29	-62	37
23	53	47	26	-62	44
23	54	47	23	-62	50
23	55	47	19	-62	57
23	56	47	16	-63	4
23	57	47	12	-63	11
23	58	47	9	-63	18
23	59	47	5	-63	25
0	0	47	2	-63	32
0	1	46	58	-63	39
0	2	46	55	-63	45
0	3	46	51	-63	51
0	3	46	47	-63	57
0	5	46	44	-64	3
0	5	46	39	-64	11

DATE: MONTH DAY YEAR

CONTRIBUTOR NO.: CODE NUMBER ASSIGNED TO A GIVEN CONTRIBUTOR.

OMEGA: MANUFACTURER AND MODEL OF THE OMEGA SET INSTALLED IN THE PLANE.

GMT: GREENWICH MEAN TIME IN HOURS AND MINUTES.

LAT: PRESENT POSITION LATITUDE (+ = NORTH) IN DEGREES AND MINUTES.

LONG: PRESENT POSITION LONGITUDE (+ = EAST) IN DEGREES AND MINUTES.

80-191-6

FIGURE 6. POINT-BY-POINT DATA LISTING, IDENTIFICATION, DATE, TIME, LATITUDE/LONGITUDE

SIGNAL TO NOISF NO.0-9

10.2	13.6	11.3
63790592*	78880871*	88870762*
74890693*	78880871*	88860762*
63790692*	78880871*	89870762*
74890692*	77880871*	88860761*
63790592*	78880871*	88770771*
74790693*	77880871*	88860772*
74790692*	78980871*	88770762*
74890693*	77880870*	88870762*
73790692*	78880871*	89870772*
74890693*	77980871*	88860773*
73790693*	78980871*	88870763*
64890593*	78880871*	88870763*
74790493*	78980571*	88860472*
74890293*	77980271*	88870262*
63790393*	77880571*	88870462*
64890492*	77880771*	88870662*
64790592*	78980772*	89860773*
64890692*	77980872*	88870772*
64790593*	77980882*	88860763*
64890693*	77980882*	88870763*
63790692*	78980882*	88860773*
21340352*	32340441*	33330431*
73790592*	78880872*	88870773*
64780682*	77780772*	77760763*
63790592*	78880872*	88870772*

SIGNAL TO NOISE NO.: NUMBER BETWEEN 0 AND 9 WHICH REPRESENTS RELATIVE SIGNAL-TO-NOISE VALUES; EIGHT CONSECUTIVE DIGITS REPRESENT STATIONS A THROUGH H FOR EACH FREQUENCY.

-, *, / : FREQUENCY USAGE IS INDICATED FOLLOWING THE EIGHT SIGNAL-TO-NOISE NUMBERS; - = FREQUENCY NOT USED, * = FREQUENCY USED, / = FREQUENCY USED TO FORM A DIFFERENCE FREQUENCY (3.4, 2.2, 1.1).

80-191-7

FIGURE 7. POINT-BY-POINT DATA LISTING, SIGNAL-TO-NOISE NUMBER, FREQUENCY USAGE

TRK DEG	DSR TRK	MAG HDG	ASP KTS	GSP KTS	WSP KTS	WDIR DEG	XTRK NMI	WP-DST NMI
232	234	225	449	368	87	250	0.4	1331.0
235	234	229	438	368	82	249	0.8	1267.0
220	236	224	465	367	89	252	-0.6	1214.0
234	234	228	438	367	83	251	1.1	1156.0
224	233	221	445	364	91	253	0.5	1108.0
232	233	226	438	365	85	252	0.7	1044.0
231	233	224	441	363	92	253	0.6	994.0
231	233	224	438	362	86	253	0.8	935.0
232	233	224	445	366	94	254	0.7	885.0
231	233	225	438	361	88	253	0.8	826.0
230	233	225	445	359	96	254	0.9	775.0
230	233	225	438	360	90	254	1.1	715.0
230	233	225	445	365	97	255	1.2	663.0
232	233	225	438	362	91	256	1.5	603.0
234	233	226	449	371	98	256	1.8	552.0
230	233	224	438	362	91	257	1.9	489.0
231	232	224	449	368	98	257	1.9	434.0
231	232	224	438	364	91	259	2.1	376.0
234	232	225	449	372	98	258	2.3	316.0
233	232	225	438	367	90	260	2.3	256.0
231	232	225	441	363	97	258	2.6	201.0
224	232	219	438	360	90	259	1.8	146.0
226	232	219	457	375	96	258	1.2	89.0
224	237	219	438	360	90	259	1.0	3409.0
236	237	228	461	389	95	259	-0.3	3345.0

TRK: TRACK ANGLE IN DEGREES (TRUE NORTH)

DSR TRK: DESIRED TRACK IN DEGREES (TRUE NORTH)

MAG HDG: MAGNETIC HEADING IN DEGREES

ASP: TRUE AIRSPEED IN KNOTS

GSP: GROUNDSPEED IN KNOTS

WSP: WIND SPEED IN KNOTS

WDIR: WIND DIRECTION IN DEGREES (TRUE NORTH)

XTRK: OMEGA-INDICATED CROSS-TRACK IN NAUTICAL MILES (- = LEFT OF TRACK, + = RIGHT)

WP-DST: DISTANCE TO THE WAYPOINT IN NAUTICAL MILES

80-191-8

FIGURE 8. POINT-BY-POINT DATA LISTING, NAVIGATION PARAMETERS

```
USABLE      VLF
STATIONS    STATIONS
---D--G-
---D--G-
---D--G-
---D--G-
---D--G-
---D--G-
---D--G-
---D--G-
---D--G-
---D--G-
---D--G-
---D--G-
---D--G-
---D--G-
---D--G-
---D--G-
---D--G-
---D--G-
A--D--GH
A--D--GH
A--D--GH
--------
A--D--GH  DR
--------
A--D--GH
```

USABLE STATIONS: OMEGA STATIONS WHICH PASS CRITERIA (SIGNAL-TO-NOISE NUMBER ABOVE THRESHOLD, GOOD GEOMETRY, ETC.) ARE PRINTED (A THROUGH H). THE CHARACTERS FOLLOWING STATION H REPRESENT DEAD-RECKONING (DR), LANE AMBIGUITY (LA), HARDWARE DEFECT ($).

VLF STATIONS: IF THE SET HAS VLF CAPABILITY, THEN USABLE VLF STATIONS (CODED A THROUGH G) ARE PRINTED; ALSO, THE SIGNAL-TO-NOISE NUMBERS FOR THE VLF STATIONS ARE PRINTED UNDER THE 11.2 SECTION OF SIGNAL TO NOISE NO., FOLLOWED BY A "V", WITH OMEGA S/N UNDER THE 10.2 AND 13.6 SECTIONS.

80-191-9

FIGURE 9. POINT-BY-POINT DATA LISTING, USABLE STATIONS (OMEGA/VLF)

CONTRIBUTOR 02 TRACOR 3 14 1980

CELL #	TIME			LAT			LONG		
493	23	0	0	48	1	37	-61	32	24
493	23	50	15	47	38	57	-62	18	7
493	23	50	58	47	35	56	-62	24	11
					3	15	1980		
493	0	52	28	43	6	38	-69	55	55
494	0	53	12	43	3	14	-70	0	20

TOP LINE ON PAGE: CONTRIBUTOR NUMBER AND OMEGA TYPE; DATE (MONTH, DAY, YEAR).

CELL NO: IDENTIFYING NUMBER OF A PARTICULAR 10° LAT BY 10° LONG AREA. DR AFTER CELL NO. = DEAD-RECKONING MODE, LA AFTER CELL NO. = LANE AMBIGUITY.

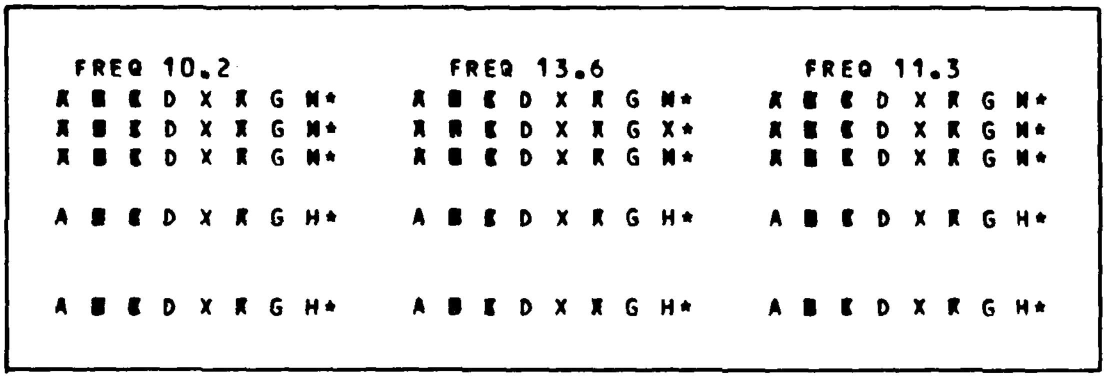
TIME: GMT IN HOURS, MINUTES, SECONDS

LAT: OMEGA-INDICATED LATITUDE IN DEGREES, MINUTES, SECONDS, (+ = NORTH, - = SOUTH)

LONG: OMEGA-INDICATED LONGITUDE IN DEGREES, MINUTES, SECONDS (- = WEST, + = EAST)

80-191-10

FIGURE 10. NAVIGATION HIGHLIGHTS IDENTIFICATION, DATE, CELL NUMBER, TIME, LATITUDE/LONGITUDE



FREQ 10.2: FOR THE 10.2 kHz FREQUENCY, A STATION LETTER (A THROUGH H) INDICATES USABLE SIGNAL-TO-NOISE NUMBER (S/N). A BLANK SPACE FOR A GIVEN STATION INDICATES S/N BELOW THRESHOLD. AN X INDICATES STATION DESELECTION; AN X SUPERIMPOSED UPON A STATION LETTER INDICATES ADEQUATE S/N, BUT DESELECTION DUE TO GEOMETRY OR STATION PROXIMITY. THE SYMBOL (-, /, *) APPEARING AFTER STATION H REPRESENTS FREQUENCY USAGE; - = NOT USED, / = USED TO FORM A DIFFERENCE FREQUENCY, * = SINGLE FREQUENCY USE. THE PRINTOUT IS ACTIVATED WHEN: THERE IS A CHANGE IN STATIONS WHICH ARE DESELECTED; S/N CROSSES THRESHOLD IN EITHER A POSITIVE OR NEGATIVE SENSE.

FREQ 13.6: SIMILAR TO ABOVE

FREQ 11.3: SIMILAR TO ABOVE

80-191-11

FIGURE 11. NAVIGATION HIGHLIGHTS USABLE STATIONS AND FREQUENCIES

XTRK	POS DIF
0.40	0.
0.80	0.
0.70	0.
-2.00	0.
-13.00	0.

XTRK: OMEGA-INDICATED CROSS-TRACK DIFFERENCE, IN NAUTICAL MILES; IF VALUE EXCEEDS 6 NMI, AN ASTERISK FOLLOWS THE VALUE. PRINTOUT IS ACTIVATED WHEN THE DIFFERENCE BETWEEN TWO CONSECUTIVE VALUES EXCEEDS 2 NMI.

POSDIF: RADIAL ERROR IN POSITION (NAUTICAL MILES) AS REFERENCED TO AN INDEPENDENT POSITIONING SYSTEM, IF AVAILABLE. AN ASTERISK FOLLOWS VALUES GREATER THAN 3 NMI. PRINTOUT IS ACTIVATED WHEN THE DIFFERENCE BETWEEN TWO CONSECUTIVE VALUES EXCEEDS 2 NMI; THIS HELPS TO INDICATE THOSE AREAS WHERE ADDITIONAL STUDY MAY BE NEEDED TO DETERMINE WHETHER OMEGA HAS MET THE CRITERIA FOR ENROUTE ACCURACY (BASED ON AC 20-101A FOR USA OVERLAND FLIGHTS; CRITERIA FOR OCEANIC NAVIGATION ARE LESS STRINGENT).

80-191-12

FIGURE 12. NAVIGATION HIGHLIGHTS CROSSTRACK, POSITION DIFFERENCE

RECEIVED SIGNAL QUALITY

TRACOR 7640 CONTRIBUTOR 02 8 25 12

8-25-79

STA	OUT	EVT	MEDN S/N 10	13	11	CELL NO.	STA	OUT	EV	MEDN S/N 10	13	11
AL		3	6	7	8	522	BL		3	6	8	9
AN			7	7	9	522	BN			7	8	9
AX						522	BX					
CL						522	DL					
CN						522	DN					
CX		3				522	DX	109	34	1	1	XX
EL		3	4	4	6	522	FL					
EN			4	5	6	522	FN			5	7	6
EX						522	FX		3	4	6	6
GL						522	HL		34	2	3	3
GN			7	7	6	522	HN					
GX		3	7	6	6	522	HX		4	2	4	3

TOP LINE: DATE (MONTH, DAY, YEAR); CONTRIBUTOR NUMBER; OMEGA TYPE, GMT AT END OF FLIGHT TIME (HOURS, MINUTES, SECONDS) WITHIN THE CELL.
STA: STATION LETTER (A THROUGH H); PROPAGATION PATH ILLUMINATION, L = TOTALLY LIGHT, N = TOTALLY DARK, X = MIXTURE OF DAY/NIGHT.
OUT: TOTAL OUTAGE TIME (MINUTES) FOR STATION WHILE AIRCRAFT TRAVERSED CELL; TOTAL DURATION LESS THAN 7 MINUTES IS OMITTED, GREATER THAN 999 MINUTES IS MARKED BY *.
EVT: EVENTS DURING FLIGHT; 1 = SOLAR X-RAY, 2 = POLAR CAP DISTURBANCE, 3 = MAGNETIC STORM, 4 = STATION POWER REDUCTION/OUTAGE, 5 = OMEGA EQUIPMENT PROBLEM.
MEDN S/N: THE MEDIAN S/N VALUE (NUMBER BETWEEN 1 AND 9), COMPUTED WITHIN A GIVEN CELL IS PRINTED FOR EACH FREQUENCY OF EACH STATION. XX = BELOW THRESHOLD; BLANK = NO DATA AVAILABLE.
CELL NO.: IDENTIFYING NUMBER FOR THE 10° LAT BY 10° LONG CELL.

80-191-13

FIGURE 13. RECEIVED-SIGNAL QUALITY LISTING

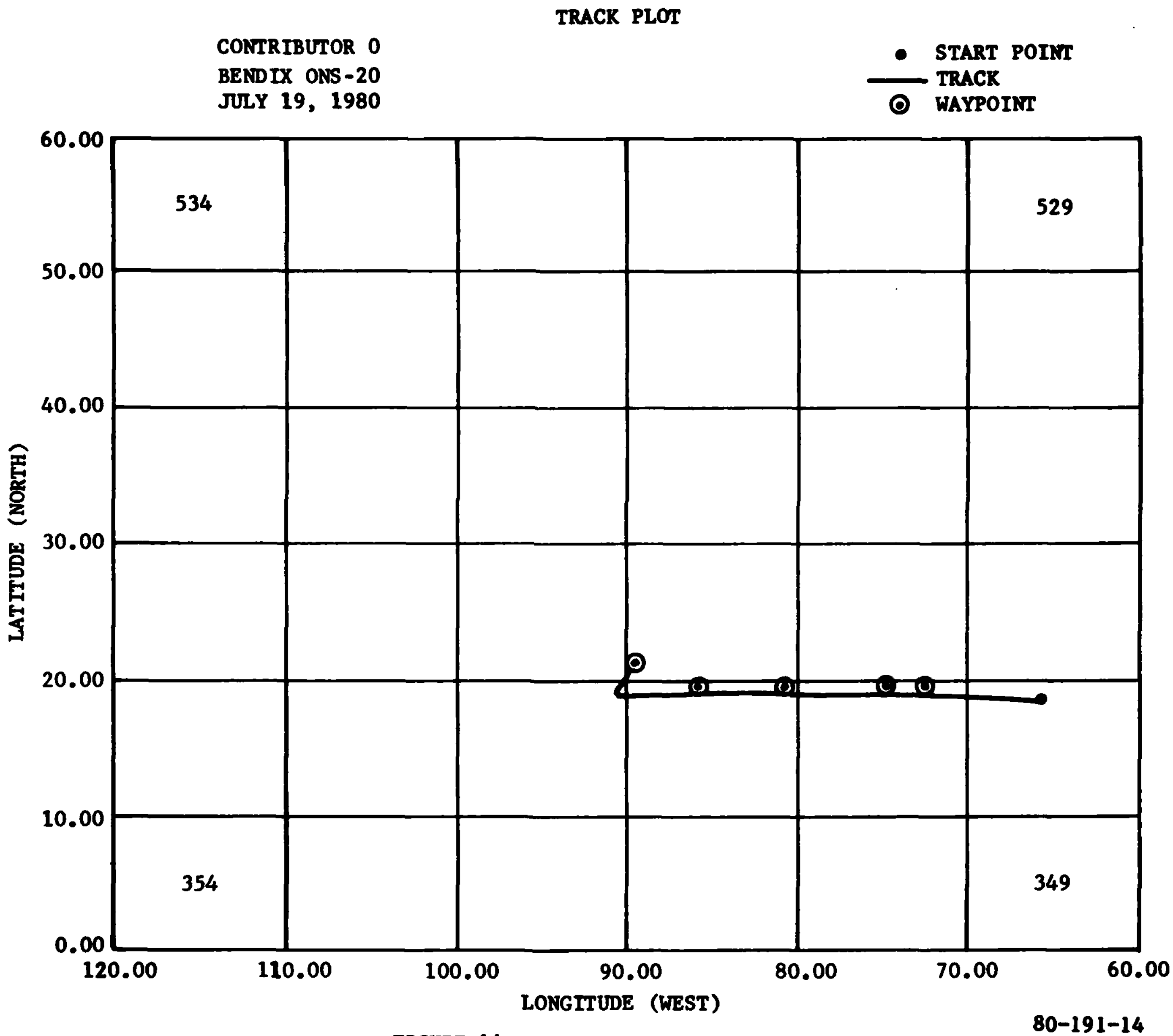


FIGURE 14. BASIC TRACK PLOT

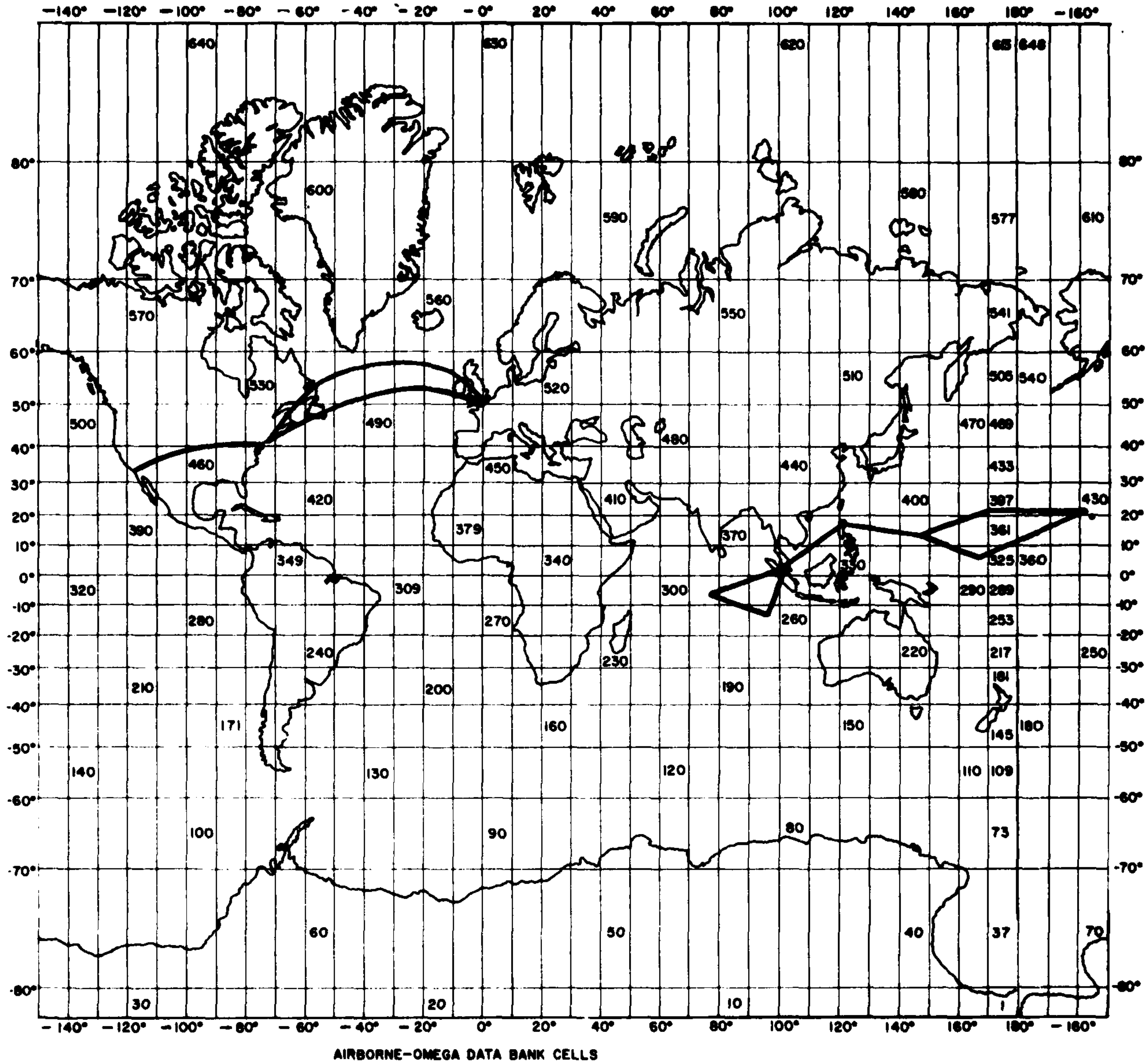


FIGURE 15. CONTRIBUTOR AIR ROUTES

magnitude of each event is given; there may be multiple events on a given day. Solar x-rays are classified according to their peak flux ("M" events have flux between 10^{-5} and 10^{-4} watt/m^2, "X" events have flux greater than 10^{-4} watt/m^2; the number following M or X acts as a multiplier). Only x-rays of flux M2 or greater are included in the list. The magnitude of a PCD is denoted by the maximum expected Omega position error, expressed in fractions of a 10.2 kHz lane. Magnetic storms are classified according to their Anchorage (high-latitude) K-index (ranges from 6 for minor storms to 9 for major storms). For transmitter outages, the identifying station letter (A through H) is printed under the "Magnitude" column. The Data Bank contains a listing of the above events beginning on March 1, 1979.

3. Operationally Usable Signals. Geographic charts (see figure 16), which include the air routes flown by each contributor, portray the stations which are normally used for navigation within each cell and the stations which are normally "deselected" automatically by the ONS. At any given time within a particular cell, the combination of stations which are usable for navigation depends upon various factors which alter the Omega signal propagation environment. (The earth-ionosphere waveguide, through which Omega signals propagate, varies in structure when there are changes in ground conductivity (ice cap versus seawater) or in ionospheric composition (diurnal, seasonal, geographic variations, and changes due to increased solar activity and magnetic storms); when the Omega signal encounters changing waveguide structure, higher order modes of propagation may begin to compete with the dominant first order mode (modal interference) and produce anomalous phase and amplitude values for the Omega signal.) Some factors have been mathematically modeled and are accounted for in the ONS software causing the ONS to deselect certain stations depending upon date, Greenwich Mean Time (GMT) and geographic location. For this reason, the dates and GMT of the flights appearing on each chart are noted. If signals have been deselected due to poor reception, the S/N listed for that particular station (A through H) will show an X, indicating the S/N is below receiver threshold level. The strongest signals will show S/N pegged at 9 and marginal signals will show relatively low S/N values. It should be noted that the S/N values presented here are not directly comparable among the different types of ONS; the S/N values

TABLE 3. EVENTS DURING FLIGHTS

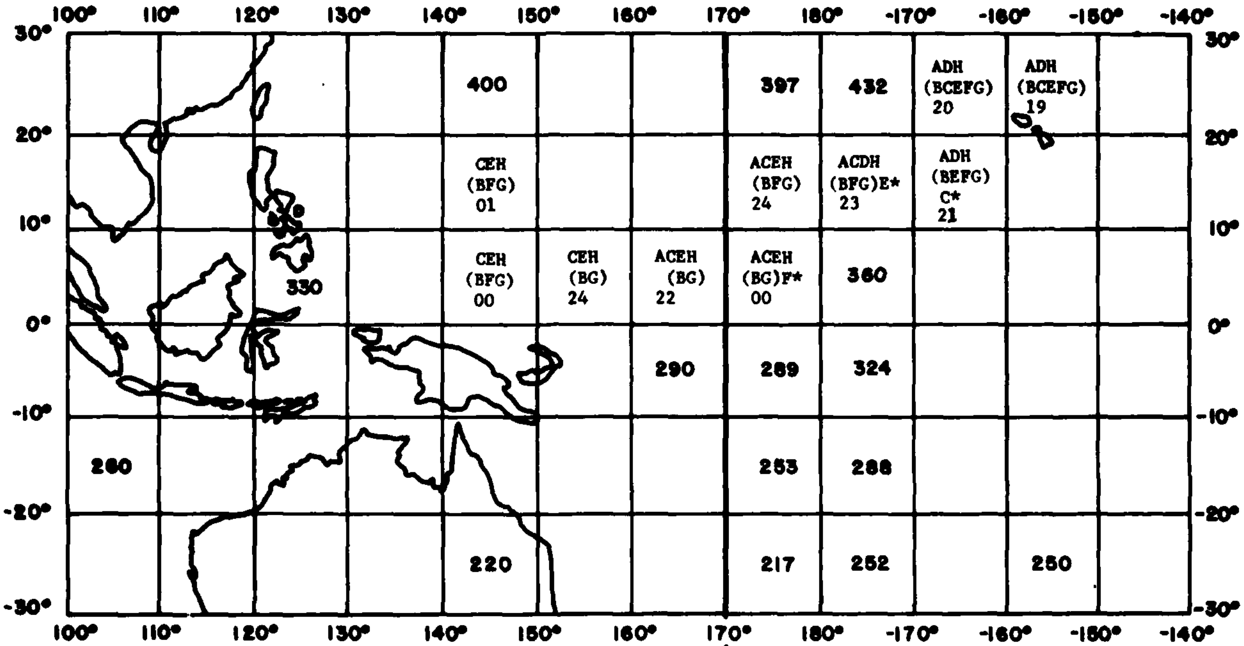
Contributor	Date	Event	Magnitude	Date	Event	Magnitude
1	3/26/79	1	M2	3/20/79	4	A
1	5/22/79	3	6	5/17/79	4	E
2	9/22/79	1	X1	2/6/80	3	8,6
2	1/14/80	2	1/3	2/3/80	4	B

AIRBORNE-OMEGA DATA BANK
OPERATIONALLY USABLE SIGNALS: WESTERN PACIFIC

10.2 kHz

(COMPOSITE DIAGRAM)

CONTRIBUTOR CODE: 01
AIRCRAFT CODE: 01
OMEGA CODE: 01
DATE: 9/11-14/78



		DATE: 9/13-14/78	DATE: 9/11-12/78		
A	X-7-3	MDN S/N NO.	MDN S/N NO.	A	1-9-8
B	X-5-2	10-13-11	10-13-11	B	X-4-2
C	7-9-9			C	9-9-9
D	X-5-1			D	2-9-7
E	7-9-9			E	5-9-9
F	X-2-1			F	X-2-1
G	X-2-1			G	X-1-X
H	9-9-9			H	9-9-9

NOTES: 1. STATIONS FOLLOWED BY AN ASTERISK SYMBOL WERE DESELECTED AT CERTAIN LOCATIONS WITHIN THE CELL, BUT NOT WITHIN THE ENTIRE CELL.
2. STATIONS IN PARENTHESES WERE DESELECTED THROUGHOUT THE ENTIRE CELL ALONG THE ROUTE FLOWN.
3. TWO DIGIT NUMBER BELOW STATIONS REPRESENTS GMT HOUR.

80-189-2

FIGURE 16. OPERATIONALLY USABLE SIGNALS: WESTERN PACIFIC

are provided for relative comparisons between stations and frequencies received by the particular ONS operated by the contributor.

4. Crosstrack/Along Track Position Differences for Dual ONS/INS Installations. For aircraft recording with ONS and INS, the mean and standard deviation of crosstrack and along track components of the position difference between ONS and the INS are computed (in nautical miles) from all data points (collected during the reporting period) within a given cell for each contributor. (Contributors, ONS type, and INS type are identified by a code number only.)

5. Highlights of Problem Areas and Propagation Events. The structure of this section is not rigidly defined but depends upon events or conditions (see table 1) which have affected Omega reception/navigation data collected by the contributors during the reporting period. Special plots may be generated to illustrate effects which have been noted in one or more flights and which may indicate the need for additional study.

6. Comments. Includes comments on the data, data collection methods, and overall effort.

FINAL REPORT. After the Data Bank has been in operation for approximately 2 years, a final report will be published. It will include: correlations of solar-geophysical events with ONS operational performance; empirical signal coverage charts (for each type of Omega set); range of variations noted between types of Omega sets under different signal environments (season, geographic location, and solar activity); statistics on Omega position differences with respect to INS; and information on possible degradation of performance of a given ONS over a long period of time.

PARTICIPATION: CURRENT AND FUTURE.

The FAA has signed agreements with Capitol International Airways, VARIG Airlines, Japan Airlines, and KLM Royal Dutch Airlines. Omega sets represented include Tracor 7640, Canadian Marconi CMA-740 or CMA-771, and Norden ONS VII.

The Initial Data Bank Report has been written (reference 4) based upon data collected by Contributor No. 2 on North Atlantic flights from August 1979 to February 1980 (268 data hours), and upon data collected by Contributor No. 1 on Pacific flights between September 1978 and May 1979 (172 data hours). This represents the first in a series of periodic technical reports which are expected to cover two years of data collection by Data Bank contributors.

In the near future, when Capitol, VARIG, Japan, and KLM Airlines are regular contributors the Data Base should begin incorporating flight data obtained from North and South Atlantic routes, and from routes between Japan and Indonesia. Airlines which have expressed interest but have not yet signed agreements include: Aeroflot, Polish LOT, and the Australian Department of Transport; Omega sets represented are Norden ONS VII and Litton LTN-211.

With additional air routes traveled, a substantial data base can be developed to provide statistical information on signal coverage degradation due to transequatorial signal path, modal interference, and antipodal interference.

Additional contributors will be sought so that flights will include more high latitude routes (very susceptible to solar disturbances), and routes which cross marginal coverage areas (reference 5) such as mid-North America, the Strait of Malacca (night) and the area around Tahiti (night).

Another capability of the Data Bank which has not yet been utilized (except for limited flights made by FAA aircraft) is the option available to contributors to record dual INS/ONS. In most cases, the FAA can supply an INS interface board for the Base Ten Recording system for those contributors who are interested in comparing ONS and INS positions.

CONCLUSION

The Airborne-Omega Data Bank is currently operating at a reduced level (one contributor), has generated its Initial Data Bank Report, expects to begin receiving cassette data from three more contributors, and anticipates signing agreements with three additional airlines in the near future.

The current status represents steady progress in implementing the plans reported at the World-Wide Omega Data Bank Conference and at the Third and Fourth Annual Meetings of the International Omega Association.

For further information, contact Lorraine Rzonca, ACT-100B.2, telephone FTS 8-346-3953, commercial (609) 641-8200, extension 3953.

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