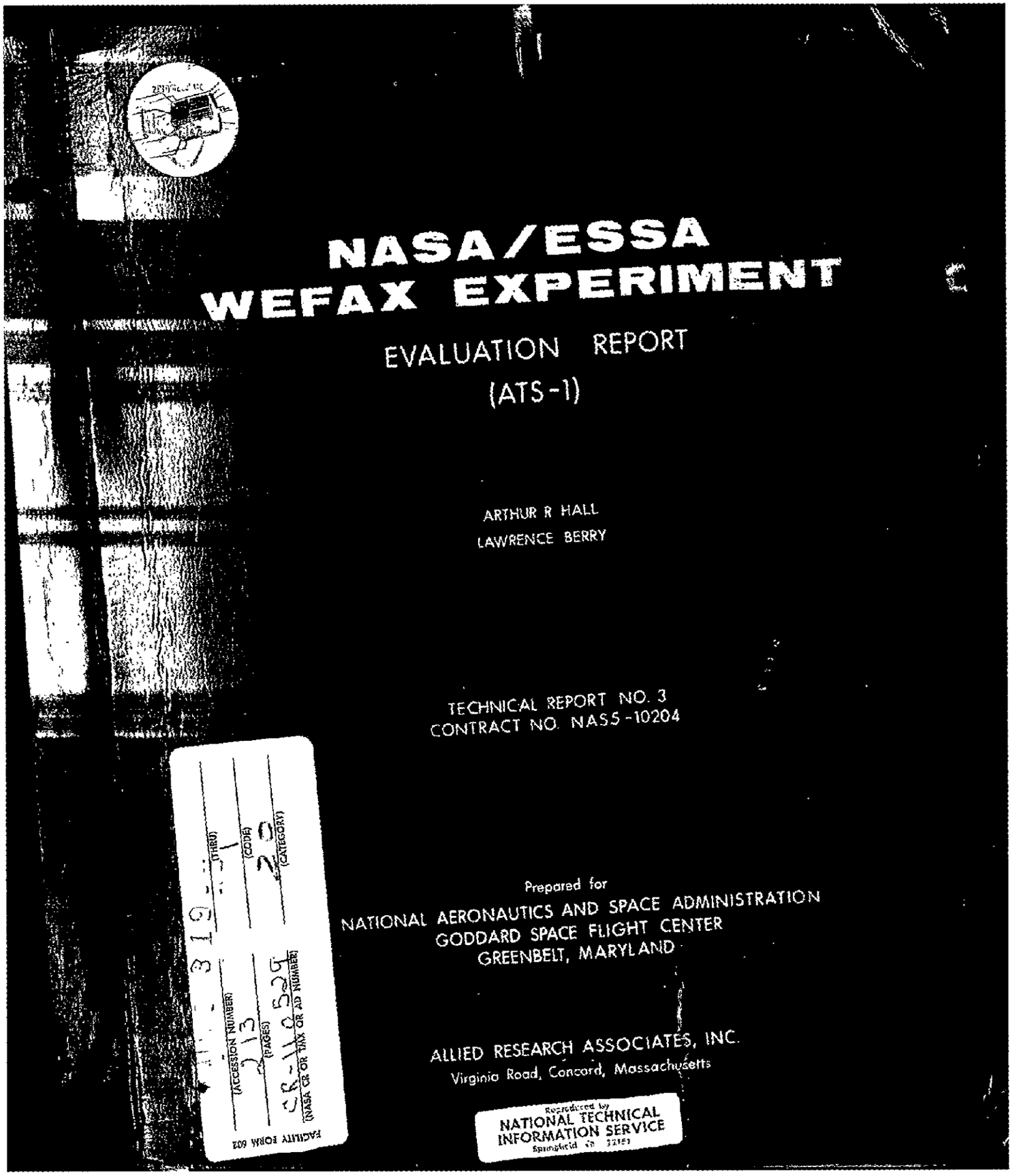

NASA/ESSA WEFAX EXPERIMENT

EVALUATION REPORT (ATS-1)

ARTHUR R HALL
LAWRENCE BERRY

TECHNICAL REPORT NO. 3
CONTRACT NO. NASS-10204

Prepared for
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND

ALLIED RESEARCH ASSOCIATES, INC.
Virginia Road, Concord, Massachusetts

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FOREWORD

The Evaluation Report was prepared by Allied Research Associates, Inc., Concord, Massachusetts; and was sponsored by the Systems Division, Goddard Space Flight Center, National Aeronautics and Space Administration, under Contract No. NAS 5-10204.

This report was prepared for Mr. Robert R. Drummond and Mr. Sheldon Wishna, the NASA WEFAX Experimenters, and Mr. David W. Holmes, the ESSA WEFAX Co-Experimenter. Mr. Wishna, as the NASA WEFAX Technical Officer, has provided excellent supervision, guidance, and technical support. Mr. Holmes has provided excellent operational support and coordination between ESSA and NASA, various branches of ESSA, and participating stations of the US government and stations of WMO member nations. Mr. William H. Risley, the NASA WEFAX Communications and Equipment Manager, has provided excellent assistance, especially in the various special WEFAX tests.

The authors wish to gratefully acknowledge the vast efforts of the participating APT stations in collecting, evaluating, and forwarding the WEFAX data. Without their valuable assistance and outstanding contributions, the WEFAX evaluations could not have been performed.

Valuable assistance has also been received from the personnel at the Mojave WEFAX Field Center; and in particular, Mr. William T. Harbour, the supervisor of the photo/gridding van and Mr. Robert Taylor, the supervisor of the APT van.

The authors are deeply indebted to various members of the Allied Research staff located in Concord, Massachusetts and at Goddard Space Flight Center. To Dr. Arnold H. Glaser, a special debt of gratitude is due for his sound guidance throughout the WEFAX experiment, and for his help in the preparation of this report. The authors are also obligated to Mr. James R. Greaves for his contribution of Appendix A. Acknowledgement is also due to Messrs. Leon Goldshlak, Ralph Newcomb, James Pike, and Paul Sherr for their review and editing of various portions of this report. Sincere thanks is also extended to Miss Monna R. Criss of the WEFAX staff for her invaluable assistance in the preparation of this report.

Mr. Arthur R. Hall, the WEFAX Coordinator, is the principal author of this report. Mr. Lawrence Berry, the co-author, conducted many of the evaluations from launch through April 1967. Mr. Louis Novotny, beginning in May 1967, has performed much of the evaluation and statistical work for this report.

ABSTRACT

This report covers the efforts of Allied Research Associates, Inc. for the Systems Division, Goddard Space Flight Center, National Aeronautics and Space Administration, under Contract No. NAS 5-10204.

The scope of the contract was to provide operational support and data utilization and evaluation services for the ATS-B WEFAX experiment. Supporting documents prepared include:

- Monthly Progress Reports (Sept 66-Feb 68)
- WEFAX Experiment Participant's Guide (Nov 66)
- WEFAX Experiment Program Plan (Dec 66)
- WEFAX Experiment Evaluation Report (Feb 68)
- WEFAX Experiment portion of ATS Technical Data Report (Feb 67 - Feb 68)

The WEFAX Experiment demonstrated that it is feasible to disseminate meteorological data from a central source through an earth synchronous satellite to widely scattered receiving units. Usable reception can be assured 95% of the time. Equipment presently in use for transmitting, relaying, and receiving WEFAX data is sufficiently capable and reliable. These conclusions are based upon the evaluation of the reception of nearly 50,000 WEFAX charts and pictures.

WEFAX has provided useful and needed meteorological data, which was previously not available to many weather stations. Worldwide cloud cover pictures from ESSA meteorological satellites, available only at the National Environmental Satellite Center, Suitland, Maryland, can be processed and transmitted over WEFAX. WEFAX has proven the operational feasibility of utilizing earth synchronous satellites for worldwide meteorological data communications.

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SECTION 1

INTRODUCTION

This report was prepared by the evaluation group of the WEFAX Experiment and presents the results of the experiment.

1.1 SCOPE

This report covers the period from launch of the ATS-1 spacecraft (6 December 1966) through 31 December 1967. The evaluations of the WEFAX transmissions during January through December 1967 are discussed and documented in separate monthly sections. The actions taken by the experimenters during December 1966 to prepare and test the WEFAX transmission system in both normal and emergency modes are briefly discussed. The major problems encountered during the experiment, and the experiment conclusions are also presented.

1.2 EXPERIMENT OBJECTIVE

The objective of the Weather Facsimile (WEFAX) Experiment is to determine, by actual demonstration, the feasibility of disseminating meteorological data and satellite cloud camera pictures from a central weather station source to widely scattered remote weather stations or receiving units. Weather facsimile charts and satellite cloud cover pictures were sent periodically, via landline, from the National Meteorological Center, Environmental Science Services Administration (ESSA) at Suitland, Maryland, to the NASA Mojave ATS ground station near Goldstone Lake, California. From there, the charts and pictures were transmitted to the ATS-1 satellite for relay via the VHF transponder in the spacecraft to all participating APT stations within the area of reception of the satellite. Satellite cloud camera pictures from the ATS-1 spacecraft after appropriate photographic processing were retransmitted through the ATS-1 spacecraft directly from the NASA Mojave ATS ground station.

1.3 PARTICIPATING STATIONS

During December 1966, responses to the Invitation Brochure which asked for voluntary participants in the experiment were received from 21 private users. Combined with the ESSA, DOD and WMO member nation stations committed to the project, a total of 49 participants initially joined in the data collection program. A few

additions and deletions have been made to the list since the start of the experiment, but normally approximately 50 stations were considered as participating. Several other stations received some of the WEFAX transmissions, but did not submit any reports or data for evaluation. Table 1-1 is a list of participants from which evaluation data have been received.

TABLE 1-1

LIST OF PARTICIPATING WEFAX APT STATIONS

NASA
- *GSFC, Greenbelt, Maryland
- *Mojave ATS Facility, California
- Toowoomba, Australia (Cooby Creek ATS Station)

ESSA
- New Orleans, Louisiana
- Great Falls, Montana
- *San Francisco, California
- *Seattle, Washington
- *Anchorage, Alaska
- Honolulu, Hawaii
- *Wake Island, Pacific

USAF
- MacDill AFB, Florida
- *Howard AFB, Canal Zone
- Petersen Field, Colorado
- Vandenberg AFB, California
- AFSCF, Sunnyvale, California
- Elmendorf AFB, Alaska
- *Kunia Forecast Center, Hawaii
- *Fuchu AS, Japan

USN
- *Point Mugu, California
- San Diego, California
- Pearl Harbor, Hawaii
- *Guam, Marianas
- *Christchurch, New Zealand
- Yokosuka, Japan
- USS Constellation, Pacific
- USS Ranger, Pacific
- USS Oriskany, Pacific

WMO MEMBERS
- Ottawa, Canada
- *Toronto, Canada
- *Papeete, Tahiti
- *Melbourne, Australia
- *Tokyo, Japan

PRIVATE STATIONS

United States:
- *WLAC-TV, Nashville, Tennessee
- *WTVT, Tampa, Florida
- KSST, Sulphur Springs, Texas
- *Northern State College, Aberdeen, South Dakota
- Mr. G. Andrews, Miami, Florida
- Mr. A. Burton, Richmond, Virginia
- *Mr. J. Goode, Lake Jackson, Texas
- Mr. R. Jones, Tulsa, Oklahoma
- Mr. K. Learner, W. Lafayette, Indiana
- Mr. J. Spillane, Seattle, Washington
- Mr. G. Toben, Mountain View, California

Canada:
- Weather Eng. Corp. of Canada, Dorval, Quebec
- Mr. D. Sloan, Vancouver, B.C.

Australia:
- University of Melbourne, Melbourne

Japan:
- Radio Research Lab, Kashima
- *Mr. Y. Miura, Aichi
- Mr. I. Yamaguchi, Tokyo

* Indicates major contributors.

SECTION 2

DECEMBER ENGINEERING TESTS

Engineering tests, utilizing the entire operational procedures on a limited basis, were conducted during December. On 12 December 1966 the WEFAX experiment was given a 10 minute period for its initial test using the spacecraft. The WEFAX test chart was transmitted from Mojave, since the WEFAX landline from Suitland, Maryland was not considered quiet enough for operational use. The transmitted test chart was received at Goddard Space Flight Center and the qualify to reproduction was considered excellent. Figure 2-1 is a photographic copy of the actual facsimile reception as received at Goddard Space Flight Center.

On 15 December 1966, notification, by means of a teletype message (TBUS-3), was given to all participants that engineering tests of the WEFAX system would be conducted one hour each day (0900Z - 1000Z) until further notice. All receiving stations were asked to monitor the transmissions, when possible, and furnish the experimenters with comments. Comments were received from 9 ground stations; many of which sent samples of the transmissions they had received. Table 2-1 is a list of sample comments.

On 14 December 1966, a one hour (0900Z - 1000Z) daily transmission schedule was initiated. During December, 21 WEFAX test charts and 62 weather charts were sent from Suitland to Mojave for transmission via WEFAX. Also during the period, 43 spin scan cloud camera pictures, 20 WEFAX test charts, and 8 weather charts were transmitted over WEFAX from the Mojave APT van. Figures 2-2, 2-3, and 2-4 are samples of reception during December.

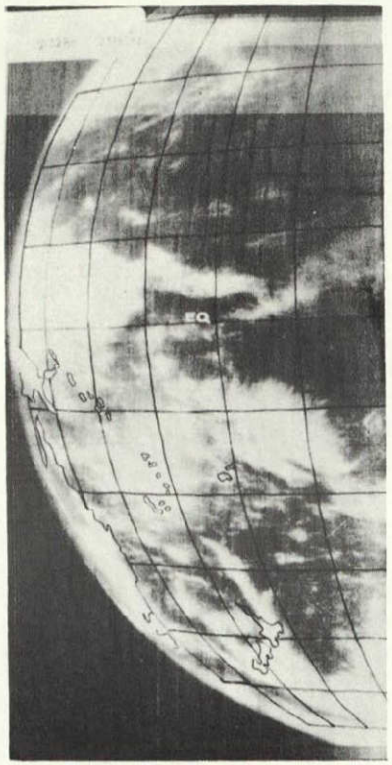
The facsimile reproductions received at the APT ground stations at Mojave and GSFC were used to obtain reception data for the initial phase of the WEFAX experiment. Intermittent receptions of transmissions were also made by several interested ground stations during December. Toronto, Canada forwarded evaluations and reception samples covering seven days of data received, which included excellent receptions recorded on a photo-facsimile recorder. A thorough study of the receptions at Mojave (antenna elevation angle 36^{o}) and GSFC (antenna elevation angle 4^{o}) afforded a reasonable indication that all stations within the spacecraft acquisition area would obtain good to excellent chart and picture copies as the experiment progressed. No major problems were encountered in the transmission and reception of weather

Figure 2-1 First WEFAX Transmission

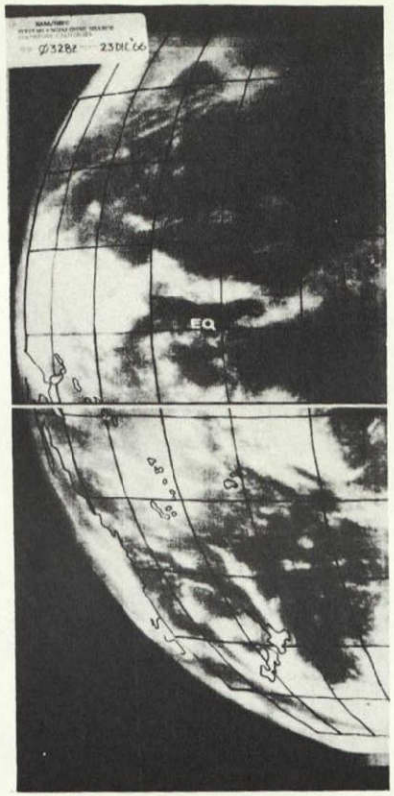
TABLE 2-1

Sample Comments from Participating APT Stations
(December 1966)

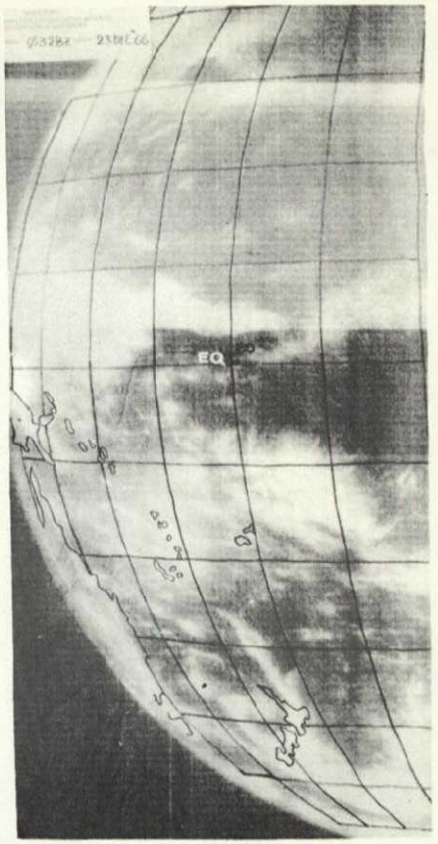
Station Location	Date	Comment
Melbourne, Australia	16 Dec	Nephanalysis quality better than most landline transmissions.
	17 Dec	Charts good as or better than, landline quality but pictures somewhat noisy.
	18 Dec	Gridded pictures in black ink seem to be superior to the white india ink. The outlined coastlines are most beneficial to picture interpretation.
	19 Dec	All charts and pictures were operationally usable.
	22 Dec	SSCCE picture contrast very low.
Toronto, Canada	23 Dec	Pictures given to personnel in Research Section for examination. Pictures given to local TV weatherman as part of explanation of ATS-1 operation.
	28 Dec	Not utilized as quality poor. Heavy noise interference throughout all charts attributed to local transmitter.
	31 Dec	Signal strength below that of previous transmissions. Cause unknown.
Fuchu AS, Japan	20 Dec	Only the spin scan picture and the S. H. analysis were good enough to be usable. Signal strength received will have to be increased somehow in order to make WEFAX usable to us.
	22 Dec	Charts used again by Prog forecasters in comparing with current Fuchu charts.
	24 Dec	Approximately 25 minutes of data lost because of radio interference and apparent weak signal.



Received at Toronto,
Canada (Elev. Angle 3°)



Received at GSFC
(Elev. Angle 8°)



Received at Mojave
(Elev. Angle 38°)

Figure 2-2 Sample of SSCC Pictures (Dec)

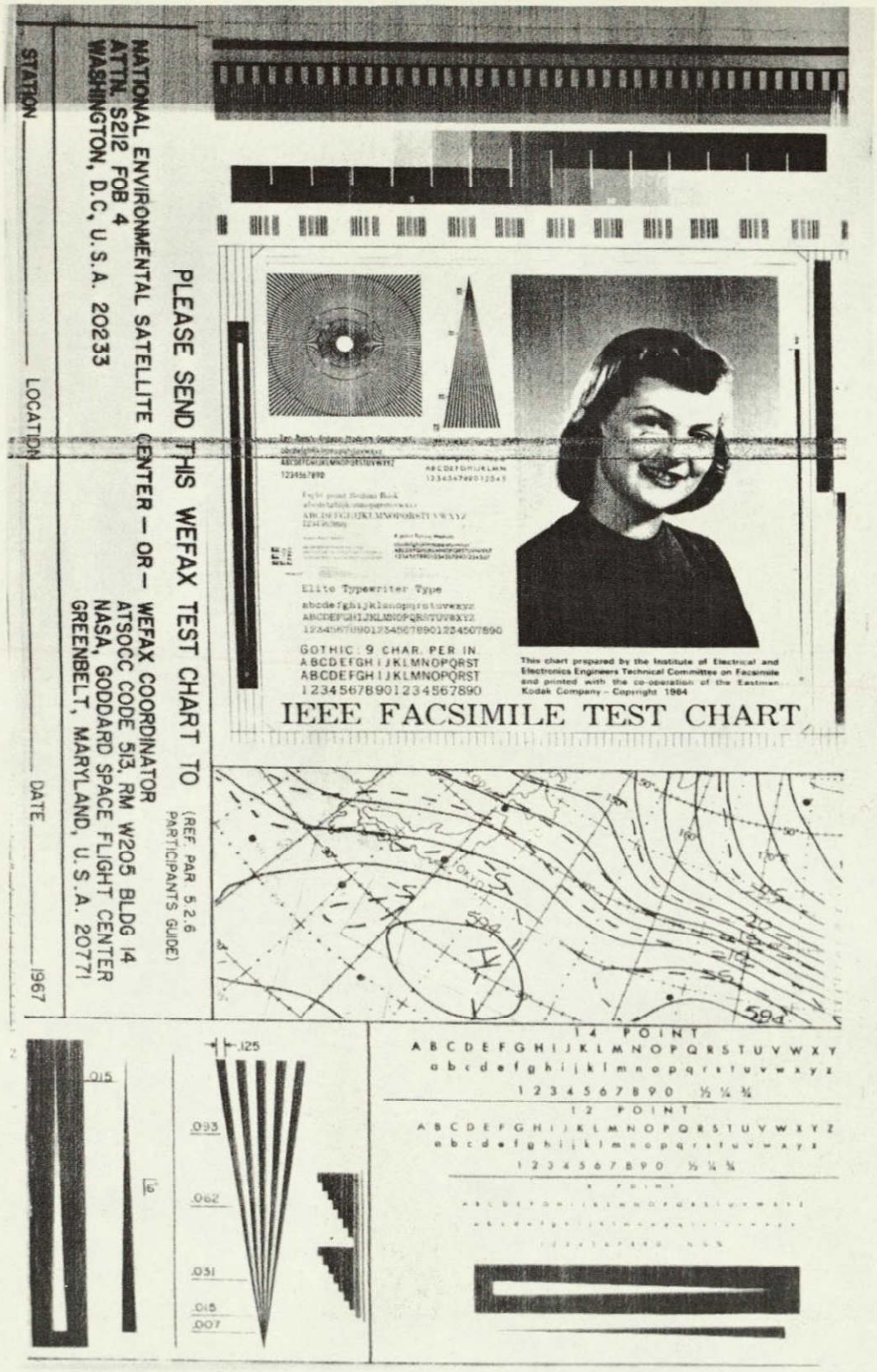


Figure 2-3 WEFAX Test Chart Reception

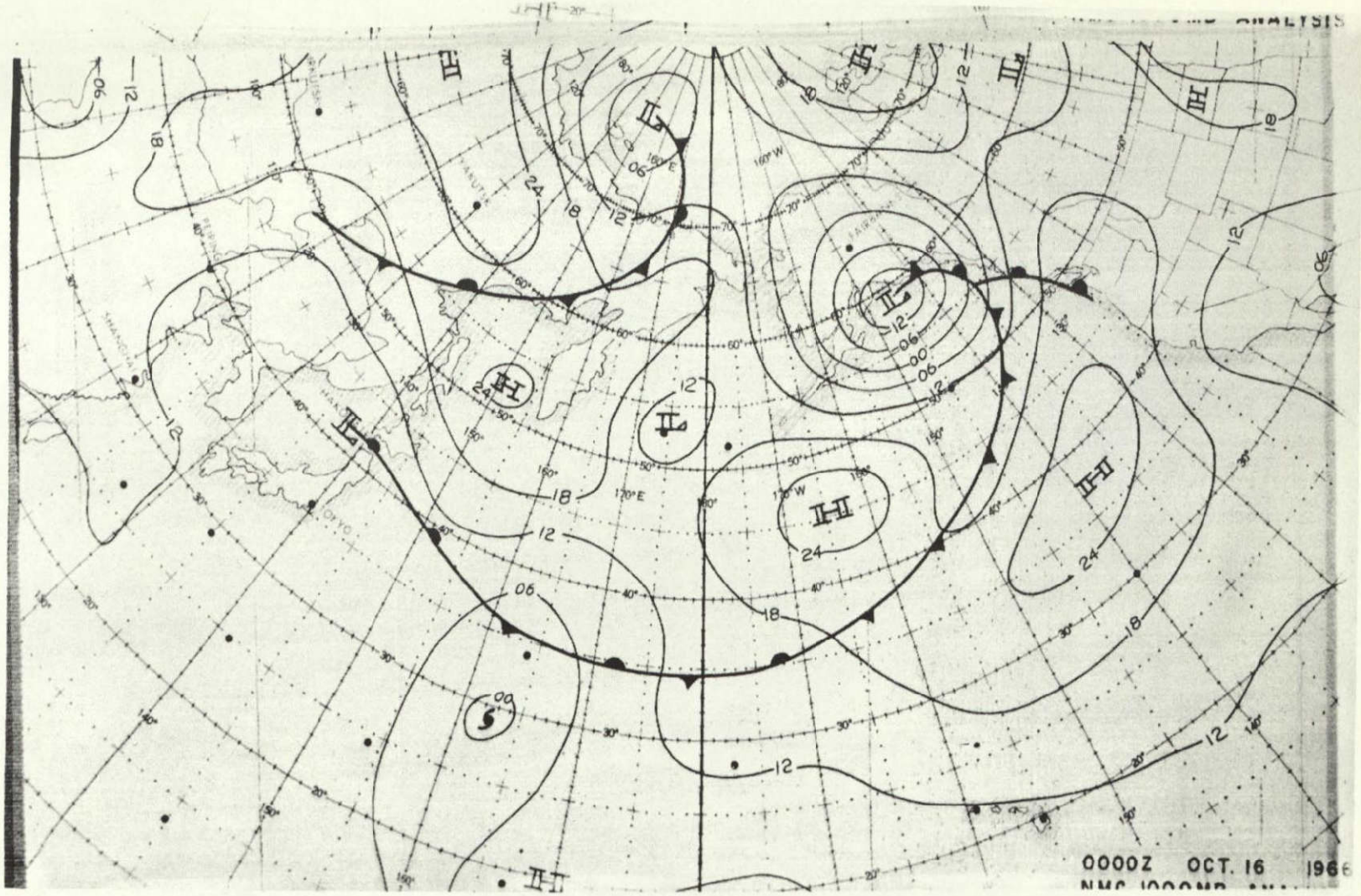


Figure 2-4 WEFAX Weather Chart Reception

charts, although the occasional high noise level in the Suitland to Mojave landline tended to degrade the quality of receptions (see Table 2-2). The transmission and reception of the spin scan camera pictures however, were not considered adequate for the purposes of the WEFAX experiment. Reception of the pictures at Mojave, with its high antenna elevation, was considered fair to good but excessive loss of detail was constantly noted and the dynamic range of the transmissions was much too low. Tests, consisting of various sized enlargements from 8-1/2" by 11" to 25" by 33" and use of various photo paper sensitivities and numerous exposure times, were conducted and monitored at both Mojave and GSFC. Only slight improvement was found to be possible with the existing equipment. The problem became further compounded by the failure of the normal contrast mode of the Electronic Imaging System which formulates the negatives. On 28 December 1966, the transmission of cloud camera pictures via WEFAX was temporarily discontinued. Cloud camera picture tests continued over a closed loop in an attempt to solve this problem.

WEFAX test charts transmitted during December were evaluated for reception difficulties using copies of test charts returned from several receiving stations. Figure 2-5 shows the results of this evaluation covering the period 14-31 December 1966. Local interference, mostly caused by VHF signals from nearby aircraft operational facilities, presented the greatest reception difficulty. Since only 68 WEFAX test charts were evaluated, the results were not considered to be conclusive.

The WEFAX test chart was the first chart scanned during each scheduled transmission period. Charts were scanned at Suitland, Maryland, sent via facsimile landline to Mojave and transmitted over VHF (149.0 MHz) to the spacecraft (ATS-1) and retransmitted to the ground by the VHF transponder (135.6 MHz). Test charts that were evaluated were received at Goddard Space Flight Center; Mojave APT Station; Kunia, Hawaii; Fuchu AS, Japan; University of Melbourne, Australia; WBAS Wake Island; Tampa, Florida; and WBAS San Francisco, California. No attempt was made to correlate the type or arrangement of receiving equipment used. Also, no consideration of the type of operator (skilled or unskilled) was entered into the evaluations even though such skill is a variable quality. Chart evaluations were subjective, but all were performed by one individual. Charts, except those received at GSFC were subjected to slight deterioration in quality prior to the evaluation by exposure to light and temperature. However, only very small statistical errors were introduced by this circumstance.

TABLE 2-2

Classification of WEFAX Receptions of
Weather Charts and Spin Scan Pictures
(December 1966)

APT Receiving Stations	Weather Charts					Satellite Pictures				
	Exc	Good	Fair	Poor	Unusable	Exc	Good	Fair	Poor	Unusable
GSFC, Maryland	26	26	7	9	20	2	7	8	15	12
Toronto, Canada	37	20	17	0	0	7	9	1	0	0
Fuchu, Japan	0	27	22	18	19	0	1	1	6	3
Melbourne, Australia	0	17	12	14	17	0	0	2	12	5
Univ Melbourne,. Australia	1	30	0	0	0	0	29	7	1	0
Guam, Marianas	5	21	5	4	2	0	1	2	0	0
Mojave, California	53	20	2	11	0	0	13	4	13	2
San Francisco, California	37	12	3	0	1	1	5	3	1	3
Wake Island, Pacific	2	4	2	1	1	7	10	8	0	0
Kunia, Hawaii	2	2	0	1	0	0	3	3	0	0
TOTALS	163 (31%)	180 (34%)	70 (13%)	58 (11%)	60 (11%)	17 (8%)	78 (38%)	39 (19%)	48 (23%)	25 (12%)

Classification Guidelines

	Legible Information Available	Quality
Excellent	100% of data	Less than 10% imperfections
Good	At least 90% of data	Less than 30% imperfections
Fair	At least 70% of data	Less than 40% imperfections
Poor	At least 50% of data	Less than 50% imperfections
Unusable	Less than 40% of data	More than 75% imperfections

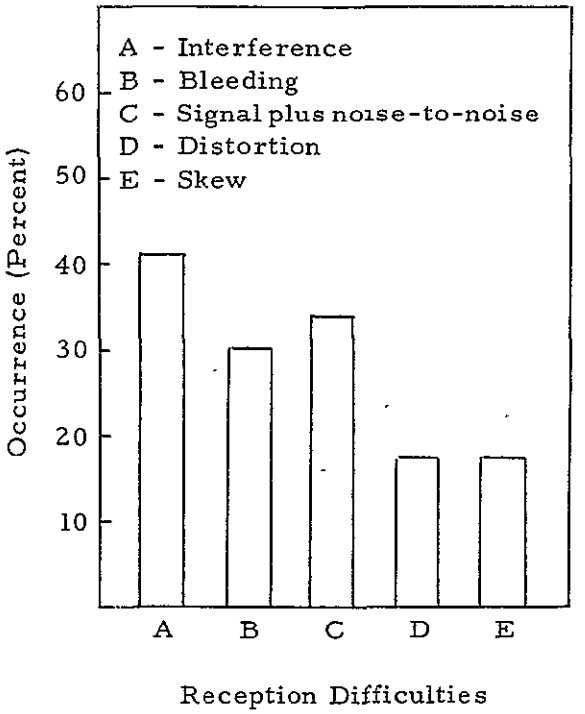


Figure 2-5 WEFAX Experiment, Facsimile Reception Difficulties Occurring at 9 APT Receiving Stations During 14-31 December 1966. 68 WEFAX Test Charts Evaluated.

A - Interference - Visible patterns appearing on chart format as a result of external signal sources or internally generated beat frequencies.

B - Bleeding - Smearing and presentation on white areas by black.

C - Signal plus noise-to-noise - White or black streaks on chart, uniformity of tonal shades, snow effect.

D - Distortion - Large scale geometric deviation from time pattern.

E - Skew - Deviation of a vertical line from a vertical normal. Test limit 1/4" in 8".

SECTION 3

JANUARY EVALUATION

Data collection for the WEFAX experiment statistical study was initiated on 2 January 1967. The reception data furnished by the several stations during the initial systems alignment in December (see December Evaluation) were recorded and used in refining WEFAX transmission techniques but were not considered representative of the actual capabilities of the WEFAX transmission procedures. Thus, the limited responses, as received during December 1966, were not entered into the reception statistics of the WEFAX feasibility study even though they provided an excellent initial estimate of WEFAX transmission possibilities.

A regularly scheduled two hour WEFAX transmission schedule (0900Z - 1100Z daily) was established on 3 January 1967 and rigidly observed until 31 January 1967. Loss of one period (24 January 1967) was the only exception to an otherwise uninterrupted evaluation of WEFAX capabilities. Transmissions originated entirely from Suitland, Maryland during 2-5 January as cloud camera pictures were not available for transmission since efforts were being made to improve the contrast and dynamic range of the enlargements to be scanned and the scanner itself. The Suitland transmissions consisted of fairly current weather charts from ESSA sources and copies of the WEFAX test chart. Test charts were to be returned by the participants to the WEFAX Coordinator for evaluation purposes.

On 6 January and again on 7 January a cloud camera picture was added to the schedule. It was concluded, after checking the reception of these pictures at GSFC and Mojave, that our picture transmitting capabilities were adequate to allow

effective evaluation and probably as refined as the scanner method of transmission would allow. On 8 January cloud camera pictures were added to the regular WEFAX schedule to be transmitted from Mojave. Generally, a full-disk spin scan picture was used, however, availability of a suitable negative was the determining factor.

A special data collection period was designated from 3 through 12 January 1967. This special period allowed the participants, who normally engage in the experiment on a part-time basis, to plan their schedules and supplies accordingly and furnish the experiment with simultaneous receptions from many different locations. Information during this selected period and during the whole of January was received from 26 different ground stations. A total of 3810 charts and 1176 cloud camera pictures were classified during January (See Table 3-1).

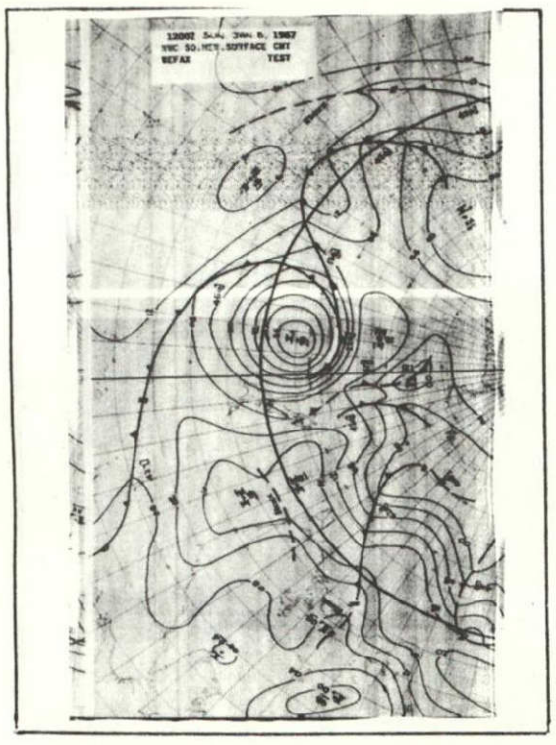
Figure 3-1 shows a comparison of the quality of reception of a weather chart transmitted over WEFAX on 9 January 1967 and received on paper facsimile recorders at Goddard Space Flight Center, Seattle, Washington and Anchorage, Alaska. In all three cases, nearly 100% of the data is legible with a small percentage of imperfections on each chart. While interference can be noted on all charts, the usability of the charts by meteorologists is only slightly affected.

Figure 3-2 shows a comparison of the quality of reception of spin scan cloud pictures transmitted over WEFAX on 11 January 1967 and received on paper facsimile recorders at Mojave, Wake Island and Seattle, Washington. Transmissions were made in four overlapping sections and assembled into one picture after receipt. A slight deterioration in the black to white contrast can be attributed to exposure of the paper to light and temperature prior to photographing. The original size of the

TABLE 3-1

Classification of WEFAX Receptions of
Weather Charts and Spin Scan Pictures
(January 1967)

APT	Weather Charts					Spin Scan Pictures				
Receiving Stations	Exc	Good	Fair	Poor	Unusable	Exc	Good	Fair	Poor	Unusable
Toronto, Canada	46	195	46	44	8	0	35	3	8	0
GSFC, Maryland	149	140	54	25	22	14	38	48	22	5
Fuchu, Japan	9	124	124	63	18	3	32	10	4	1
Howard AFB, C. Z.	0	14	37	18	6	0	1	20	0	13
Kashima, Japan	16	19	8	3	0	15	10	5	0	0
MacDill AFB, Fla.	47	27	3	5	5	13	13	7	16	10
Nashville, Tenn.	6	14	19	7	3	0	26	1	2	0
Tampa, Florida	8	27	61	14	18	13	9	8	5	3
Melbourne, Australia	18	61	64	49	28	0	10	32	34	5
Guam, Marianas	18	59	33	24	5	8	8	0	1	9
New Orleans, La.	4	54	51	23	0	9	29	0	0	0
Anchorage, Alaska	137	110	17	15	6	74	22	4	0	0
Lake Jackson, Texas	18	6	7	4	2	3	8	6	2	0
Seattle, Washington	0	19	36	49	33	0	3	26	10	0
Mojave, California	261	118	14	3	8	57	58	19	1	1
Christchurch, N. Z.	66	34	106	31	10	36	49	15	0	1
Pt. Mugu, Calif.	79	40	4	5	13	19	0	1	2	12
Wake Island, Pacific	74	78	34	4	0	39	15	3	2	3
San Francisco, Calif.	36	68	18	7	7	0	19	7	2	0
Kunia, Hawaii	14	79	17	15	6	0	32	4	0	0
Papeete, Tahiti	91	42	12	9	5	15	31	7	1	9
TOTALS	1097	1328	765	417	203	318	448	226	112	72
	(29%)	(35%)	(20%)	(11%)	(5%)	(27%)	(38%)	(19%)	(10%)	(6%)

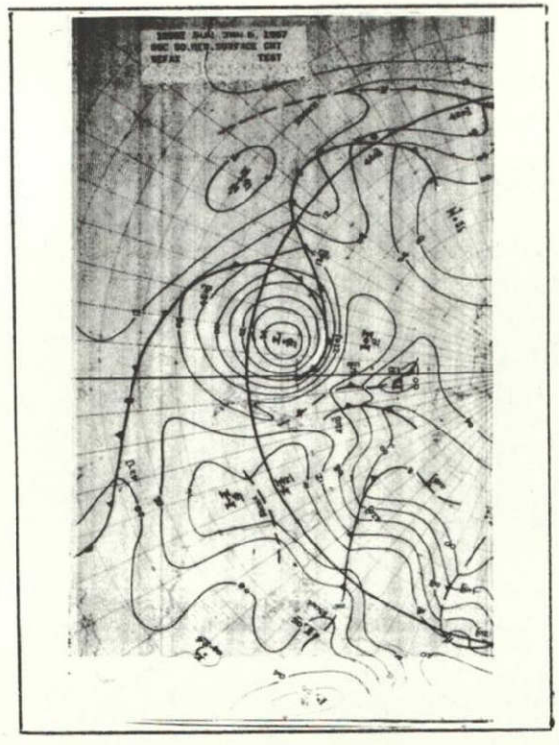


S. H. Surface Chart
Received 9 Jan 67

at

GSFC

Excellent reception even though not perfectly phased and strong interference near top of picture.

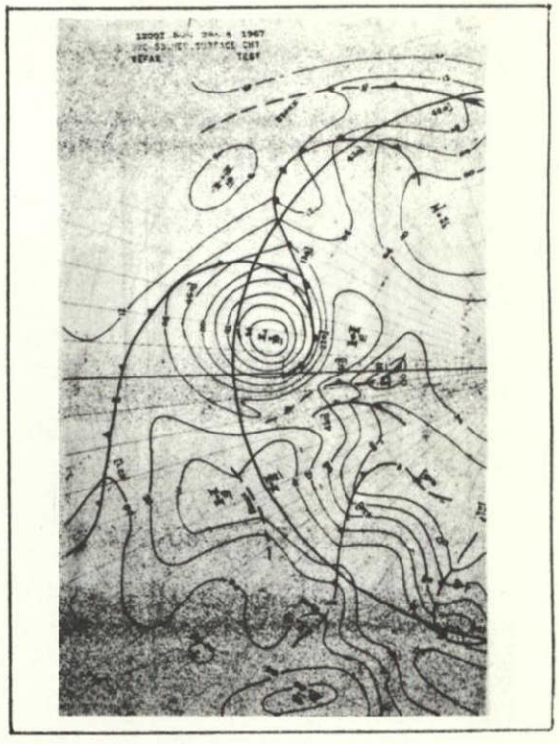


S. H. Surface Chart
Received 9 Jan 67

at

WBAS Seattle

Excellent reception even with light sporadic interference and less signal strength near end of picture.



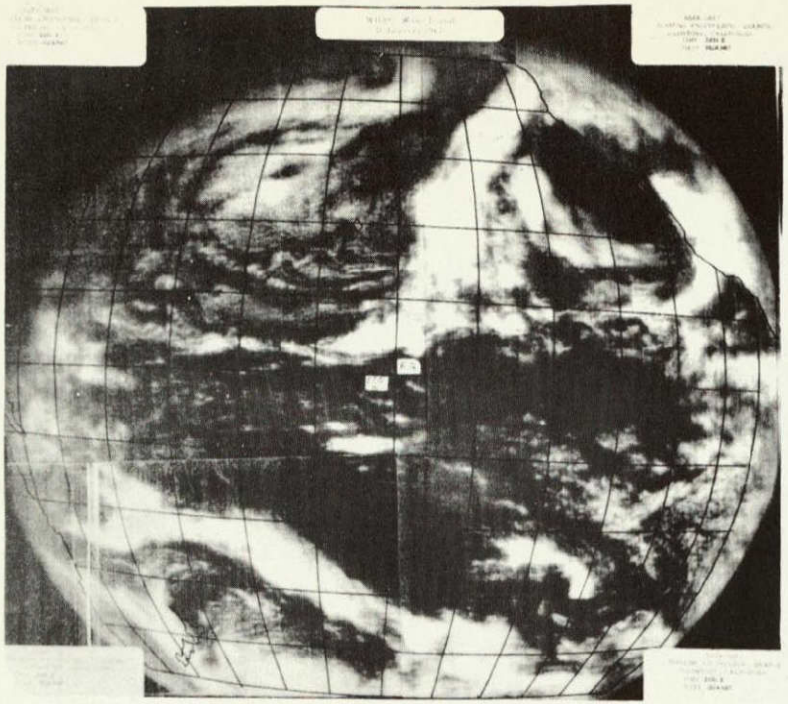
S. H. Surface Chart
Received 9 Jan 67

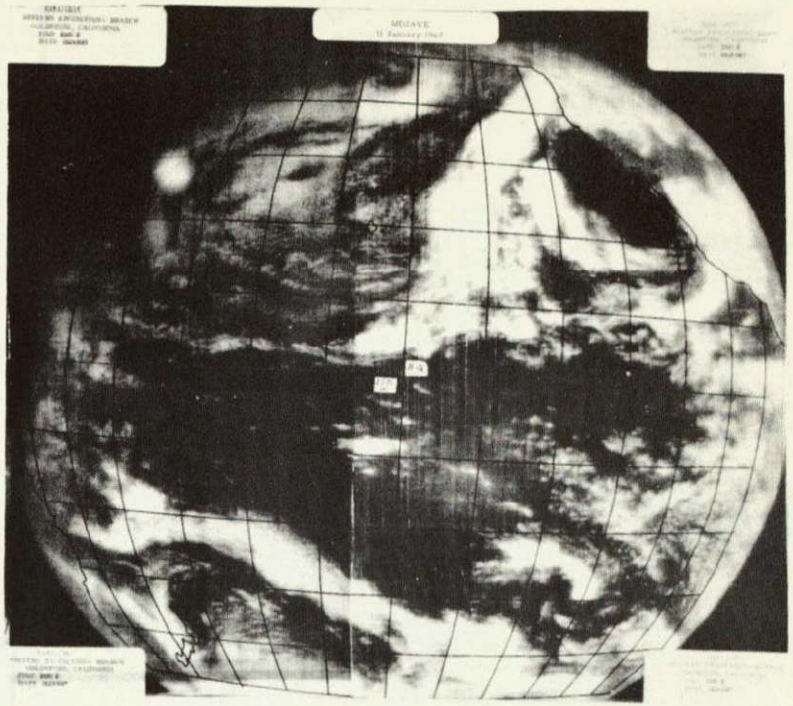
at

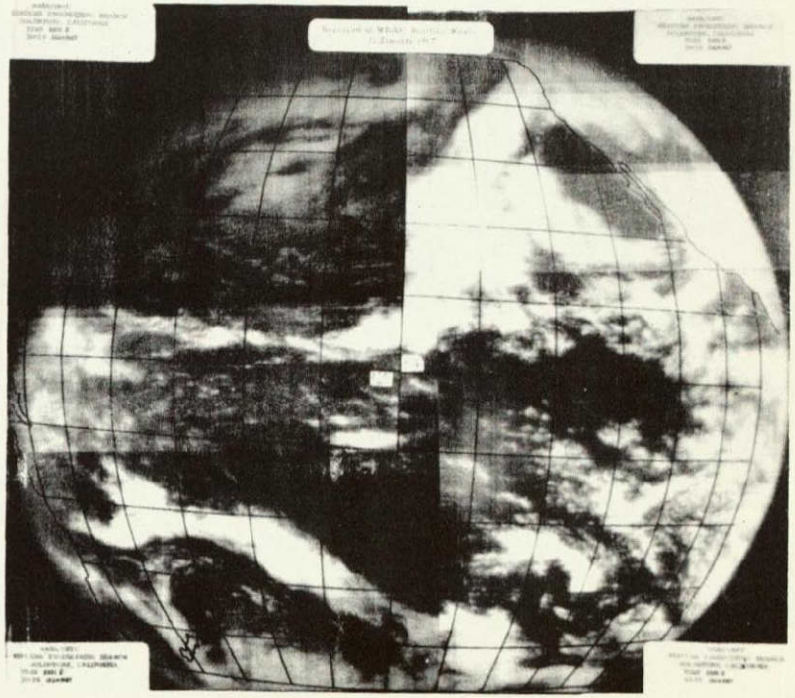
Anchorage, Alaska

Excellent reception, even considering the strong interference and noise level present throughout reception.

Figure 3-1 Simultaneous Weather Chart Reception







Three spin scan cloud pictures received over WEFAX simultaneously at Mojave (upper right); Wake Island (upper left) and Seattle (lower right)

Pictures were transmitted in four separate frames and fitted together for display after receipt. All receptions were made on a paper facsimile recorder.

Note: Saturated cloud area over N. Central Pacific, as shown on the Seattle reception, was caused by local reception difficulties.

Figure 3-2 Three SSCC Pictures

complete pictures, as received, was approximately 15" by 13". Each section of these pictures was graded as either excellent or good.

Figure 3-3 shows a comparison of simultaneous picture reception at Papeete, Tahiti (elevation angle 68^{o}) on a paper facsimile recorder and Goddard Space Flight Center, Maryland (elevation angle 8^{o}) on a photo facsimile recorder. The size of the complete original picture as received on a paper facsimile was approximately 15" by 13" and over the photo facsimile was approximately 7" by 5". Both pictures, when compared to the original enlargement (top center) as transmitted from Mojave, show only slight loss of detail during transmission with the photo facsimile showing less loss of detail than the paper facsimile reception.

Figure 3-4 shows the reception percentage of both weather charts and spin scan cloud pictures that were classified in the excellent or good category during January. Percentages are arranged for descending increments of elevation angles. Reception quality, which should seemingly be a function of the angle of acquisition, is not indicated by the January statistics although, with the exception of the 31^{o} - 44^{o} group of stations, weather chart quality does show poorer receptions as the angle decreases. The exception may be explained somewhat by the fact that three of the four stations in this category are ones almost constantly affected by local interference and the quality of receptions is definitely degraded. As more data is received, this condition may tend to rectify itself. The higher percentage of quality picture receptions as compared to weather charts can be attributed to two factors:

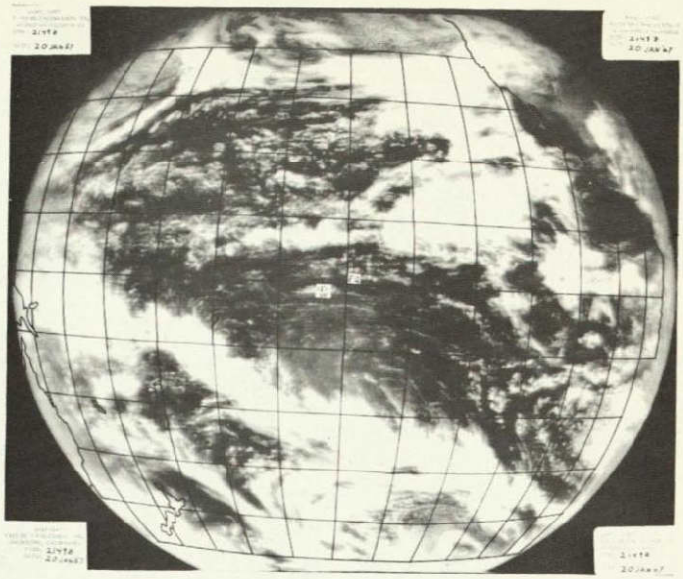
a. Most ground station operators are more interested in the cloud pictures, thus supervise picture reception more closely and carefully.

Papeete, Tahiti
Elevation angle 68°
Goddard Space Flight Center
Elevation angle 8°

Note: Loss of some detail in the paper facsimile reception may be attributed to fading characteristics of facsimile paper by exposure to light and temperature prior to photographing.

The two lower pictures are photographs of the reception of the picture at the right that was transmitted over WEFAX from Mojave on 21 Jan. 67. Picture was transmitted in four sections (overlapping quarters) and assembled at the receiving sites. Papeete used a paper facsimile receiver and GSFC used a photo facsimile machine.

CLOUD PICTURE SCANNED at MOJAVE, CALIF.



PAPER FACSIMILE RECEPTION at TAHITI

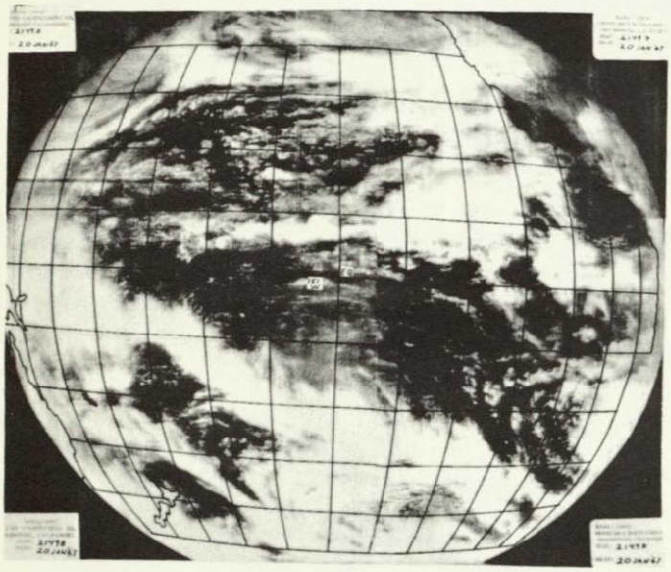


PHOTO FACSIMILE RECEPTION at GSFC

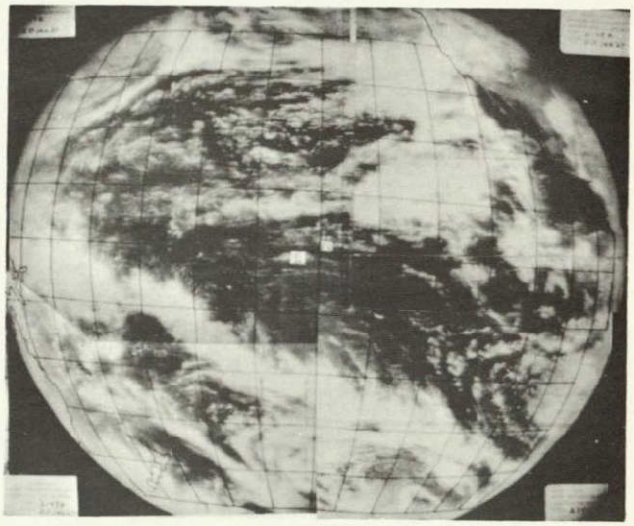
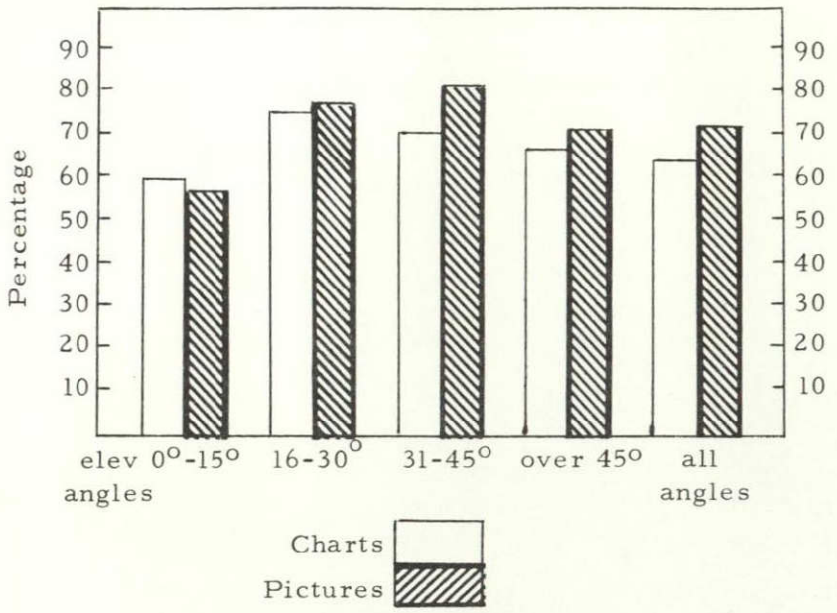


Figure 3-3 Simultaneous SSCC Reception

Percentage of Excellent or Good Receptions of
WEFAX by Elevation Angle Increments.
(3692 charts and 1175 pictures evaluated)
(January)



WEFAX Participating Stations
(by antenna elevation angle)

Station	Antenna Elevation Angle	
Toronto, Canada	3°	
GSFC, Maryland	8°	
Fuchu, Japan	8°	
Howard AFB, C. Z.	8°	
Kashima, Japan	8°	
MacDill AFB, Fla.	10°	0° to 15°
Nashville, Tenn.	10°	
Tampa, Florida	11°	
Melbourne, Australia	11°	
Guam, Marianas	15°	
New Orleans, La.	20°	
Anchorage, Alaska	21°	
Lake Jackson, Texas	22°	16° to 30°
Seattle, Washington	28°	
Mojave, California	30°	

Station	Antenna Elevation Angle	
Christchurch, N. Z.	32°	
Pt. Mugu, Calif.	37°	
Wake Island, Pac.	38°	31° to 45°
San Francisco, Calif.	40°	
Kunia, Hawaii	65°	
Papeete, Tahiti	68°	Over 45°

Figure 3-4. Percentage of Good or Excellent Receptions (Jan)

b. Many operators may inflate the picture classifications feeling that "just being able to receive such remarkable pictures is a great accomplishment". Also, they do not possess a copy of the original photograph to use as a standard.
It is encouraging to note on this graph that even the receiving stations on the fringe areas of acquisition still received over 50% of their receptions in at least a "good" quality classification.

WEFAX test charts were again transmitted as the first chart of each scheduled WEFAX period. These charts were returned by the participants to the WEFAX Coordinator for evaluation of the following parameters:

a. Signal strength (not available from all stations)

b. Resolution

c. Grey Scale Steps

d. Skew (1/4" in 8")

e. Distortion

f. Clarity

g. Bleeding

h. Interference

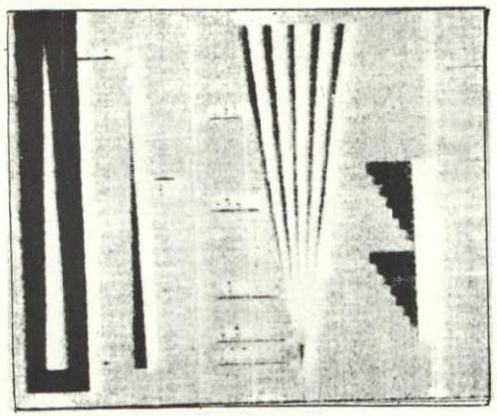
i. Signal to Noise

j. Multiple Image

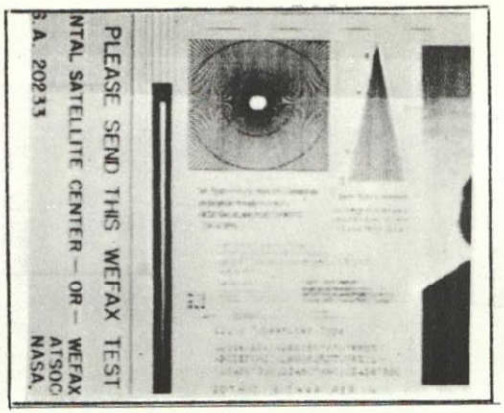
Figure 3-5 shows samples of the most common difficulties encountered in the WEFAX receptions.

Figure 3-6 shows the degree that reception difficulties were found in January evaluation of the test charts. During January, 317 WEFAX test charts were evaluated. This graph indicates only the overall occurrence of such difficulties and at this time,

BLEEDING

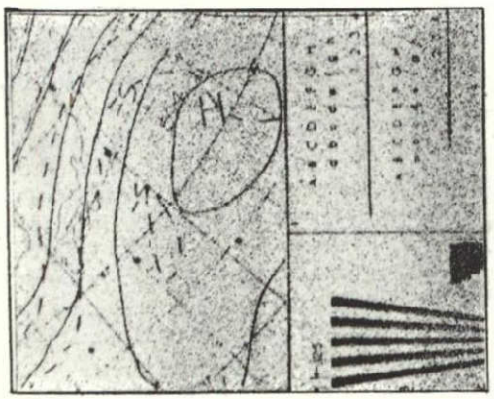


DISTORTION

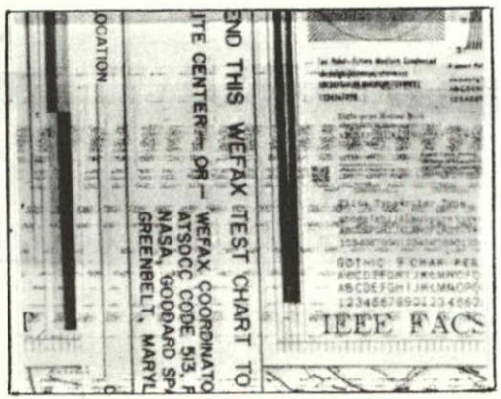


SKEW

SIGNAL TO NOISE



INTERFERENCE



MULTI IMAGE

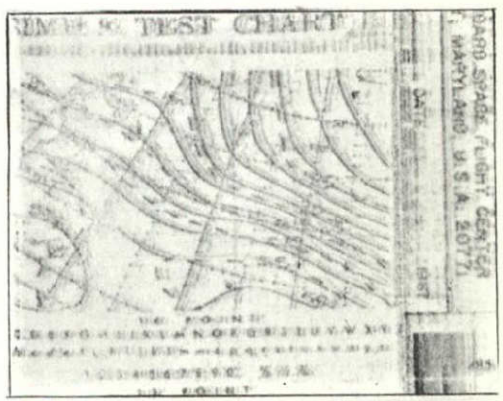


Figure 3-5 Examples of Reception Difficulties

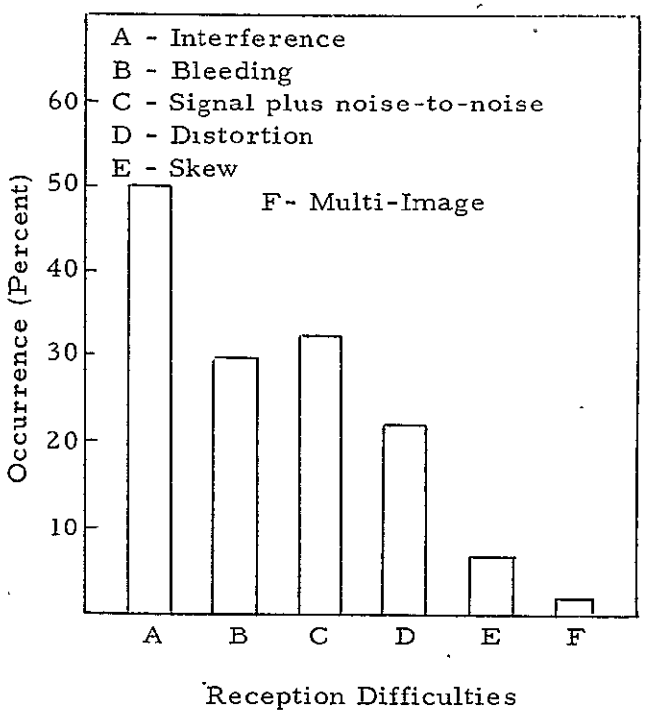


Figure 3-6 WEFAX Experiment, Facsimile Reception Difficulties Occurring at 23 APT Receiving Stations During 2-31 January 1967. 317 WEFAX Test Charts Evaluated.

A - Interference - Visible patterns appearing on chart format as a result of external signal sources or internally generated beat frequencies.

B - Bleeding - Smearing and presentation on white areas by black.

C - Signal plus noise-to-noise - White or black streaks on chart, uniformity of tonal shades, snow effect.

D - Distortion - Large scale geometric deviation from time pattern.

E - Skew - Deviation of a vertical line from a vertical normal. Test limit - 1/4" in 8".

F - Multi-Image - The multiple chart reproduction (ghosts) caused by multiple path transmission or reflection.

no attempts have been made to isolate the occurrences of their difficulties with individual stations, elevation angles, azimuth angles or time of day. When more data is available, such correlations will be investigated.

Figure 3-7 shows the average grey scale steps reported by certain stations during January 1967. The elevation angle of acquisition is shown for each station in an ascending order from top to bottom on the graph. As is indicated, the receipt of grey scales is not entirely a function of the range distance from the spacecraft but in all probability, must vary with type of equipment and the skill of the operating personnel.

Figure 3-8 shows the percentage of receiving stations who were affected by interference on any day during January. Since the effects of interference appear to be the most prevalent difficulty experienced by the APT receiving stations, this parameter will be further investigated during the experiment.

Table 3-2 lists many of the comments received from the participating APT ground stations during January. Certain recommendations contained in these comments, i. e. need for larger picture legends, need for reducing details in certain weather charts, improvement of phasing signal, and others, will be considered in the future plans of the WEFAX experiment.

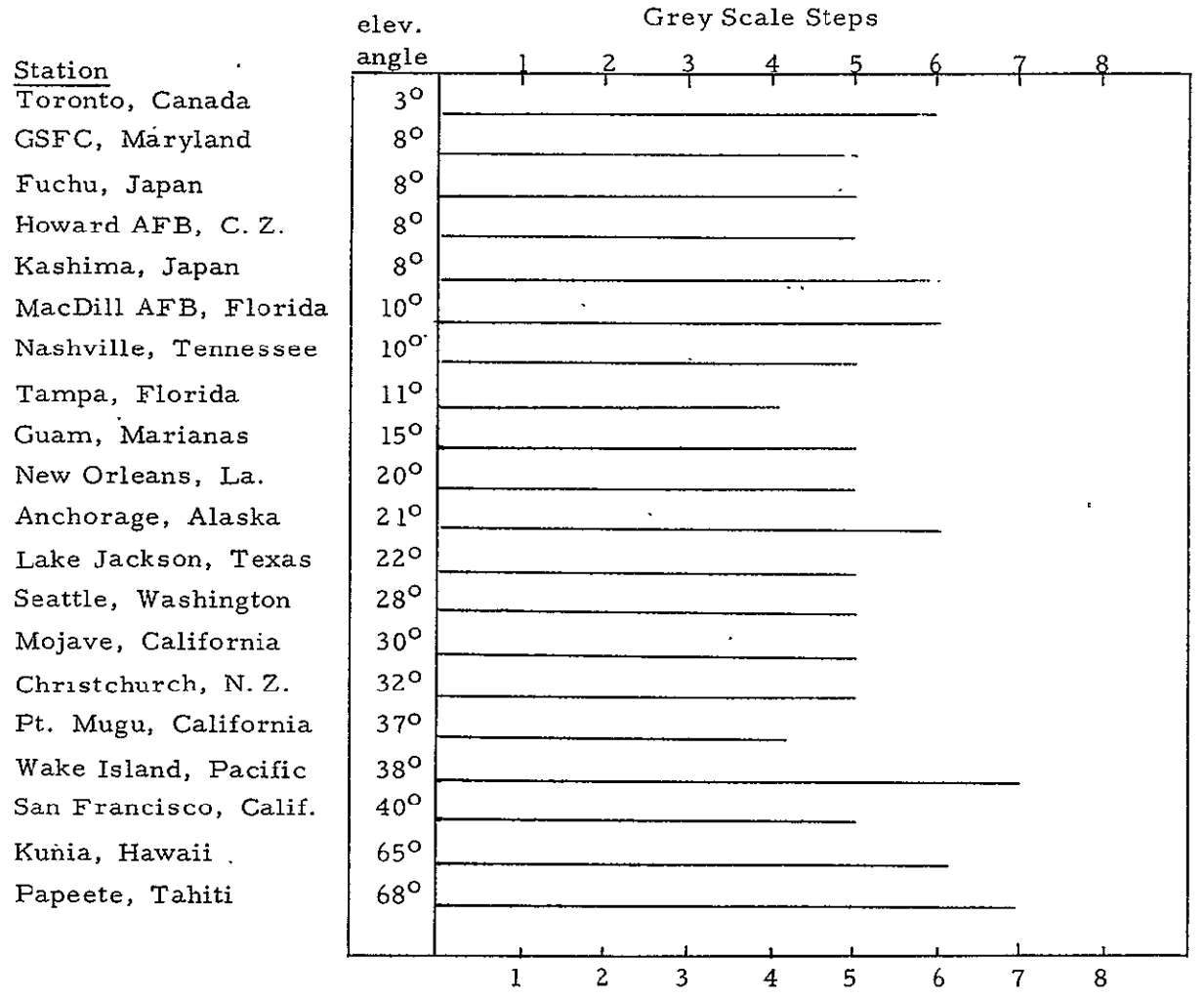


Figure 3-7. Received Grey Scales (Jan)

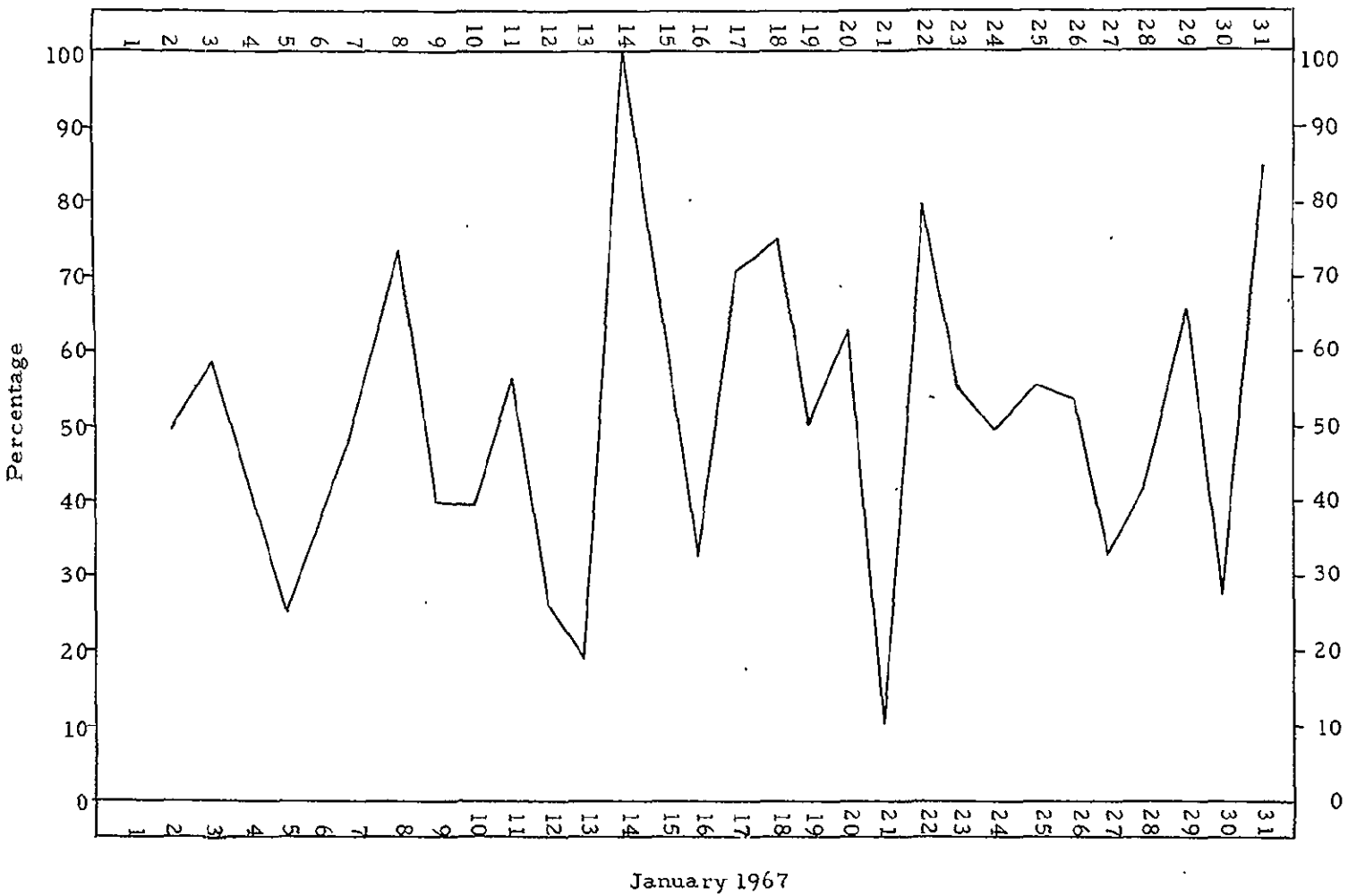


Figure 3-8. Interference Reported During January.

TABLE 3-2

Sample Comments from Participating APT Stations
(January)

STATION LOCATION	COMMENT
Tampa, Florida	Legends on pictures not always legible. Pictures must be gridded for best use. Pictures improved greatly today. Picture halves are easier to use than quads. Printing in legends still need to be larger.
Howard AFB, Canal Zone	When you switch from charts to pictures, we get a drastic darkening of picture reception. Operator did not catch change and several pictures were very dark.
Nashville, Tennessee	It is noted that generally the pictures and charts are slightly noisy even though our signal strength is good. The start and phasing portions of the picture seem to be free of this noise.
Guam, Marianas	Antenna changes failed to eliminate interference.
Wake Island, Pacific	Nephanalysis and Actual Photos - These will probably prove to be the most useful to this station. The actual photos particularly provide a useful and impressive briefing aid. Pictures/maps with too much detail very hard to read.
Christchurch, New Zealand	Interference increased at 13/0945Z.
Kashima, Japan	Lack of uniformity was observed in the received charts. This seems to be due to the fluctuation of the power source voltage at the receiving side.
Lake Jackson, Texas	The signal level from the ATS is approximately the same as that from ESSA and Nimbus satellites.
Kunia, Hawaii	In general, received signal strength decreases slowly throughout the transmission period.

Table 3-2 (Continued)

Station Location	Comment
Kunia, Hawaii (cont'd)	Interference is normally not an operational problem. Interference has degraded the quality of given charts but the data is still readable and useable. The composite NESC nephanalysis (several strip "nephs" on one chart) have been the poorest in quality. The detail and labeling is degraded by the small scale. We prefer the individual 1:20,000,000 scale nephanalyses. The contrast setting has varied from picture to picture and from day to day. The picture quality has been a function of the individual operator's ability to set the AGC/contrast.
Seattle, Washington (WBAS)	Occasional interference was apparently local. Chart legibility was not consistently good enough for operational use; there was too much background shading.
Pt. Mugu, California	No difficulties encountered in data acquisition or reception. Spin scan pictures are considered excellent as an aid to map analysis, project forecasts and investigation of weather phenomena.
Anchorage, Alaska	Overmodulation of some of the pictures but this has been minor.
Fuchu AS, Japan	In general we find the chart/picture labels too small for good readability. Pictures appear to survive the transmission in better shape than charts. The single transmission of three panels of satellite nephanalyses is too small for effective use.
Toronto, Canada	Pictures: Some difficulty has been encountered in phasing pictures in our Muirhead K-300 photo-facsimile unit. The phasing signal phases the picture okay, but the tone transmitted after the long pause generally upsets the phasing.

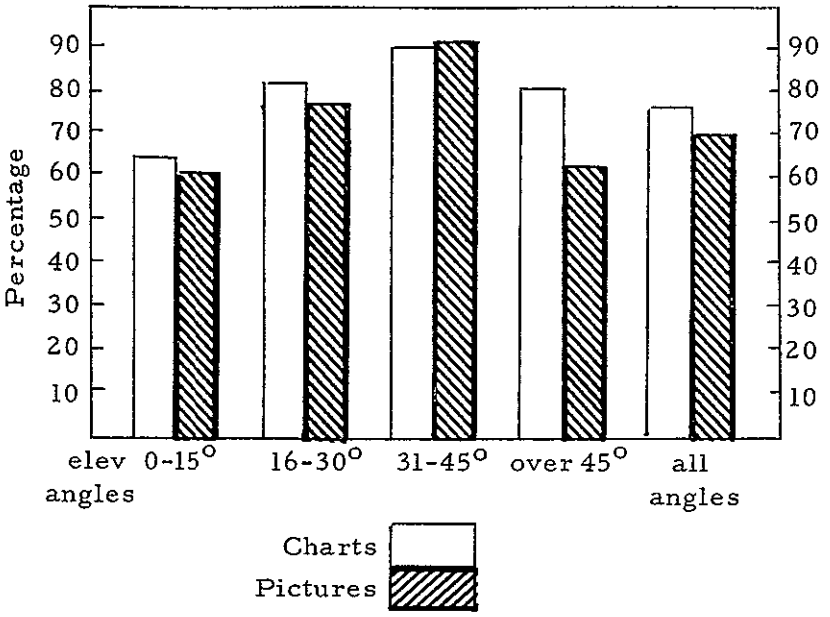
SECTION 4

FEBRUARY EVALUATION

During February the evaluation of the charts and pictures received over WEFAX continued. A slight decrease in the monthly number of charts classified and an increase in the number of pictures classified was noted. The decrease in charts can be accounted for as certain ESSA stations, New Orleans, San Francisco and Seattle were able to offer only limited support for the experiment during the month and also, no input was received from the station at Guam in the Marianas (see Figure 4-1).

A designated data collection period was scheduled from 7-11 February, inclusive, and the response from the participating ground stations was excellent. This period was shortened to only four days as no WEFAX transmission time was available on 11 February. Fifteen different ground stations submitted daily reception data during the special period. Transmissions during this time and for nearly all of February were excellent and free from problems. Figure 4-2 shows the full-disk cloud pictures sent daily at approximately 24 hour intervals on 7, 8, 9 and 10 February. Only the cloud pictures received at Goddard Space Flight Center (GSFC) are shown, however, all stations were offered this opportunity to determine the usability of WEFAX picture transmissions in following cloud systems, frontal systems, etc. It is hoped that such opportunities will be offered during subsequent months.

Percentage of Excellent or Good Receptions of
WEFAX by Elevation Angle Increments.
(1778 charts and 1376 pictures evaluated)
(February)

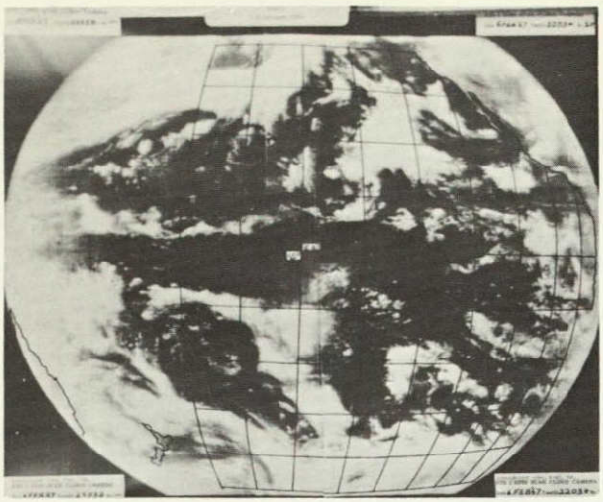


WEFAX Participating Stations
(by antenna elevation angle)

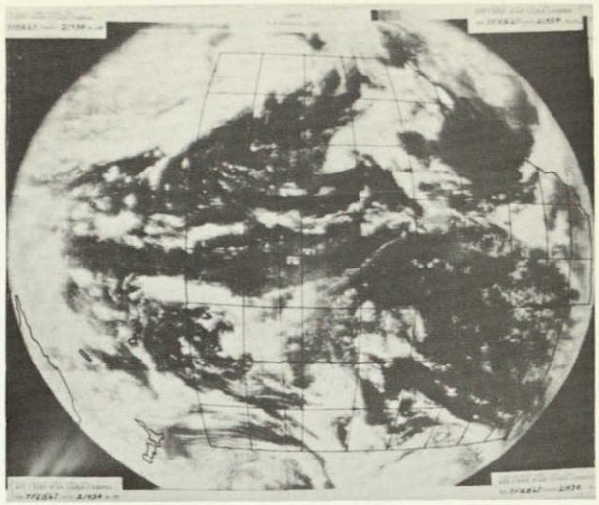
Station	Antenna Elevation Angle	
Toronto, Canada	3°	
GSFC, Maryland	8°	
Fuchu, Japan	8°	
Howard AFB, C. Z.	8°	0° to 15°
Nashville, Tenn.	10°	
Tampa, Florida	11°	
Melbourne, Australia	11°	
New Orleans, La.	20°	
Anchorage, Alaska	21°	
Lake Jackson, Texas	22°	16° to 30°
Seattle, Washington	28°	
Mojave, California	30°	

Station	Antenna Elevation Angle	
Christchurch, N. Z	32°	
Pt. Mugu, Calif.	37°	31° to 45°
Wake Island, Pac.	38°	
San Francisco, Calif.	40°	
Kunia, Hawaii	65°	Over 45°
Papeete, Tahiti	68°	

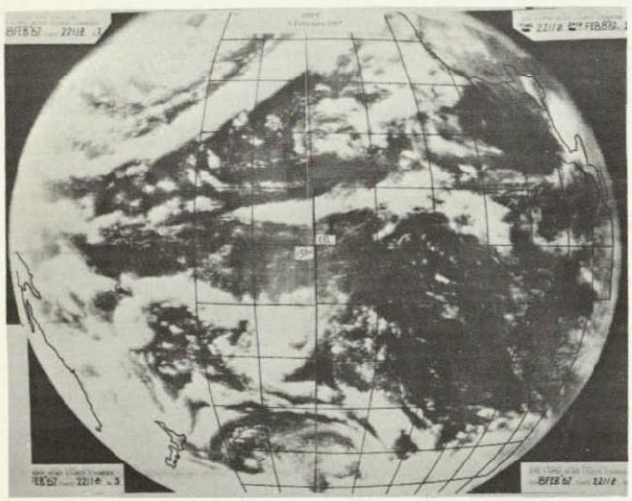
Figure 4-1. Percentage of Good or Excellent Receptions (Feb)



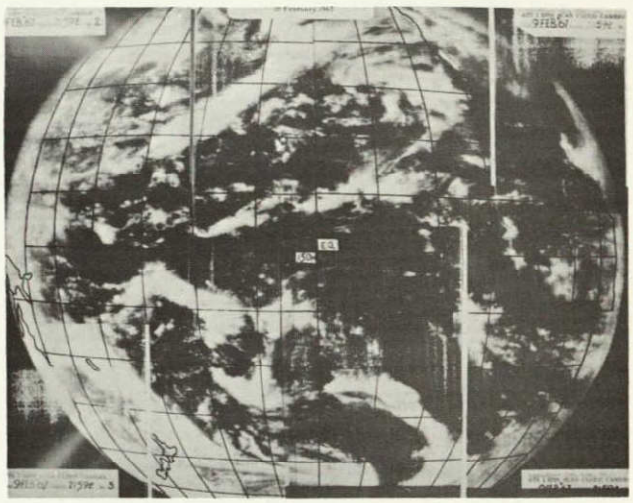
Picture Time: 06/2203Z
Receipt Time: 07/1100Z



Picture Time: 07/2143Z
Receipt Time: 08/1100Z



Picture Time: 08/2211Z
Receipt Time: 09/1100Z

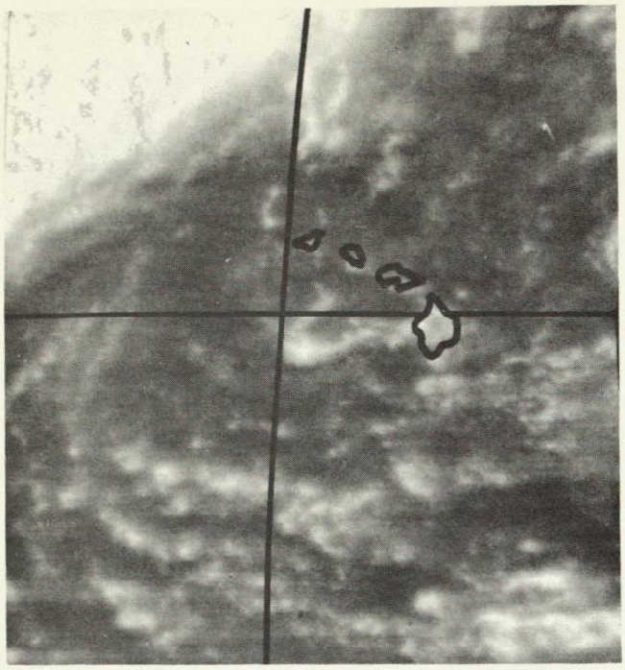


Picture Time: 09/2159Z
Receipt Time: 10/1100Z

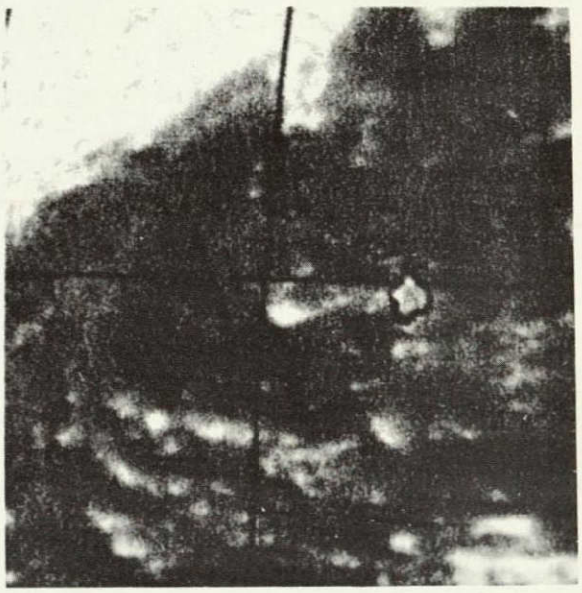
The four cloud camera pictures were transmitted to all stations on consecutive days during period February 7-10. Samples shown above were received at GSFC using a paper facsimile machine. Actual size of pictures as received 15" by 13".

Figure 4-2 Full Disk SSCC Picture Reception

Numerous comparisons were made during February between the actual photograph scanned for WEFAX transmissions and the pictures as received at the ground stations. Figure 4-3 shows an enlarged section of a cloud camera picture received over WEFAX on a paper facsimile recorder as compared to the same enlarged section of the actual photograph scanned at Mojave. While some deterioration of the paper facsimile copy has already begun, it can be readily noticed that cloud details show a substantial loss during the transmission. While only a few photo-facsimile receptions of cloud pictures were available for study, the photo-facsimile recorder does retain more of the cloud detail. Even so, it appears that, if an adequate amount of detail is to be retained during the transmission of the cloud pictures, another method of transmission must be used. In line with this requirement, on 13 February 1967 the first test of a system to demonstrate the retransmission over WEFAX of an ATS-1 spin scan picture utilizing digital, rather than photographic processing was conducted. The data used was from an analog tape recording of a 10 December 1966 picture. The picture with a recorded line sync was played back into an analog to digital converter and the values were entered into a stored program telemetry processor. Some lower frequencies were removed from the signal to eliminate some of the noise and to cause some detail enhancement. The telemetry processor formatted the data and transferred it to a digital magnetic tape until the full picture was stored digitally. The data was sampled 3150 times per 20 degrees of spacecraft spin, centered on the earth, with 64 possible grey steps. The picture was played back from the telemetry processor in APT format without loss in line resolution by selecting the first 800 elements of the first 800 lines and outputting them as 800 lines of one APT picture. This can be repeated nine times in order to



Enlarged Section of Picture Scanned at
Mojave Ground Station (7 February 1967)



Enlarged Section of Picture Received at
GSFC, Greenbelt, Maryland (7 February 1967)

Figure 4-3 SSCC Pictures Showing Loss of Detail

transmit the full spin scan picture in nine sections. The pictures received via WEFAX show that considerable fine detail may be relayed in this fashion and that the digital processing is superior to the photographic process presently in use. Further work is necessary in the digital processing procedure and more tests will be run over WEFAX in the future.

Figure 4-4 shows the reception difficulties experienced by the ground receiving units during February. It can be noted when comparing these with the January results (Figure 3-6) that, while showing a decrease during February, interference still is the most prevalent of the reception difficulties within the program. Also, it will be noted that "Jitter" was added to the February statistics (19%). This condition had been noted previously in several receptions but seemed to be associated with only one or two stations. Since the receptions at other stations were also affected during February, this item will be monitored more closely during subsequent evaluation periods.

On 16 February 1967, to replace the spin scan cloud pictures in the regular (0900-1100Z) WEFAX transmission period, which had been rescheduled at special times for relay to the Line Islands, certain cloud pictures from the operational weather satellite, ESSA 3, were added to the WEFAX program. These pictures received at ESSA, Suitland, Maryland from the satellite by 0800Z daily were transmitted over WEFAX, generally in seven frames. The pictures were transmitted directly from a taped video signal reconstituted from digitalized picture data which eliminates the scanning requirement and its apparent loss of detail. Excellent results have been obtained and ESSA 3 cloud pictures will continue to be a part of the WEFAX schedule. Figure 4-5 shows two reproductions of an ESSA 3 picture

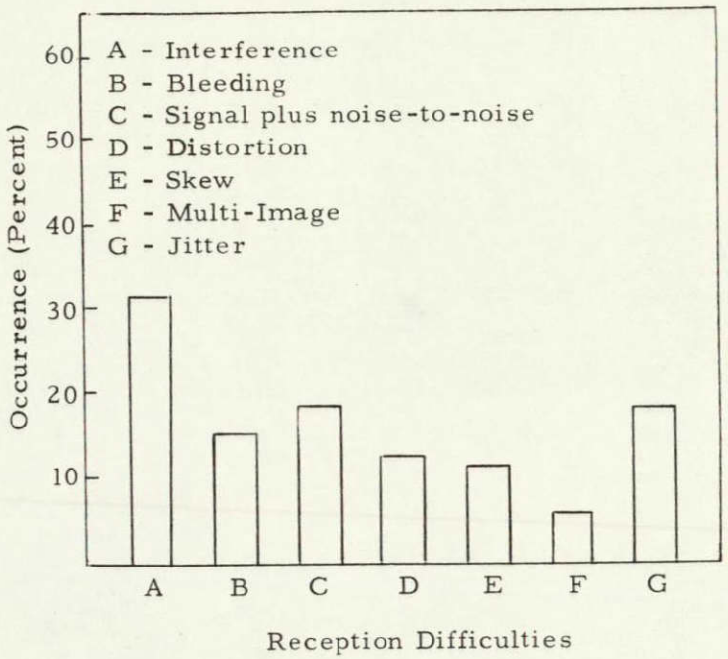


Figure 4-4 WEFAX Experiment, Facsimile Reception Difficulties Occurring at 20 APT Receiving Stations During February 1967. 216 WEFAX Test Charts Evaluated.

A - Interference - Visible patterns appearing on chart format as a result of external signal sources or internally generated beat frequencies.

B - Bleeding - Smearing and presentation on white areas by black.

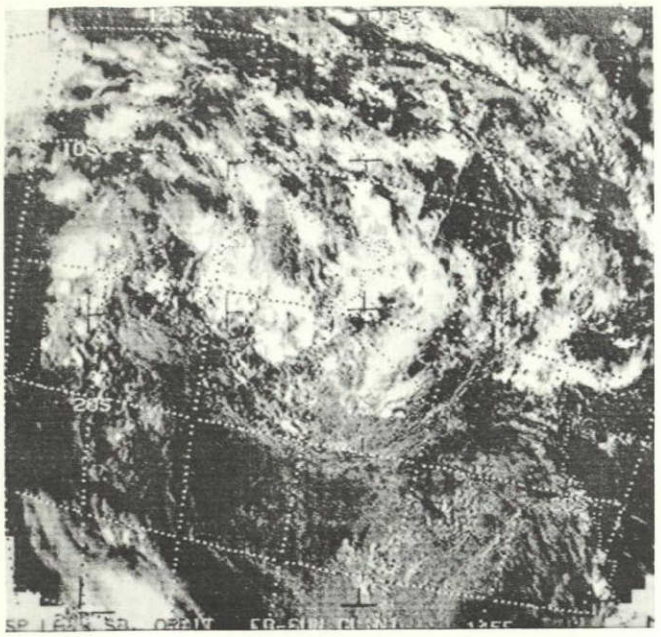
C - Signal plus noise-to-noise - White or black streaks on chart, uniformity of tonal shades, snow effect.

D - Distortion - Large scale geometric deviation from time pattern.

E - Skew - Deviation of a vertical line from a vertical normal. Test limit - 1/4" in 8".

F - Multi-Image - The multiple chart reproduction (ghosts) caused by multiple path transmission or reflection.

G - Jitter - Periodic irregularities on lines and patterns.



Paper Facsimile Reception
Original Size: 8-1/2" x 9"

The two pictures shown here were received at satellite data lab at Toronto, Canada on 21 Feb. 67. The picture on the left is a paper fax copy and the picture below was reproduced on a photo-facsimile recorder. The contrast and amount of detail are very similar. Transmission was made by a taped video signal reconstituted from digitalized data.

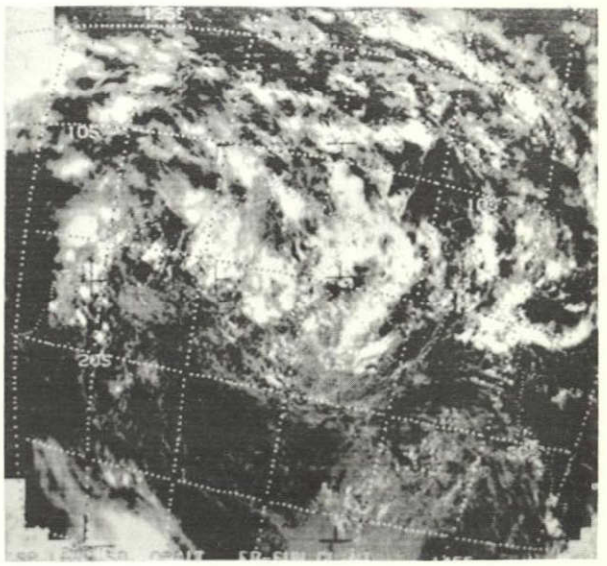
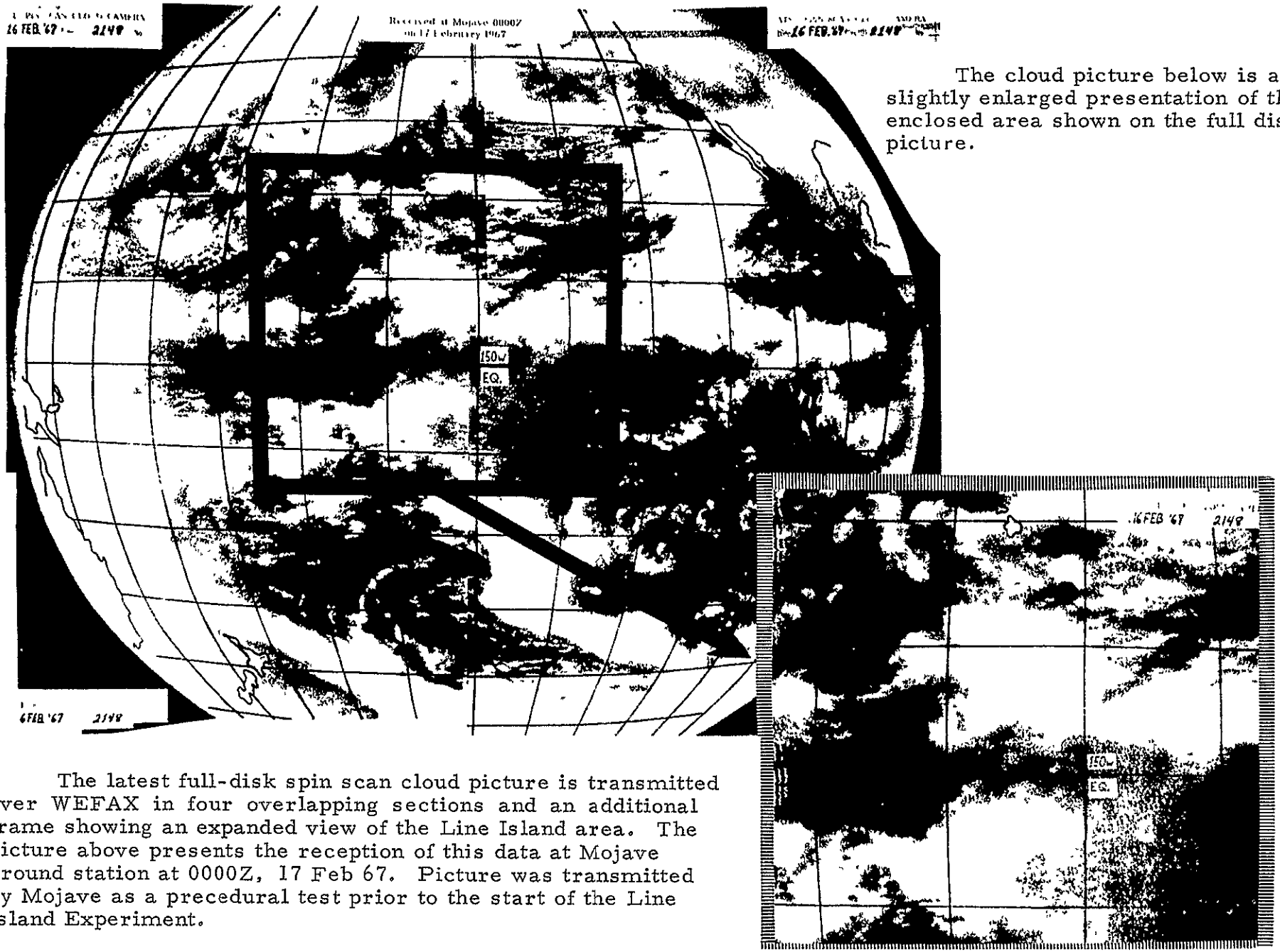


Photo Facsimile Reception
Original Size: 7-3/4" x 8"

Figure 4-5 Receptions of ESSA 3 Pictures

received at the Satellite Data Laboratory, Toronto, Canada. The pictures show simultaneous receipt of the transmission on a D-900 paper facsimile recorder and a K-300A photo facsimile recorder. As can be seen, both recorders are equally effective and the contrast and amount of detail in the pictures are very similar.

Beginning on 20 February 1967 and terminating on 21 April 1967 the WEFAX experiment will be providing cloud cover picture support for the Line Island Experiment. This meteorological experiment is under the direction of the National Center for Atmospheric Research and is being conducted along a series of islands in the Pacific stretching in a straight line from 20°N, 170°W to 20°S, 150°W. On 13 February 1967 test transmissions were initiated to determine the procedures to be used in furnishing cloud camera pictures to the units conducting the Line Island Experiment. When available, one complete picture with a single frame enlargement of the Line Island area was transmitted. The complete picture was sent in 11 inch overlapping squares to facilitate reception on the photo facsimile recorder operating on Palmyra Island. Pictures were gridded as accurately as possible. Figure 4-6 shows a sample of the information as transmitted during this test. Transmissions, using both the Mojave transmitter and the Rosman transmitter, were conducted with the transmitted pictures originating at the Goddard Space Flight Center, Greenbelt, Maryland. Transmissions through Rosman were necessitated because the Mojave ground station and transmitter were scheduled "down" during certain allotted transmission times. Also, during the latter part of February, the Mojave SHF antenna was undergoing modification and all cloud camera pictures from the spin scan camera were received at Rosman, North Carolina.



The cloud picture below is a slightly enlarged presentation of the enclosed area shown on the full disk picture.

The latest full-disk spin scan cloud picture is transmitted over WEFAX in four overlapping sections and an additional frame showing an expanded view of the Line Island area. The picture above presents the reception of this data at Mojave ground station at 0000Z, 17 Feb 67. Picture was transmitted by Mojave as a precedural test prior to the start of the Line Island Experiment.

Figure 4-6 Line Island Support Picture

The first tests using the Rosman station showed very poor results and were attributed to two conditions:

1. Lack of experience in WEFAX transmissions by personnel at Rosman which caused frequent over-modulation of pictures and frequent improper equipment settings during transmissions.

2. The presence of a 60 cycle hum in the video signal received at Goddard Space Flight Center, which caused a strong "ripple" in the photographs which degraded the usefulness of the final picture furnished the ground station. During the limited time available for the test, technicians were unable to eliminate the 60 cycle interference.

Twenty-one extra transmission times, at either 0000Z, 0400Z or 2000Z, were allotted WEFAX for the Line Island Experiment during February. On 20 February 1967 the transmission of actual timely information to the Line Island Experiment was initiated. Twenty-one transmissions of 25 minutes each were made during the period 20-28 February in support of this project. No comments from the Line Island project concerning the data transmitted has been received, however, receptions of the spin scan cloud pictures monitored and classified at Mojave and GSFC, show the following results:

	Excellent	Good	Fair	Poor	Unusable
Mojave	2	20	17	6	0
GSFC	6	14	9	8	6

The overall results of the weather chart and picture classifications during February are shown in Table 4-1. No differentiation was made by the ground stations between the receptions of the spin scan cloud pictures and the ESSA 3 pictures which were added during the latter part of the month. The reception statistics include

TABLE 4-1

Classification of WEFAX Receptions of
Weather Charts and Satellite Pictures
(February 1967)

APT	Weather Charts					Satellite Pictures				
Receiving Stations	Exc	Good	Fair	Poor	Unusable	Exc	Good	Fair	Poor	Unusable
Toronto, Canada	15	120	36	14	10	4	137	35	9	6
GSFC, Maryland	118	75	22	6	3	46	65	17	13	11
Fuchu, Japan	7	81	55	42	13	3	63	22	6	4
Howard AFB, C. Z.	0	17	13	0	5	0	0	24	2	2
Nashville, Tenn.	0	0	4	5	0	0	0	7	0	0
Tampa, Florida	0	11	0	0	0	24	2	0	0	0
Melbourne, Australia	1	4	14	6	1	0	7	9	0	0
New Orleans, La.	0	5	2	2	1	0	8	0	0	0
Anchorage, Alaska	163	4	2	4	3	90	0	9	0	0
Lake Jackson, Texas	8	0	2	0	0	10	14	5	1	0
Seattle, Washington	0	7	9	6	0	0	6	7	1	0
Mojave, California	89	148	39	16	0	64	137	44	21	0
Christchurch, N. Z.	49	29	13	0	0	16	23	3	0	0
Pt. Mugu, Calif.	30	9	0	2	0	18	4	0	0	0
Wake Island, Pacific	18	6	0	0	0	14	3	0	0	0
San Francisco, Calif.	5	7	1	0	0	0	5	3	0	0
Kunia, Hawaii	118	50	12	4	12	35	80	40	24	25
Papeete, Tahiti	104	76	31	12	8	63	68	18	18	12
TOTALS	725	649	255	119	56	387	622	240	95	60
	(40%)	(36%)	(14%)	(7%)	(3%)	(28%)	(44%)	(17%)	(7%)	(4%)

all receptions, including those received during the special Line Island support times inserted in the WEFAX schedule after 13 February 1967.

Figure 4-7 depicts the variations of interference difficulties experienced by the participants throughout the month. Stations, as a whole, were less affected by this difficulty during February than previous months, although interference still remains the most prevalent of the reception difficulties evaluated.

Table 4-2 lists sample comments from the February participants. The phasing problem mentioned is being investigated along with the reports of signal fade during transmission periods. The usefulness to the weather stations of both the spin scan cloud picture and the recently added ESSA 3 pictures is established by many of these comments. Dissemination of last minute schedule changes is a serious and ever-present problem and all possibilities are being explored to alleviate this situation.

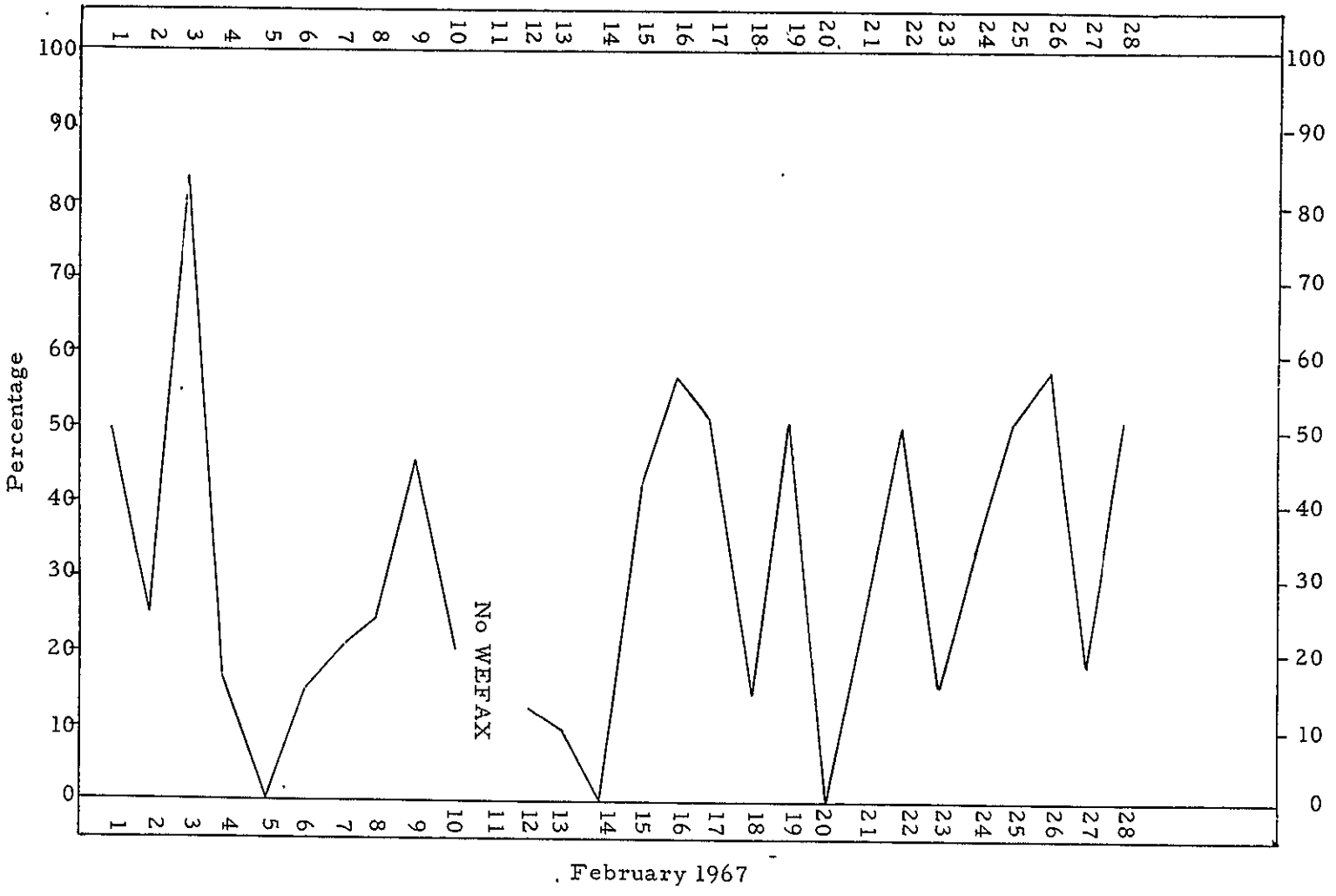


Figure 4-7. Interference Reported During February.

TABLE 4-2

Sample Comments from Participating APT Stations
(February)

STATION LOCATION	COMMENT
Toronto, Canada	No difficulties acquiring the ATS-1 VHF signal. Last days of February signal strength frequency below 10 microvolts. Voice transmissions from Goddard sometimes cause interference.
Papeete, Tahiti	Photos: Very useful especially the coverage to the East of Tahiti. The Southern hemisphere surface chart is excellent. Indispensable.
Lake Jackson, Texas	Signal fade during transmission period frequently noted. Particularly 0000Z time period. ESSA 3 pictures excellent quality.
Kunia, Hawaii	2000Z and 0900Z generally produce best quality reproductions. 0000Z and 0400Z produce worst quality. ESSA 3 digitalized and gridded mosiacs seem promising. ESSA 3 pictures received over WEFAX earlier than over the overburdened land facsimile system.
Fuchu AS, Japan	Frequent juggling of WEFAX transmission schedules and unannounced omissions decrease the usefulness and reliability of WEFAX. ESSA 3 pictures very useful.
Anchorage, Alaska	Using ATS (pictures) we were able to view a depression NW of Hawaii that was out of range of ESSA IV.
Seattle, Washington	Charts with two sets of lines still appear too cluttered and hard to read.
Wake Island, Pacific	Must phase recorder manually for most pictures.
Christchurch, New Zealand	Change in schedule not received, missed first part of transmission.

SECTION 5

MARCH EVALUATION

During the month of March, the number of participating stations again decreased by two. Twenty-two stations submitted data for evaluation. The reduction in participating stations can be attributed to the difficulties in manning the stations caused by the frequent changes in the scheduled WEFAX transmission times. Some of the WEFAX transmission times had to be adjusted due to the effects of the eclipse on the spacecraft power supply. Many scheduled WEFAX transmission times were cancelled because of the Line Island Experiment requirement for spin scan cloud camera pictures. There were no WEFAX transmissions on March 3, 7, and 29. The special WEFAX data collection period was from 13 thru 17 March, and data collected during this period was received from 15 stations.

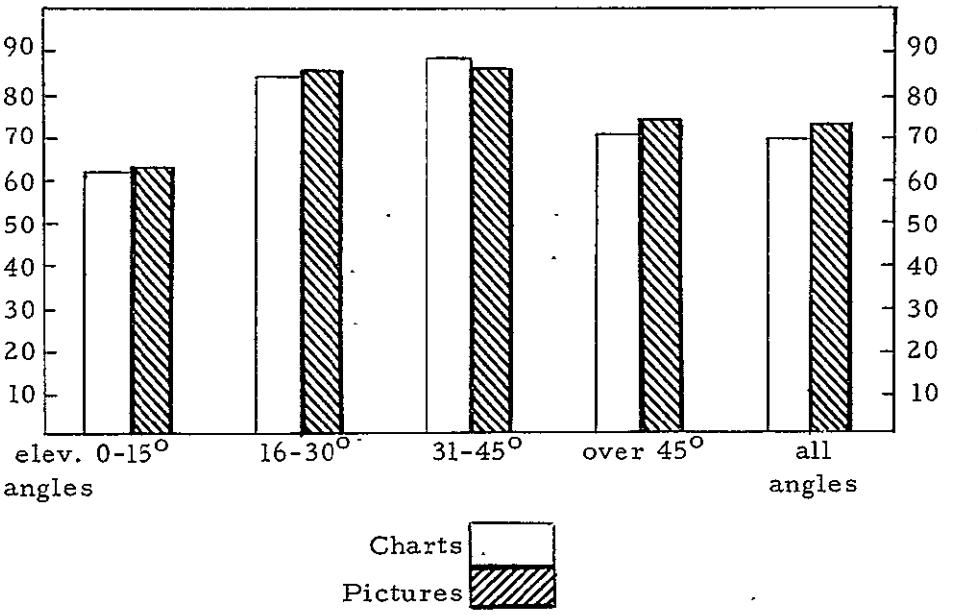
The classification of the quality of reception of weather charts and satellite pictures as received by various stations during March is shown in Table 5-1. Both the weather charts and the satellite pictures continue to be received in an excellent or good category at least 70% of the time. The percentage of excellent or good receptions grouped in relation to the station's antenna elevation angle is displayed in Figure 5-1. The average number of grey scale steps discernible on the WEFAX test charts as received on paper facsimile machines continued to be very good. As indicated in Figure 5-2, two stations (Papeete and Wake Island) averaged 8 grey scale steps discernible. There were 11 different grey shades discernible on the test chart received at Papeete on 30 March. Table 5-2 is a list of sample comments received from participating stations concerning WEFAX receptions during March.

TABLE 5-1

Classification of WEFAX Receptions of
Weather Charts and Satellite Pictures
(March 1967)

APT Receiving Stations	Weather Charts					Satellite Pictures				
	Exc	Good	Fair	Poor	Unusable	Exc	Good	Fair	Poor	Unusable
Toronto, Canada	9	51	32	23	11	5	93	43	18	11
Miami, Florida	0	1	0	0	0	1	1	0	0	0
GSFC, Maryland	120	48	16	5	6	119	68	63	20	2
MacDill AFB, Florida	0	2	5	1	4	0	8	5	5	2
Fuchu, Japan	13	73	49	16	5	27	83	20	3	0
Howard AFB, C. Z.	0	9	9	17	2	0	4	35	1	2
Nashville, Tenn.	0	8	4	6	0	0	12	17	4	3
Tampa, Florida	4	6	0	2	2	28	1	4	0	0
Melbourne, Australia	12	47	35	0	1	25	124	77	12	4
Aberdeen, S. D.	0	0	0	0	0	0	8	12	2	2
New Orleans, La.	0	3	0	0	0	0	9	0	0	0
Anchorage, Alaska	38	38	7	3	0	214	16	7	0	0
Lake Jackson, Texas	6	2	3	0	0	0	18	6	2	0
Petersen Field, Colo.	1	0	1	0	0	0	2	0	0	0
Seattle, Washington	0	1	0	2	0	0	1	5	1	0
Mojave, California	95	103	26	1	8	118	118	30	6	8
Pt. Mugu, Calif.	9	16	0	1	0	33	1	0	0	0
Wake Island, Pacific	7	0	0	0	0	2	5	2	0	1
Mountain View, Calif.	0	0	3	0	0	0	0	3	0	0
Kunia, Hawaii	48	35	19	16	29	100	56	28	28	25
Papeete, Tahiti	52	79	16	6	1	68	153	21	22	4
TOTALS	414	522	225	99	69	740	781	378	124	64
	(31%)	(39%)	(17%)	(8%)	(5%)	(35%)	(37%)	(19%)	(6%)	(3%)

Percentage of Excellent or Good Receptions of
WEFAX by Elevation Angle Increments.
(1329 charts and 2087 pictures evaluated)
(March)



WEFAX Participating Stations
(by antenna elevation angle)

Station	Antenna Elevation Angle	
Toronto, Canada	3°	
GSFC, Maryland	8°	
Fuchu, Japan	8°	
Howard AFB, C. Z.	8°	
Miami, Florida	8°	0° to 15°
MacDill AFB, Florida	10°	
Nashville, Tenn.	10°	
Tampa, Florida	11°	
Melbourne, Australia	11°	
Aberdeen, S. Dakota	17°	
New Orleans, La.	20°	
Anchorage, Alaska	21°	
Lake Jackson, Texas	22°	16° to 30°
Petersen Field, Colo.	25°	
Seattle, Washington	28°	
Mojave, California	30°	

Station	Antenna Elevation Angle	
Mountain View, Calif.	37°	
Pt. Mugu, Calif.	37°	31° to 45°
Wake Island, Pac.	38°	
Kunia, Hawaii	65°	Over 45°
Papeete, Tahiti	68°	

Figure 5-1. Percentage of Good or Excellent Receptions (March)

Average Grey Scale Steps of
Receiving Stations (March)

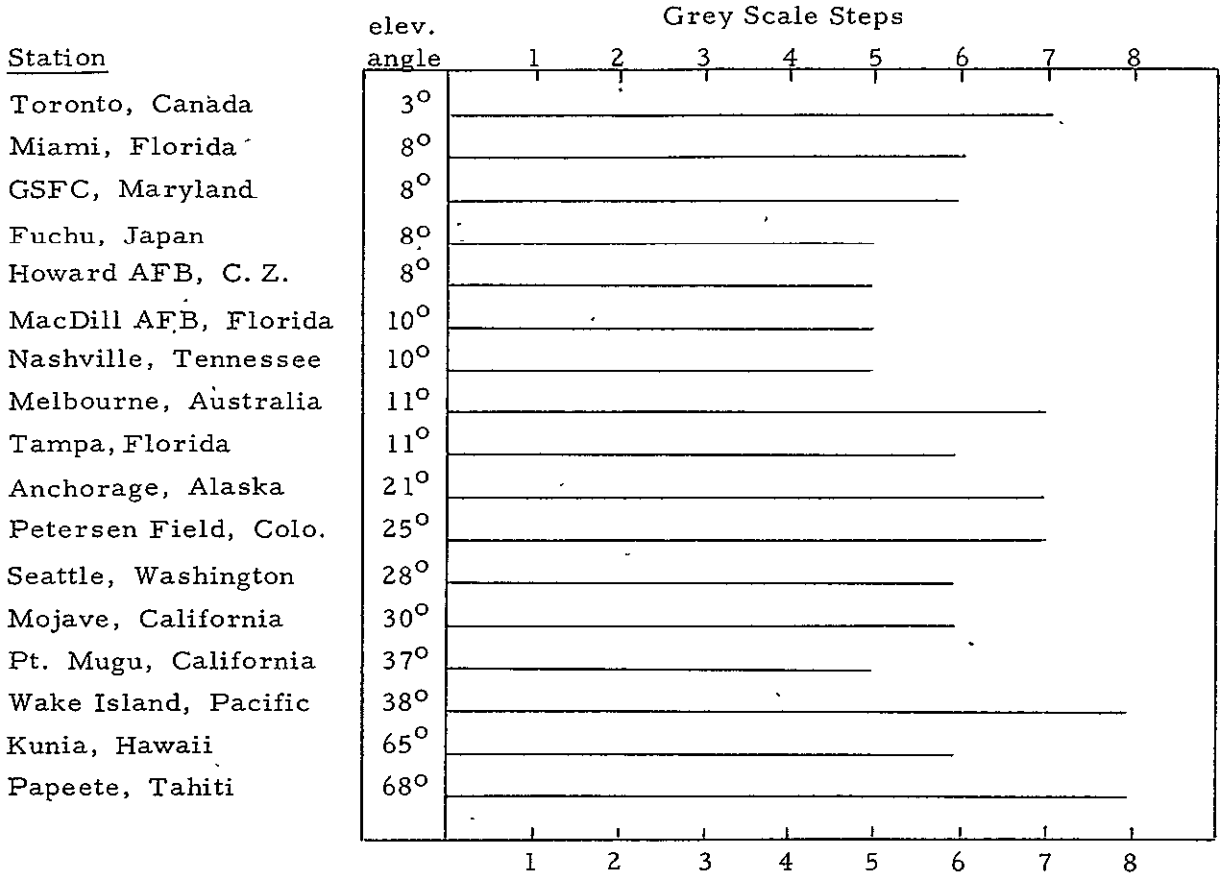


Figure 5-2. Received Grey Scales (March)

TABLE 5-2

Sample Comments from Participating APT Stations
(March)

Station Location	Comment
Toronto, Canada	Certain charts, particularly Surface and 500 mb analyses, are sometimes used in briefing pilots making non-stop flights from Toronto to Hawaii. In these briefings, ATS-1 spin scan pictures are also studied.
Anchorage, Alaska	The ESSA III pics are the best and of most interest as they are of a geographical area adjacent to us and despite being 12 hours or more old are still useful. We continue to follow the WEFAX experiment with great interest.
Tampa, Florida	Timeliness and quality of ESSA III pictures excellent and quite useful.
Pt. Mugu, California	Daytime (PST) reception was not as good as nighttime (PST) reception. Charts are of little value to PMR. Pictures are used extensively for closed television circuit or for map analysis.
Fuchu, Japan	Our best WEFAX reception is when the antenna is pointing at 25° elevation and 103° azimuth. Theoretically our antenna should be pointed directly at ATS-1 with angles of 8° elevation and 103° azimuth. We prefer your present WEFAX transmission time schedule (0900-1000Z) to a later one.
Melbourne, Australia	The Meteorologists using the WEFAX data are very impressed with the quality of the charts when spin modulation is not present. They are using the Pacific Nephanalysis and 500 mb Tropical Stream Function analyses and are anxious to obtain as many Southern Hemisphere charts as possible. Transmission Schedules: We have found the present 1100Z, 2200Z and 0200Z times are quite satisfactory. The TBUS 3 and Mojave/WEFAX messages are being received on a regular basis and are adequate.
Kunia, Hawaii	As stated last month we believe the pictures are over rated by at least one category. The ESSA III gridded strips are in general excellent when signal strength is high enough. The spin scan pictures are mostly good to fair.

Comments from stations (cont)

Lake Jackson, Texas	Throughout this month I have noticed noise bursts which appear to be related to the spin frequency, but occur randomly. These bursts do not appear to occur during a signal "dip" and therefore probably are in the uplink to the ATS. In the near future I plan to put a recorder on my "RF level" circuit in an attempt to correlate these bursts with signal level variations.
Aberdeen, S. Dakota	Severe rotational (spin by satellite) fading (0200-0225Z). Same spin fading 2203-2225Z, March 25.
MacDill AFB, Florida	There should be a better method of getting schedule changes to the users. Those of us who don't copy every transmission are liable to miss one.
Nashville, Tennessee	Incidentally, we enjoy the cartoons.

Interference continued to be a major problem in WEFAX receptions as shown in Figures 5-3 and 5-4. A new type of interference appeared during March and has been included in Figure 5-4 as "spin modulation". It is noise which is apparently originating in the ATS-1 spacecraft. The noise bursts are at (or near) the rate of the spacecraft spin rate. Various tests have been conducted to attempt to isolate the cause and to eliminate or reduce this noise interference. As yet, no definite cause or cure has been discovered. Figure 5-5 shows the affects of the noise interference on WEFAX transmissions on a weather chart and a satellite picture.

Additional test transmissions were conducted during March in the retransmission of the ATS-1 spin scan pictures over WEFAX utilizing digital processing. On 13 March a digitized tape of an early ATS-1 picture was transmitted. Figure 5-6 is a copy of one section of the picture as received at GSFC on a paper facsimile recorder. Even though there is considerable local interference in the picture received at GSFC, considerable cloud and land detail is visible in the picture. Tests were also run on 22 and 23 March, with additional tests scheduled in succeeding months. Although minor modifications are necessary in the program, the tests prove that the ATS-1 spin scan pictures retransmitted utilizing digital processing is far superior to those by the photographic processing method.

A multiple access test was conducted on 3 March 1967 with simultaneous transmissions of WEFAX on 135.575 MHz and Voice on 135.625 MHz. For this test, 3 active transmitting stations were used:

Station	Frequency	Transmission
Mojave, California	135.575 MHz	WEFAX
Rosman, North Carolina	135.625 MHz (keyed)	Voice
Hughe El Segundo, Calif.	135.625 MHz (keyed)	Voice

Figure 5-3. Interference Reported During March.

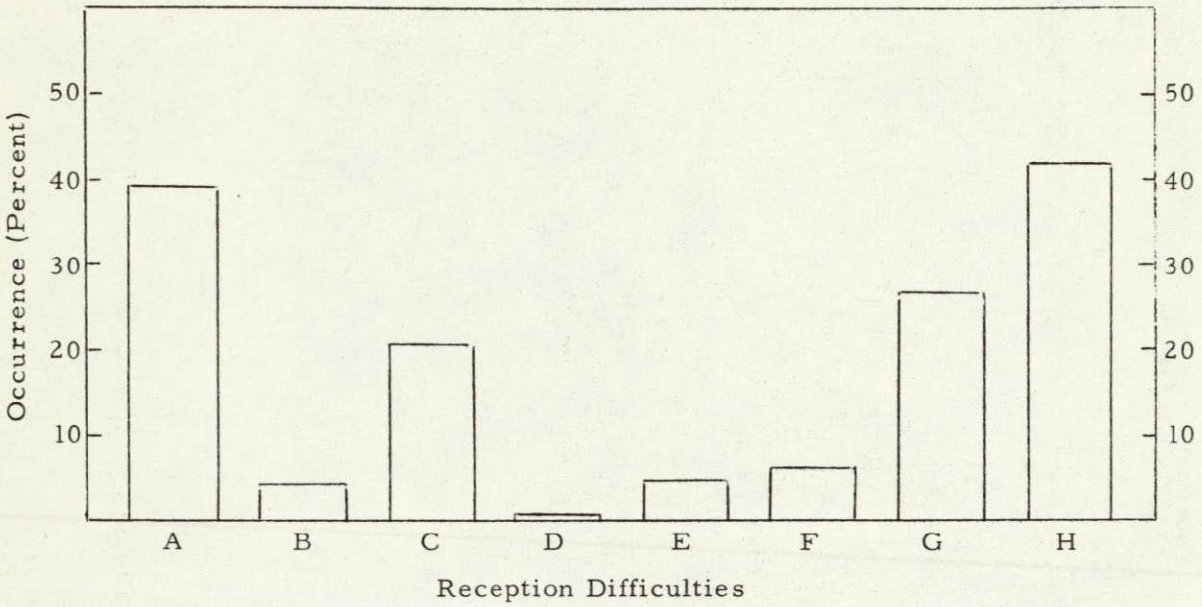


Figure 5-4. WEFAX Experiment, facsimile reception difficulties occurring at 17 APT receiving stations during March 1967. 226 WEFAX Test Charts evaluated.

A - Interference - Visible patterns appearing on chart format as a result of external signal sources or internally generated beat frequencies.
B - Bleeding - Smearing and presentation on white areas by black.
C - Signal plus noise-to-noise - White or black streaks on chart, uniformity of tonal shades, snow effect.
D - Distortion - Large scale geometric deviation from time pattern.
E - Skew - Deviation of a vertical line from a vertical normal. Test limit - 1/4" in 8".
F - Multi-Image - The multiple chart reproduction (ghosts) caused by multiple path transmission or reflection.
G - Jitter - Periodic irregularities on lines and patterns.
H - Spin Modulation - Noise interference apparently originating in the spacecraft and near the frequency of the spin rate.

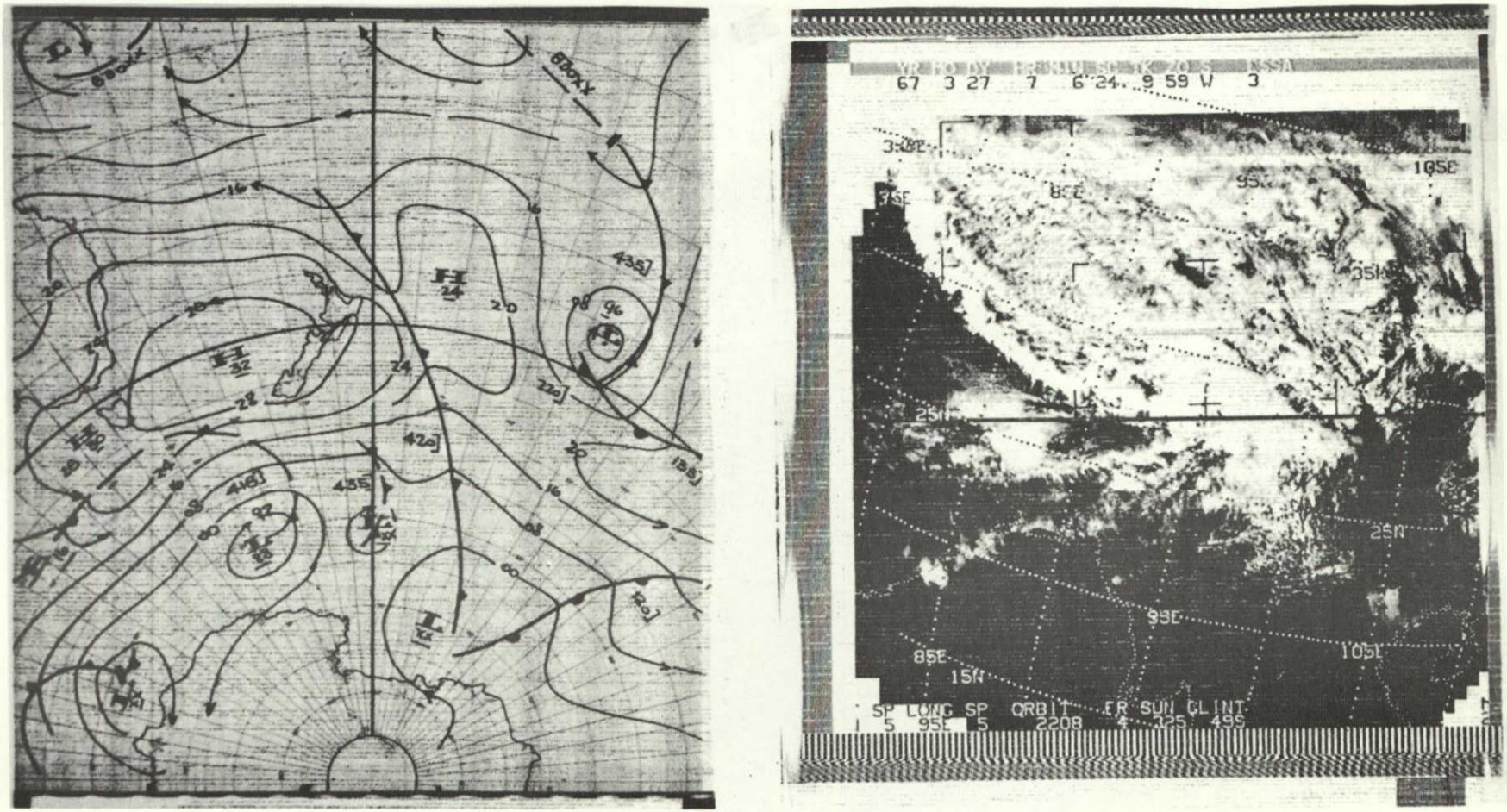


Figure 5-5. WEFAX Receptions Showing "Spin Modulation" Effects.

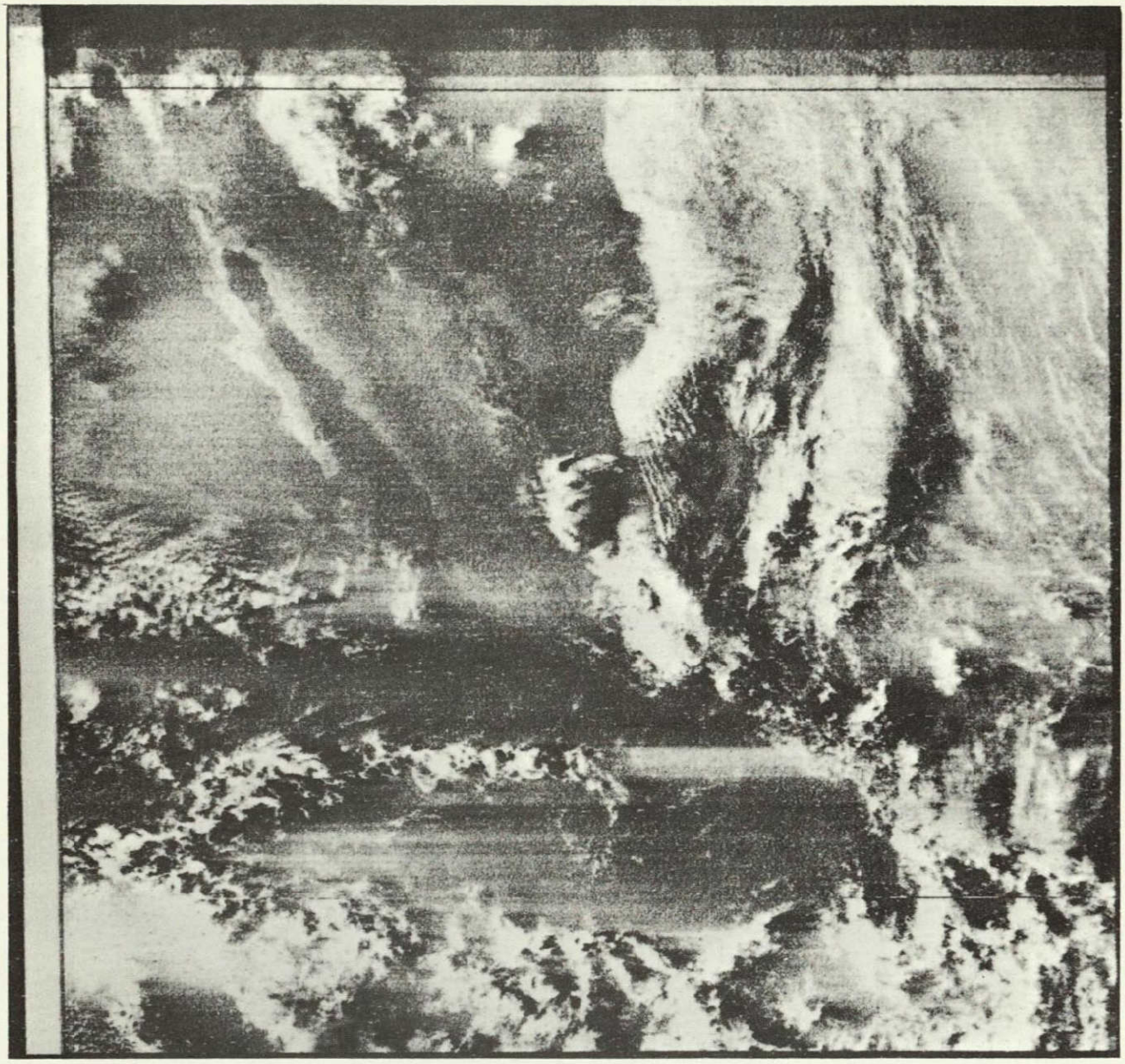


Figure 5-6. Digitally Processed ATS-1 SSCC WEFAX Transmission.

The WEFAX transmissions from the spacecraft were recorded at GSFC and showed the following results:

- Mojave transmitting alone (Rosman transmitter OFF)--- WEFAX reception excellent.
- Mojave transmitting with Rosman transmitter ON --- Interference with strong 60 cycle.
- Mojave transmitting with Rosman transmitting --- Very strong interference.
- Mojave transmitting with Hughes transmitting --- Only slight interference.

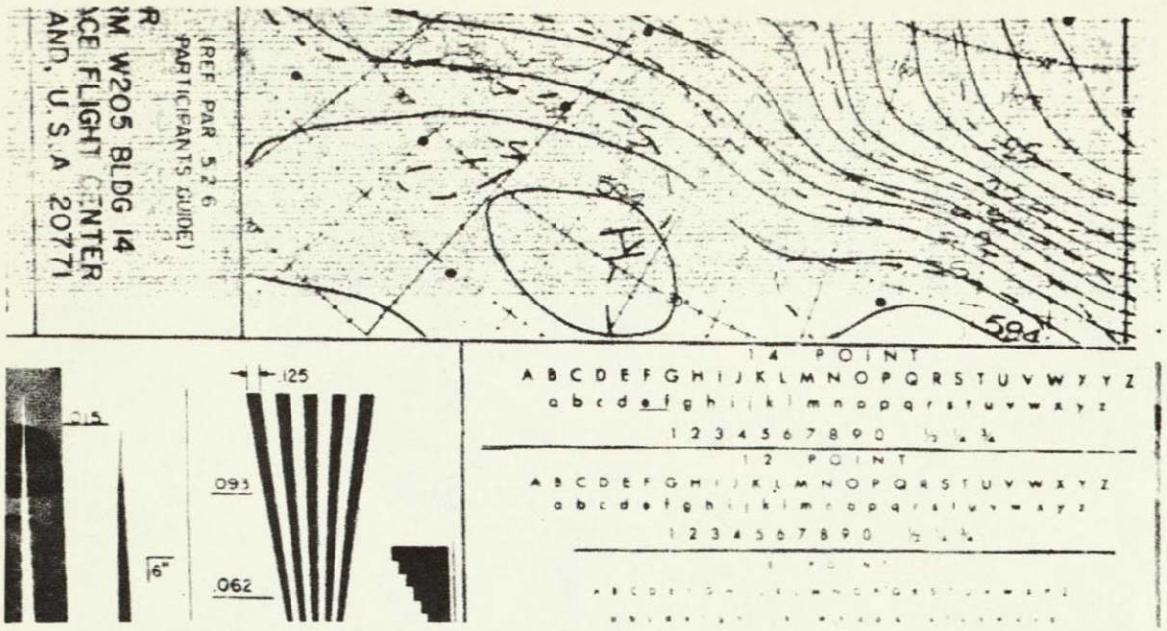
Figure 5-7 is a copy of portions of the WEFAX transmissions as received at GSFC and shows the affects on WEFAX of the Rosman and Hughes transmissions. The following signal strengths were observed at GSFC:

Transmitting Station(s)	Signal Strength
Mojave	10.5 μ v
Mojave plus Rosman	4.0 μ v
Mojave plus Hughes	10.5 μ v

Evaluation of this test indicated that:

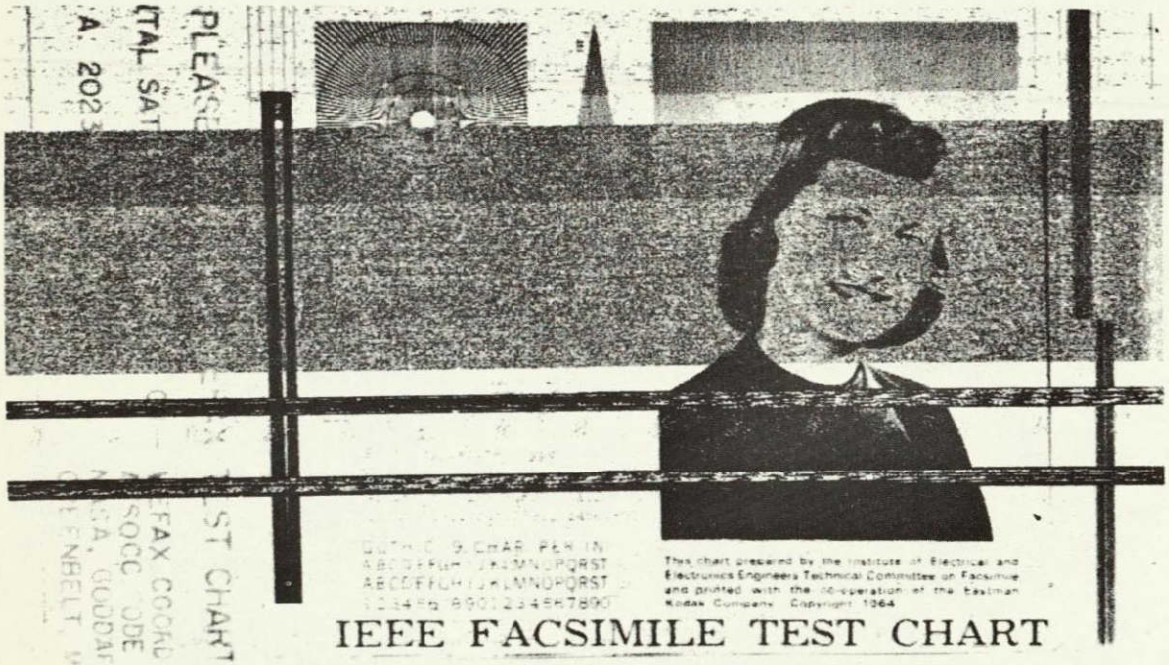
- Voice transmissions from Hughes did not materially affect the WEFAX transmissions.
- WEFAX transmissions did not adversely affect the Hughes voice transmissions.
- Voice transmissions from Rosman did affect (greatly) the WEFAX transmissions.

The Rosman interference is believed to be a result of a higher radiated power from Rosman than from Mojave which severely reduced the WEFAX transmission from the transponder. This could be corrected if a proper power balance from the two sources could be maintained at the input of the satellite transponder. Other multiple access tests of this type involving WEFAX will be conducted in the future.



Rosman Transmitter ON

Rosman Transmitter OFF



Rosman Transmitting Voice

Hughes Transmitting Voice

Figure 5-7. WEFAX Multiple Access Test on 13 March 1967.

SECTION 6

APRIL EVALUATION

The number of stations submitting data for evaluation remained at 22 for the month of April. Data was received from 2 new stations -- San Diego Naval Air Station, California and the USS Constellation aircraft carrier in the Pacific. It is anticipated that in the future, data will be received from other aircraft carriers in the Pacific area. WEFAX transmissions were made every day during April; however, the transmissions were limited to only one hour per day from 6 thru 27 April. The special WEFAX data collection period was from 15 thru 19 April, and data collected during this period were received from 16 stations.

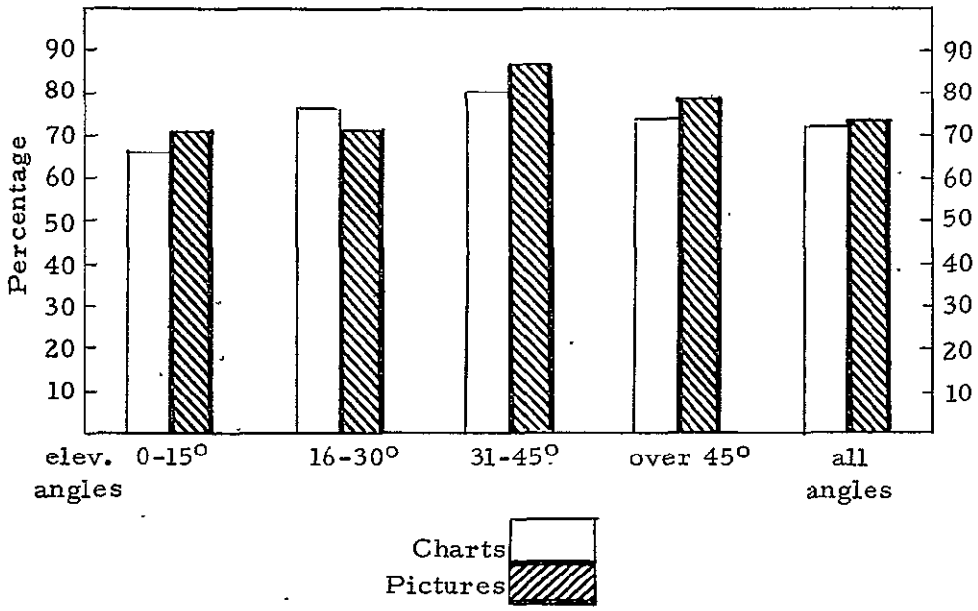
The quality of reception of weather charts and satellite pictures continued to be in an excellent or good category at least 70% of the time, and in the unusable category less than 5% of the time. Table 6-1 depicts the classification of the quality of reception by the various stations during April. The percentage of excellent or good receptions grouped in relation to the station's antenna elevation angle is shown in Figure 6-1. There was a slight decrease in April of the average number of grey scale steps discernible on the WEFAX test charts as received on paper facsimile machines. Grey scales received remained relatively good, and as indicated in Figure 6-2, two stations (Papeete and Wake Island) continued to average 8 grey scale steps discernible. Sample comments received from participating stations are listed in Table 6-2. Many favorable comments were received on the spin scan picture transmissions with excellent comments regarding the digitized pictures.

TABLE 6-1

Classification of WEFAX Receptions of
Weather Charts and Satellite Pictures
(April 1967)

APT	Weather Charts					Satellite Pictures				
Receiving Stations	Exc	Good	Fair	Poor	Unusable	Exc	Good	Fair	Poor	Unusable
GSFC, Maryland	79	79	21	5	1	22	117	58	13	3
Toronto, Canada	24	45	23	19	13	27	78	27	19	7
Fuchu, Japan	27	66	31	12	6	35	65	30	14	8
Tokyo, Japan	0	48	20	5	1	0	72	16	0	1
Howard AFB, C. Z.	1	3	1	0	0	0	0	0	0	0
Melbourne, Australia	9	44	38	11	2	22	89	49	10	3
Tampa, Florida	4	0	0	1	0	12	0	0	0	0
Aberdeen, S. D.	6	25	22	2	0	19	21	28	3	7
Anchorage, Alaska	48	51	8	0	0	89	68	27	1	0
Lake Jackson, Texas	15	17	1	3	1	15	38	19	6	8
Petersen Field, Colo.	0	1	1	0	0	0	0	0	0	0
Christchurch, N. Z.	1	3	5	0	1	0	12	1	0	0
Seattle, Washington	0	2	2	3	0	0	0	8	1	0
Mojave, California	111	68	12	0	1	130	69	9	1	1
Mountain View, Calif.	0	0	16	0	0	0	0	4	0	0
Pt. Mugu, Calif.	11	7	4	0	0	18	13	0	0	2
San Diego, Calif.	0	10	4	0	0	0	17	1	0	1
USS Constellation, Pac.	0	0	1	0	15	0	0	0	5	8
Wake Island, Pacific	1	0	0	0	0	0	1	3	0	0
Kunia, Hawaii	11	10	6	13	29	23	2	4	9	21
Honolulu, Hawaii	0	3	3	0	1	2	5	3	0	1
Papeete, Tahiti	85	58	6	1	1	86	74	11	0	0
TOTALS	433	540	225	75	72	500	741	298	82	71
	(32%)	(40%)	(17%)	(6%)	(5%)	(30%)	(43%)	(18%)	(5%)	(4%)

Percentage of Excellent or Good Receptions of
WEFAX by Elevation Angle Increments
(1345 charts and 1692 pictures evaluated)
(April)



WEFAX Participating Stations
(by antenna elevation angle)

Station	Antenna Elevation Angle	
GSFC, Maryland	4°	
Toronto, Canada	5°	
Fuchu, Japan	7°	
Tokyo, Japan	8°	0° to 15°
Howard AFB, C. Z.	11°	
Melbourne, Australia	11°	
Tampa, Florida	11°	
Aberdeen, S. Dakota	18°	
Anchorage, Alaska	21°	
Lake Jackson, Texas	22°	
Petersen Field, Colo.	26°	16° to 30°
Christchurch, N. Z.	27°	
Seattle, Washington	28°	

Station	Antenna Elevation Angle	
Mojave, Calif.	36°	
Mountain View, Calif.	37°	
Pt. Mugu, Calif.	38°	
San Deigo, Calif.	38°	31° to 45°
USS Constellation, Pac.	38°	
Wake Island, Pacific	38°	
Kunia, Hawaii	65°	
Honolulu, Hawaii	65°	Over 45°
Papeete, Tahiti	68°	

Figure 6-1. Percentage of Good or Excellent Receptions (April)

Average Grey Scale Steps of
Receiving Stations (April)

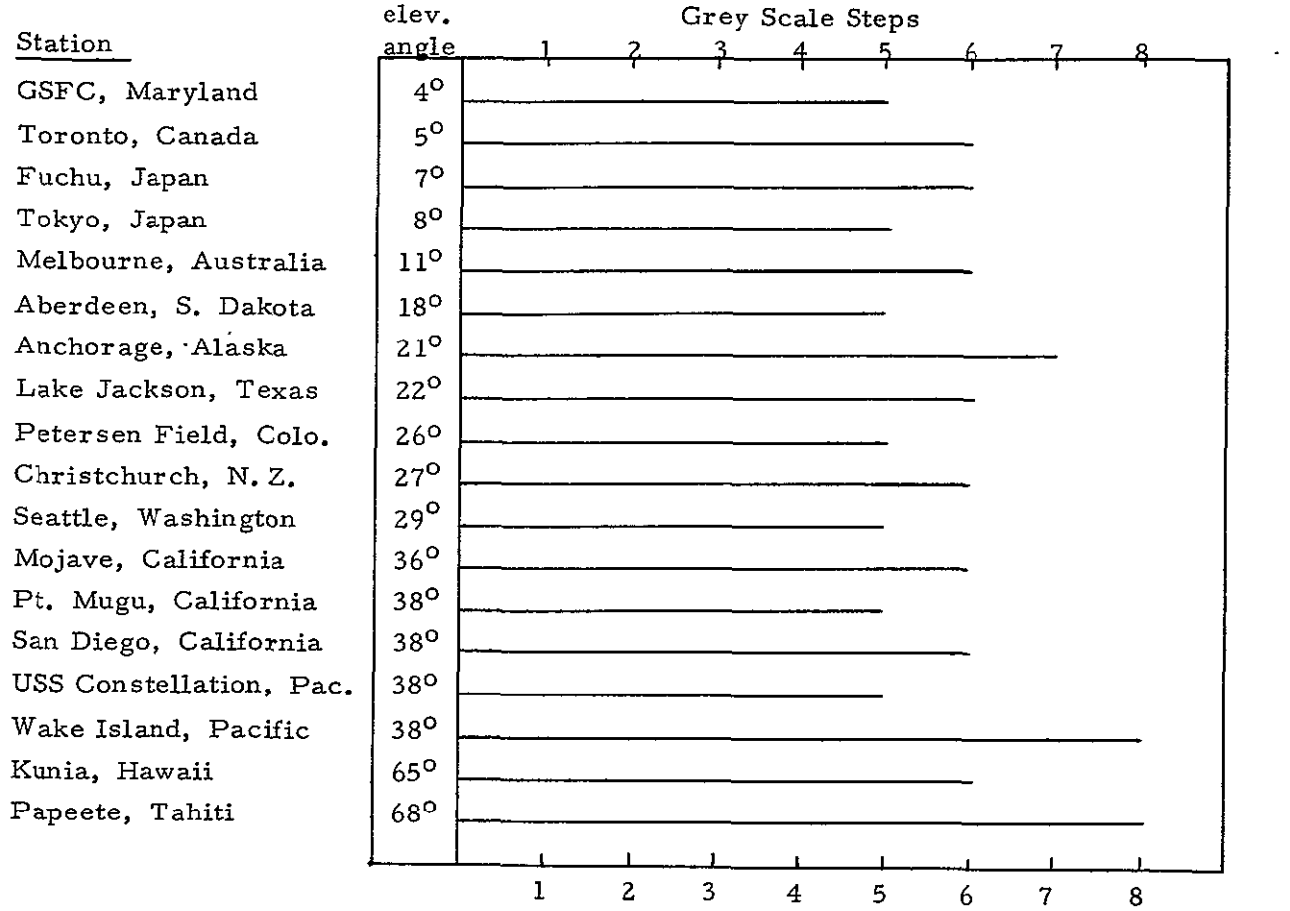


Figure 6-2. Received Grey Scales (April)

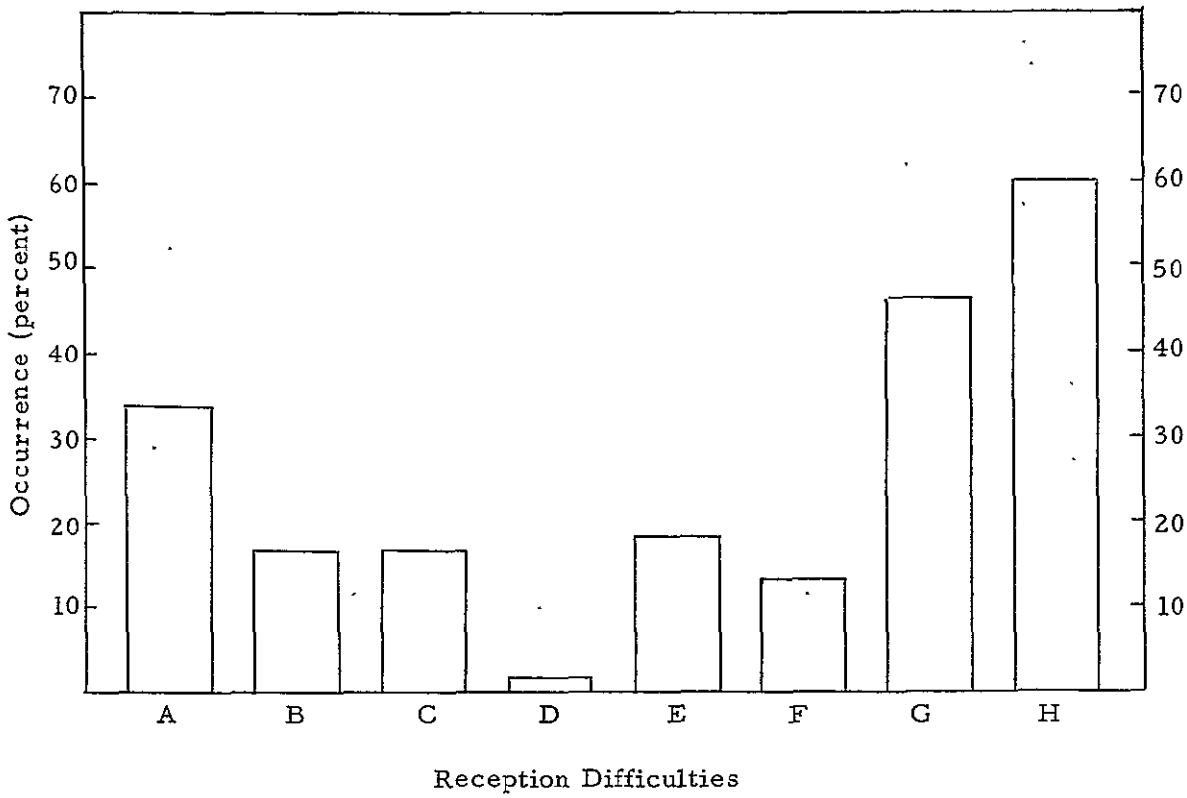
TABLE 6-2

Sample Comments from Participating APT Stations
(April)

Station Location	
Lake Jackson, Texas	Noise burst interference (spin modulation) appeared to be less frequent at the end of the month, but still occurs.
Tampa, Florida	We utilize spin scan pix whenever they are current.
Toronto, Canada	Special transmission - April 28th, 2245Z. Reception was extremely good throughout the special SSCC transmission, with detail the best ever received here from the spin scan camera. The Hawaiian Islands, Baja California and the coasts of Mexico were easily discerned, and the Salton Sea was clearly evident. Picture segments were easily fitted into composite.
Pt. Mugu, California	No difficulty in receiving charts and pictures. Nighttime reception was superior to daytime receptions. Pictures lose value if not gridded. Only spin scan pictures utilized for map analysis and discussion.
Kunia, Hawaii	Received signal strength was much too low the entire month (less than 2 microvolts). We acquired a strong audio signal in most cases, but the signal was not strong enough to activate the recorder. Are we unique, or have all stations had problems this month?
Melbourne, Australia	The resumption of SSCC pix is most welcome. The quality of the digitized SSCC pix is a great improvement over the conventional SSCC pix sent through the satellite.
Anchorage, Alaska	Resumption of the spin scan pics is welcome. They seem to be much better or is that only because of the lapse?
Tokyo, Japan	Southern hemisphere sfc chart is very valuable for us as this WEFAX data is the only one source we get. ESSA III central Pacific and S.E. Asia data are also very useful, as they are not covered by our APT ESSA and Nimbus data.

The spin modulation type of noise interference continued thru the month of April. The percentage of occurrence of spin modulation increased to 60% in April (See Figure 6-3) from 42% in March. Interference decreased slightly during April to 34% from 39% in March. Figure 6-4 shows the daily occurrence of interference as a percentage of the number of stations submitting data for evaluation. The occurrence of jitter has continued to increase for some unapparent reason. Jitter increased from 19% in February to 27% in March and to 46% in April.

On 28 April, a "real-time turn around" test was conducted of a digitized ATS-1 spin scan picture. The picture signal, starting at 2158Z, as received at the Rosman ground station from the ATS-1 spacecraft, was relayed in real time over the wide band link to Goddard where it was digitized and stored on a digital magnetic tape. The picture was then retransmitted over WEFAX as eight APT pictures beginning at 2245Z, a difference of 27 minutes from end of picture signal to beginning of picture retransmission. The excellent results of this test are indicated by the samples of reception in Figures 6-5 thru 6-10.



A - Interference - Visible patterns appearing on chart format as a result of external signal sources or internally generated beat frequencies.
B - Bleeding - Smearing and presentation on white areas by black.
C - Signal plus noise-to-noise - White or black streaks on chart, uniformity of tonal shades, snow effect.
D - Distortion - Large scale geometric deviation from time pattern.
E - Skew - Deviation of a vertical line from a vertical normal. Test limit - 1/4" in 8".
F - Multi-Image - The multiple chart reproduction (ghosts) caused by multiple path transmission or reflection.
G - Jitter - Periodic irregularities on lines and patterns.
H - Spin Modulation - Noise interference apparently originating in the spacecraft and near the frequency of the spin rate.

Figure 6-3. WEFAX Experiment, facsimile reception difficulties occurring at 19 APT receiving stations during April 1967. 253 WEFAX Test Charts evaluated.

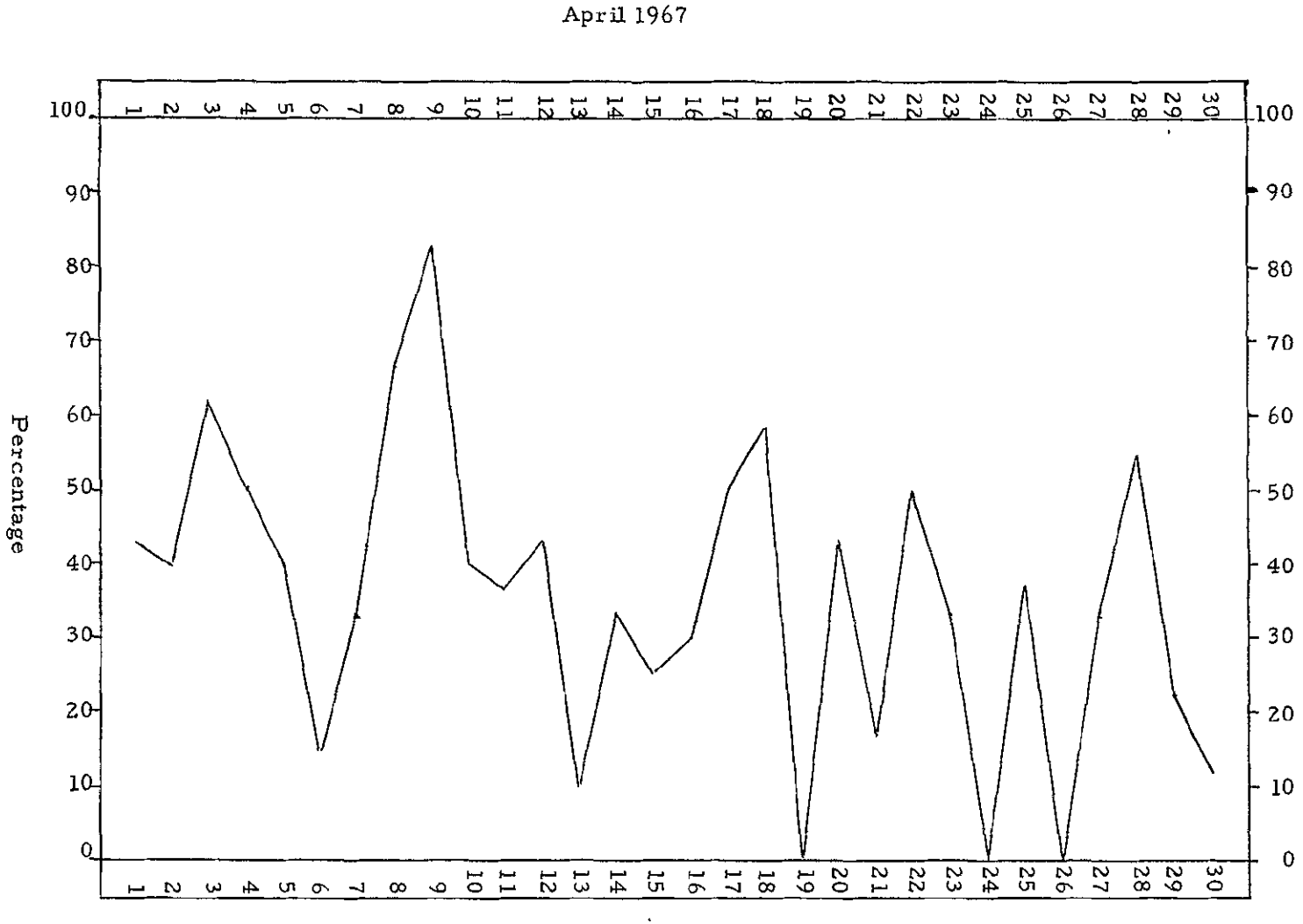


Figure 6-4. Interference Reported During April.

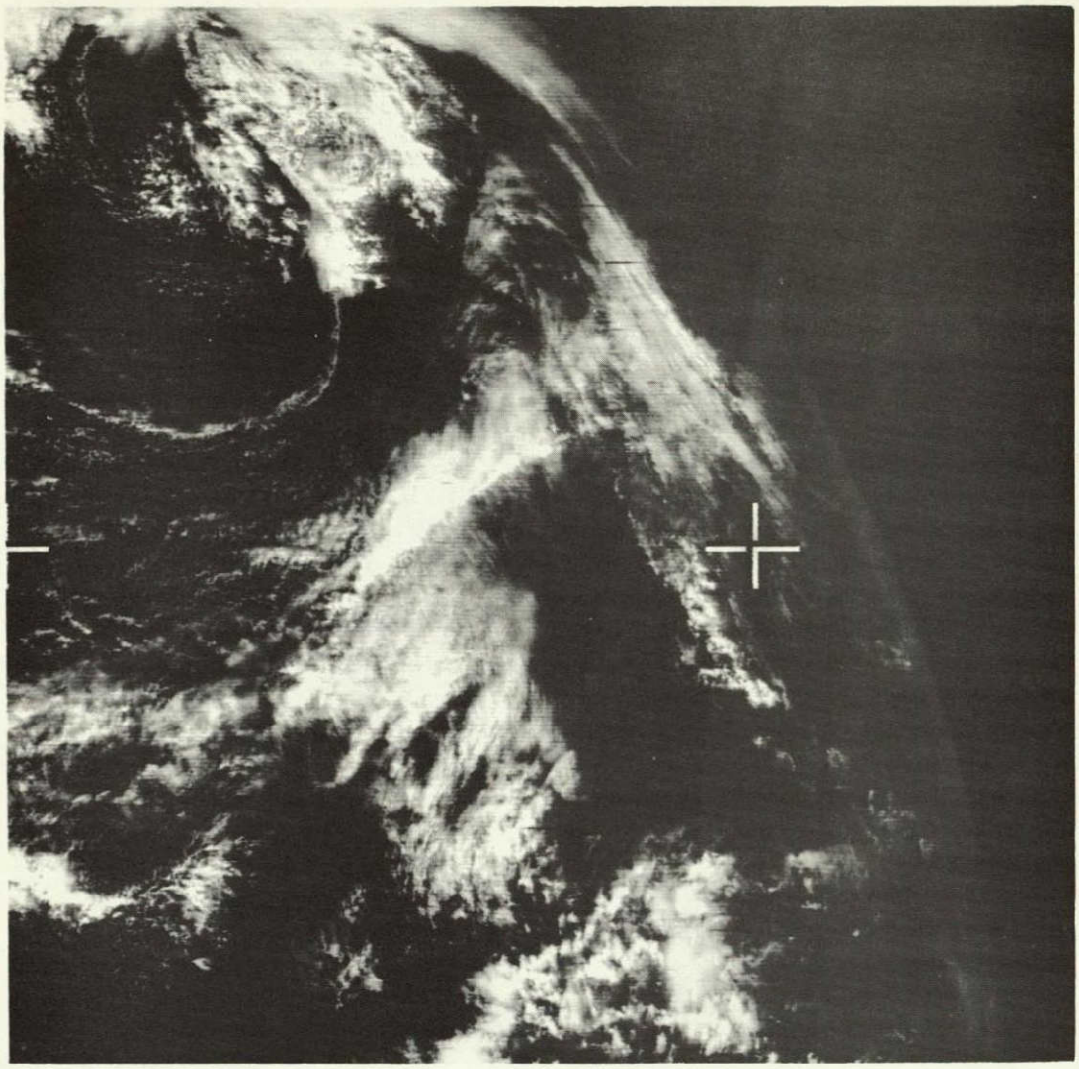


Figure 6-5. Northeast Section of 28 April Digitized SSCC Picture. Portions of North, Central, and South America are Visible.

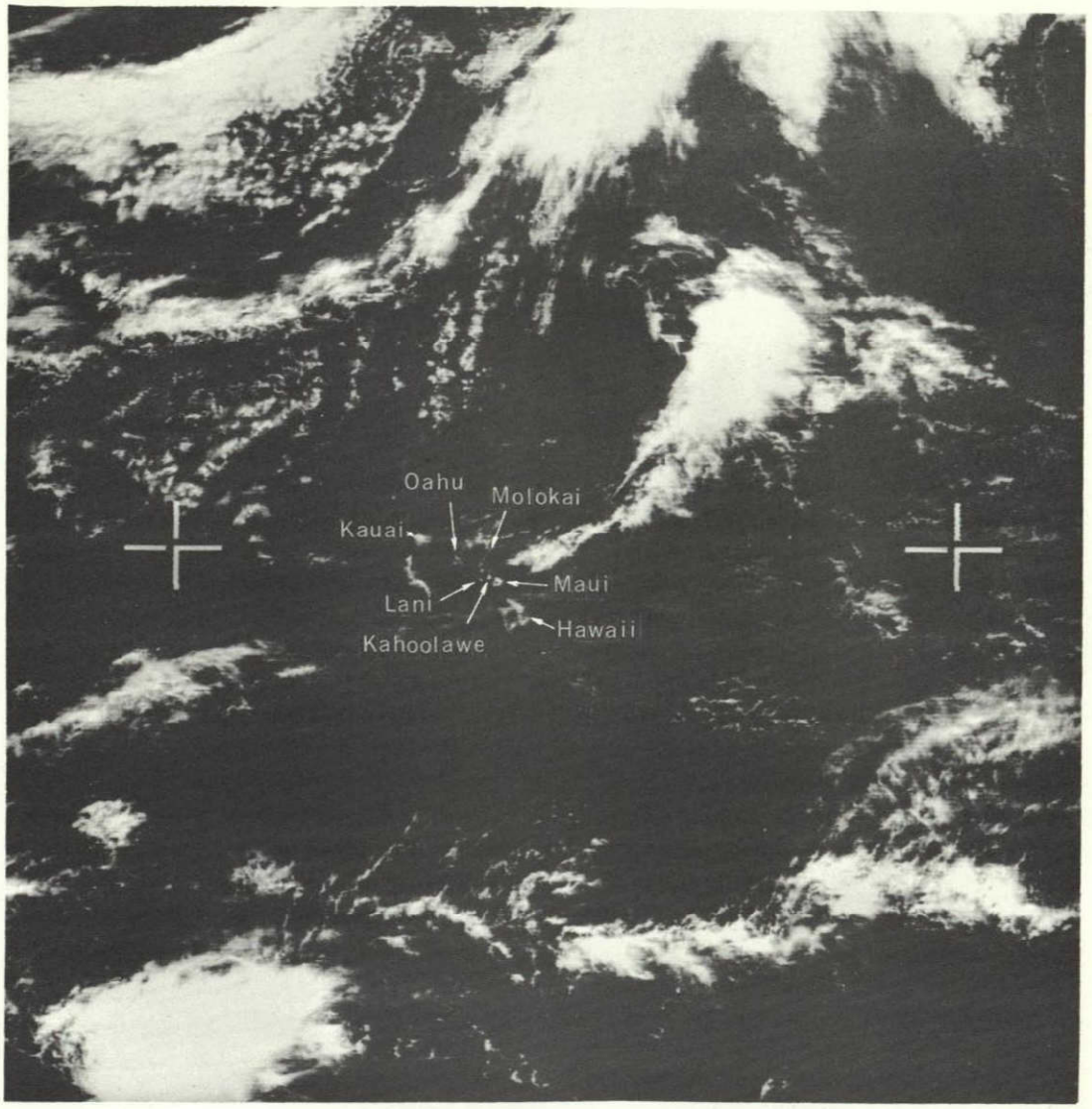


Figure 6-6. North Central Pacific Section of 28 April Digitized SSCC Picture. The Hawaiian Islands are Visible in the Center of the Picture.

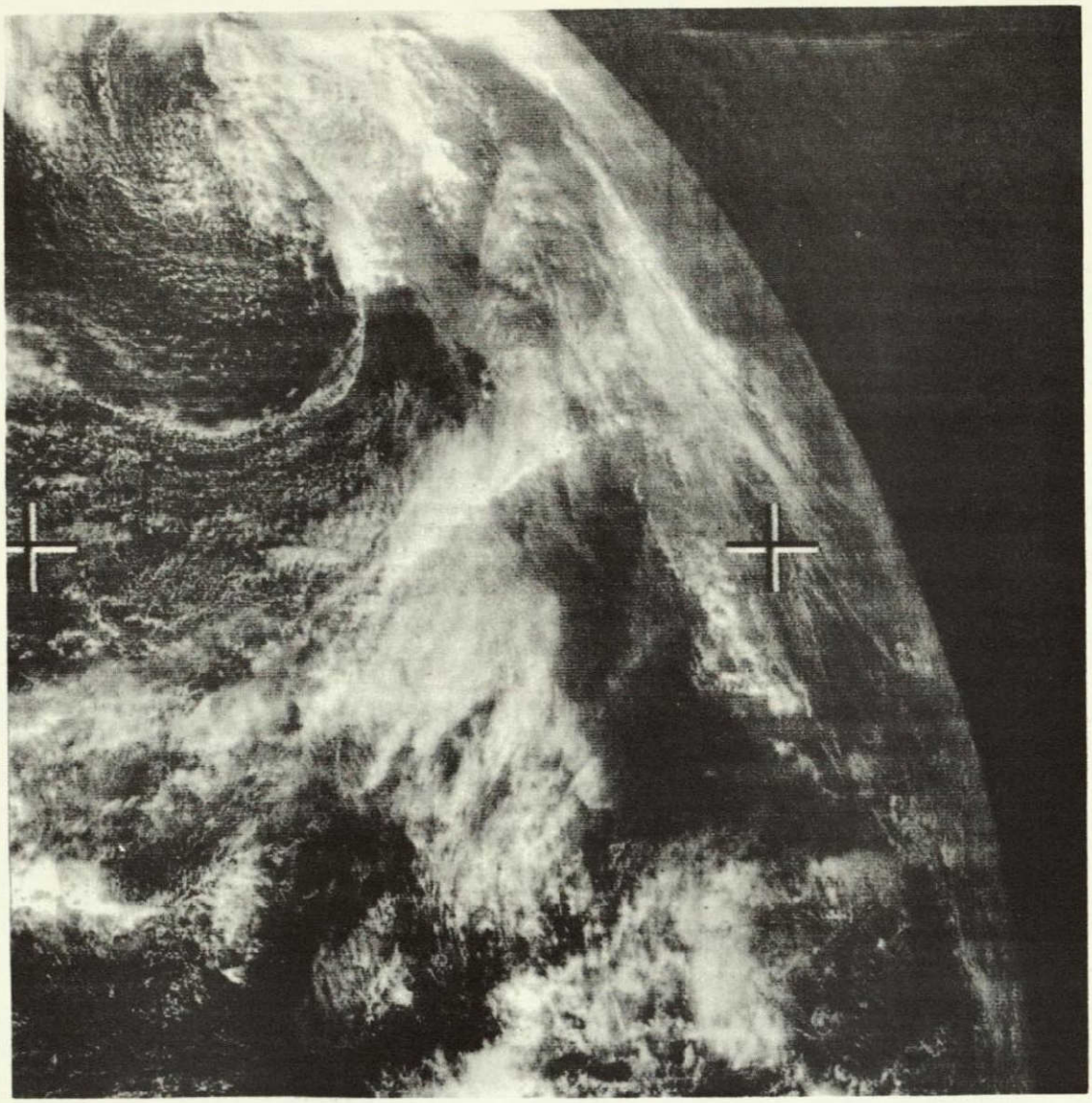


Figure 6-7. Digitized SSCC Picture Received at Toronto. The Northeast Section of the 28 April Picture Recorded on a Paper Facsimile.

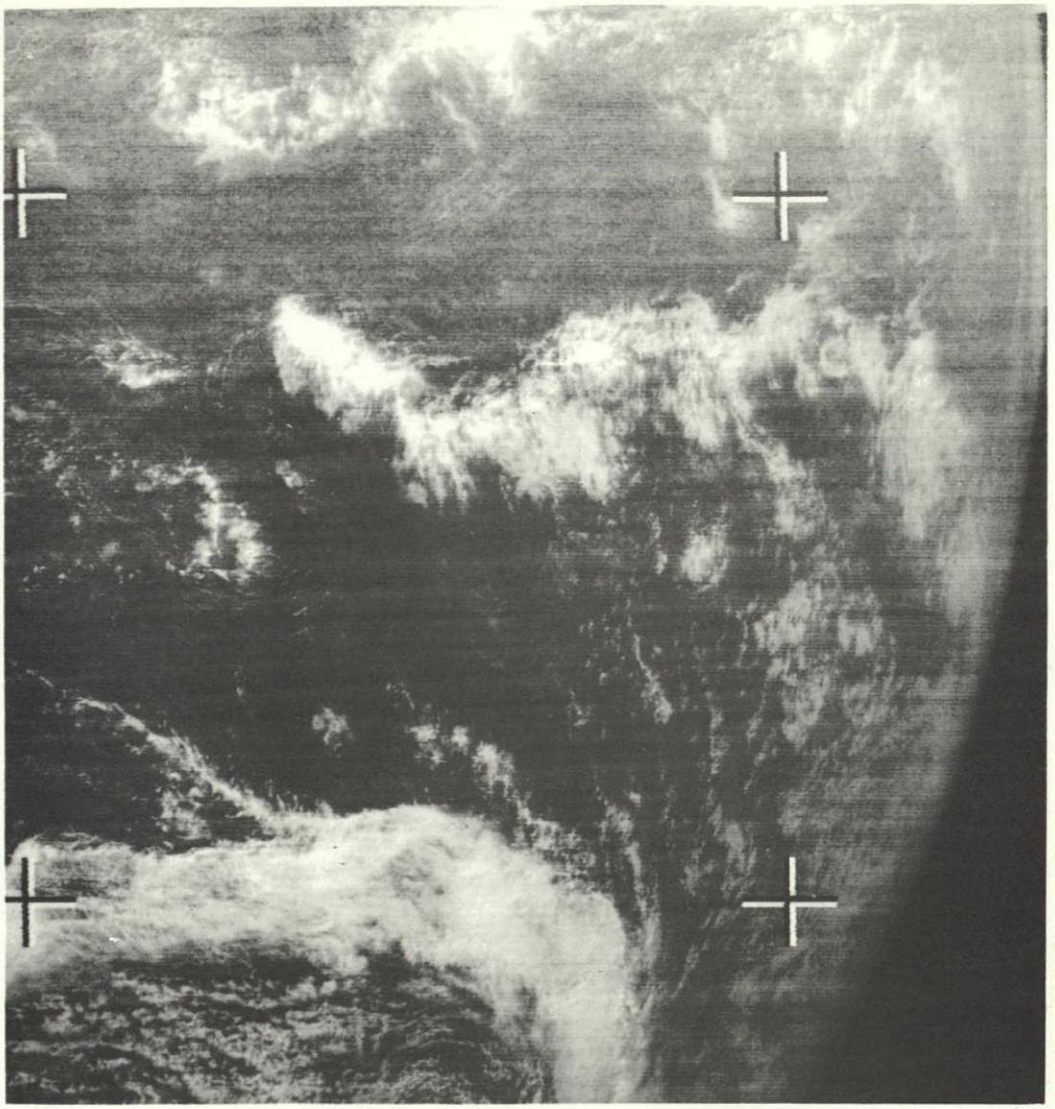


Figure 6-8. Digitized SSCC Picture Received at Toronto. The Southwest Section of the 28 April Picture Recorded on a Photo Facsimile.

Figure 6-9. Digitized SSCC Picture Received at Mojave. The North Central Pacific Section of the 28 April Picture Recorded on a Paper Facsimile.

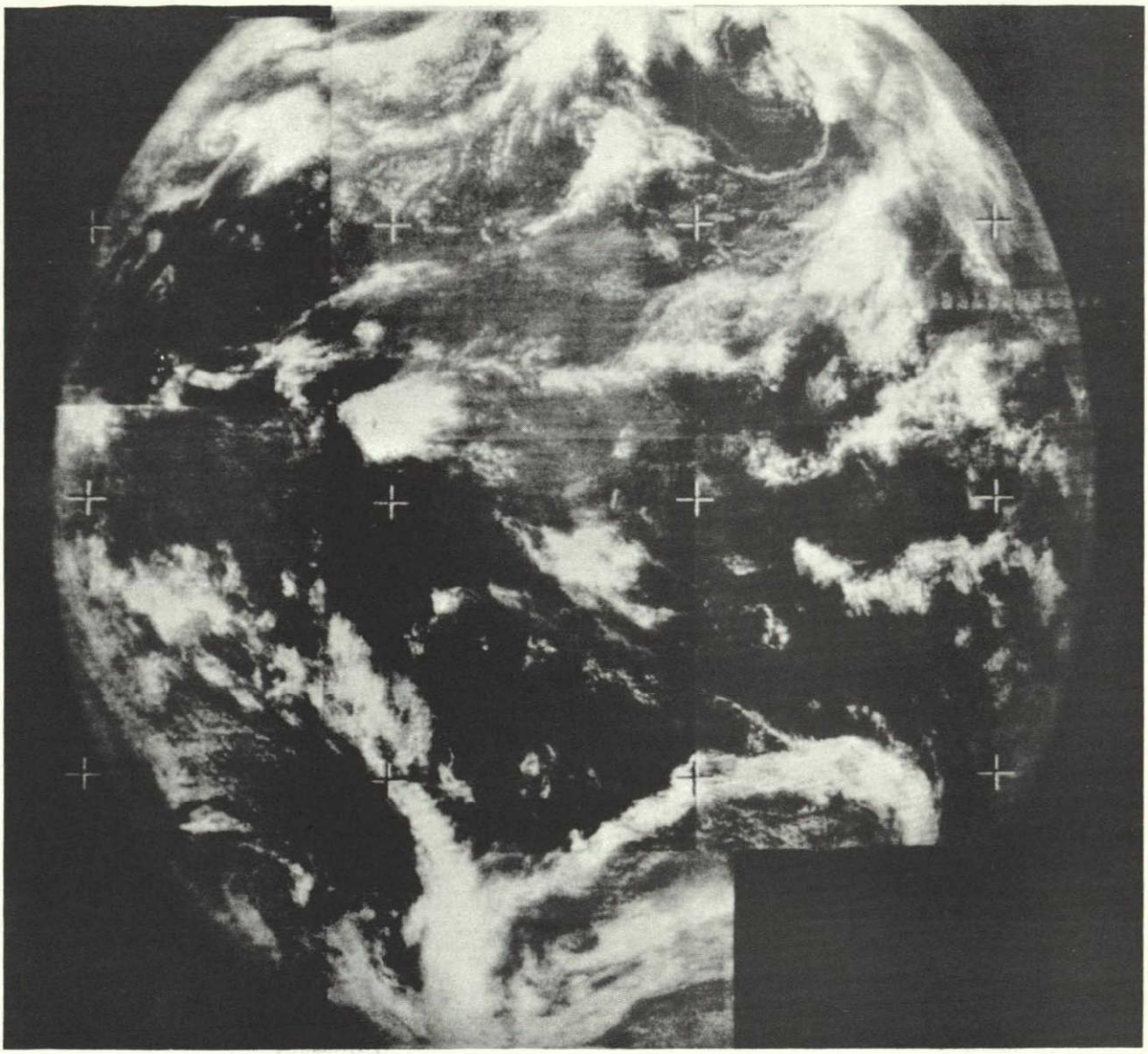


Figure 6-10. Digitized SSCC Picture Received at Lake Jackson. A Copy of a Mosaic Made of the Sections of the 28 April Picture.

SECTION 7

MAY EVALUATION

Twenty-one stations submitted data for evaluation in May; including one new station -- KSST, Sulphur Springs, Texas. WEFAX transmissions were made daily except for 22 and 27 May, and on most days there were 2 to 3 transmission periods. The special WEFAX data collection period was from 23 thru 27 May; however, the scheduled transmissions on the 27th were cancelled due to the Mojave transmitter being inoperative. Data were received from 18 stations during the special collection period.

The quality of reception of weather charts and satellite pictures during May by the various participating stations is depicted in Table 7-1. The weather charts and satellite pictures continued to be received in an excellent or good category at least 70% of the time and in the unusable category less than 5% of the time. The percentage of excellent or good receptions grouped in relation to the station's antenna elevation angle is displayed in Figure 7-1. The average number of grey scale steps discernible on the WEFAX test chart remained relatively good during May and the averages for 19 stations are shown in Figure 7-2.

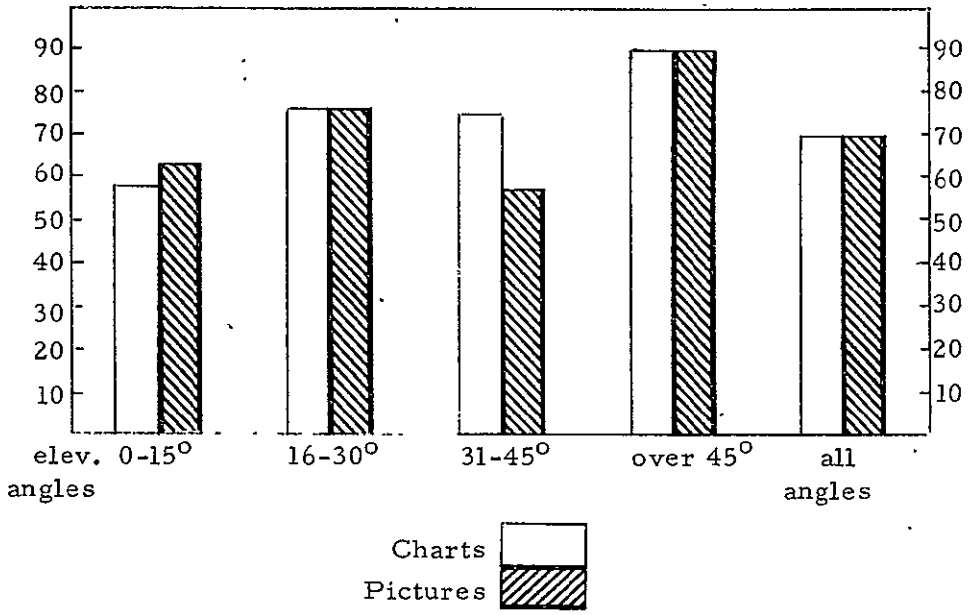
The spin modulation type of noise interference continued through May; however, the percentage of occurrence decreased from 60% in April to 49% in May. The occurrence of signal-to-noise increased markedly during May to 44% from 23% in April. Another reception difficulty (see Figure 7-3) which showed an appreciable change was jitter, which decreased from 45% in April to 32% in May. Figure 7-4 shows the daily occurrence of interference during May as a percentage of the number

TABLE 7-1

Classification of WEFAX Receptions of Weather Charts and Satellite Pictures
(May 1967)

APT Receiving Stations	Weather Charts					Satellite Pictures				
	Exc	Good	Fair	Poor	Unusable	Exc	Good	Fair	Poor	Unusable
GSFC, Maryland	26	94	43	7	8	48	177	124	41	27
Aichi, Japan	0	10	2	7	4	0	60	18	6	4
Toronto, Canada	34	70	22	12	8	58	111	20	18	1
Fuchu, Japan	9	69	60	18	9	55	138	55	24	3
Tokyo, Japan	0	18	22	12	5	0	61	68	13	4
Howard AFB, C.Z.	12	11	4	0	1	28	10	2	4	2
Tampa, Florida	2	1	14	0	1	15	21	6	4	2
Nashville, Tenn.	3	4	1	2	2	6	13	14	14	6
Aberdeen, S. D.	0	29	13	1	11	0	121	49	0	23
New Orleans, La.	5	4	0	0	0	4	10	0	0	0
Anchorage, Alaska	89	24	13	3	1	233	69	20	0	0
Sulphur Springs, Tex.	0	0	0	0	0	0	4	0	0	0
Lake Jackson, Texas	1	4	3	0	0	10	15	22	1	0
Seattle, Washington	1	1	1	0	0	0	3	25	0	0
Mojave, California	54	103	16	4	10	108	220	98	5	12
Mountain View, Calif.	0	0	1	0	0	0	0	5	0	0
San Francisco, Calif.	6	17	4	5	7	9	31	22	15	22
Pt. Mugu, California	3	8	2	3	2	2	1	2	5	13
USS Constellation, Pac.	4	7	6	2	4	0	1	24	19	23
Kunia, Hawaii	74	33	6	2	0	50	154	21	0	0
Papeete, Tahiti	80	50	14	2	2	169	192	23	16	2
TOTALS	403 (30%)	557 (41%)	247 (18%)	80 (6%)	75 (5%)	795 (25%)	1412 (45%)	618 (20%)	185 (6%)	144 (4%)

Percentage of Excellent or Good Receptions of
WEFAX by Elevation Angle Increments
(1362 charts and 3154 pictures evaluated)
(May)



WEFAX Participating Stations
(by antenna elevation angle)

Station	Antenna Elevation Angle	
GSFC, Maryland	4°	
Aichi, Japan	5°	
Toronto, Canada	5°	
Fuchu, Japan	7°	
Tokyo, Japan	8°	0° to 15°
Howard AFB, C. Z.	11°	
Melbourne, Australia	11°	
Tampa, Florida	11°	
Nashville, Tennessee	13°	
Aberdeen, S. Dakota	18°	
New Orleans, La.	18°	
Anchorage, Alaska	21°	
Sulphur Springs, Tex.	21°	16° to 30°
Lake Jackson, Tex.	22°	
Seattle, Washington	29°	

Station	Antenna Elevation Angle	
Mojave, California	36°	
Mountain View, Calif.	37°	
San Francisco, Calif.	37°	31° to 45°
Pt. Mugu, Calif.	38°	
USS Constellation, Pac.	38°	
Kunia, Hawaii	65°	
Papeete, Tahiti	68°	Over 45°

Figure 7-1. Percentage of Good or Excellent Receptions (May)

Average Grey Scale Steps of
Receiving Stations (May)

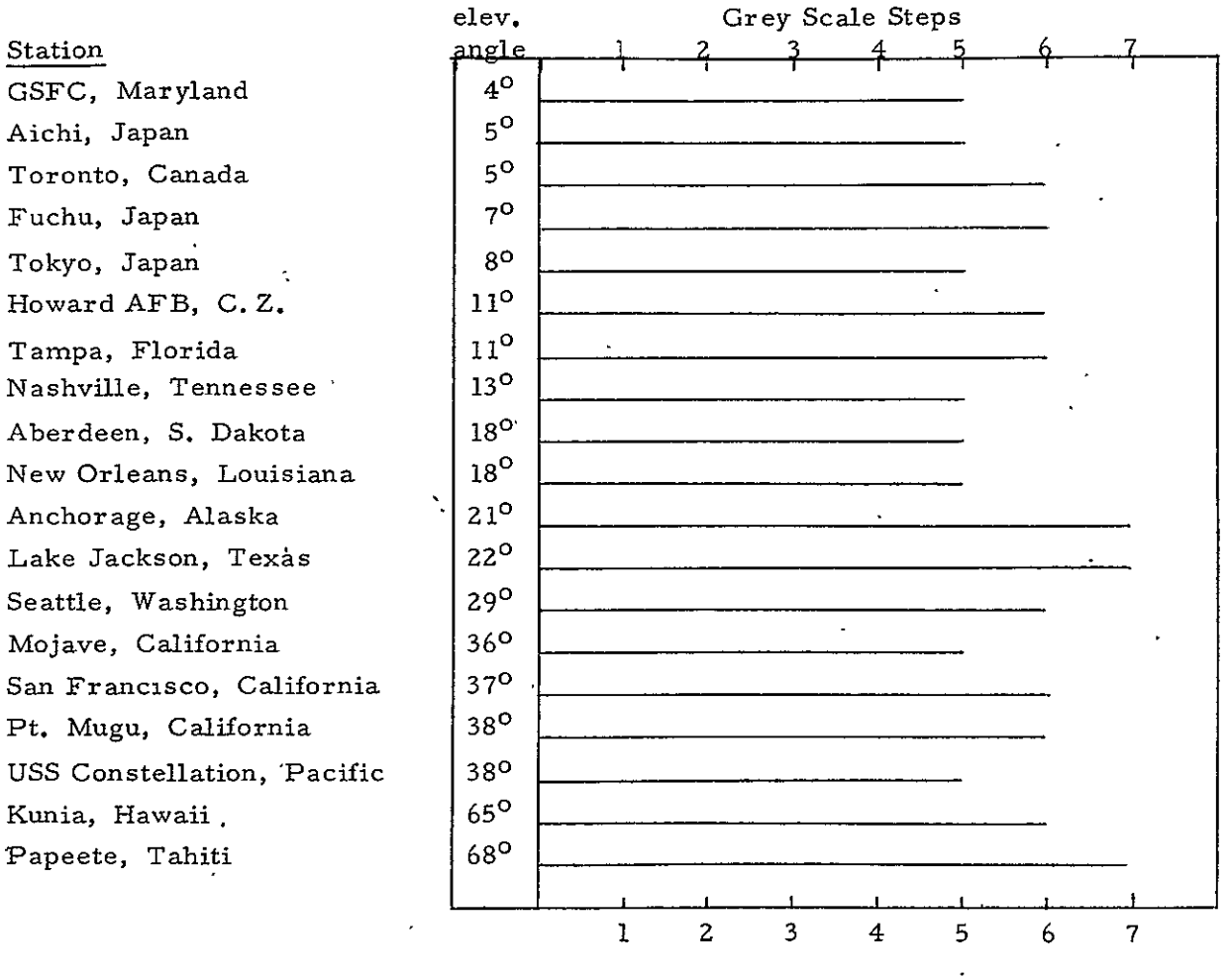
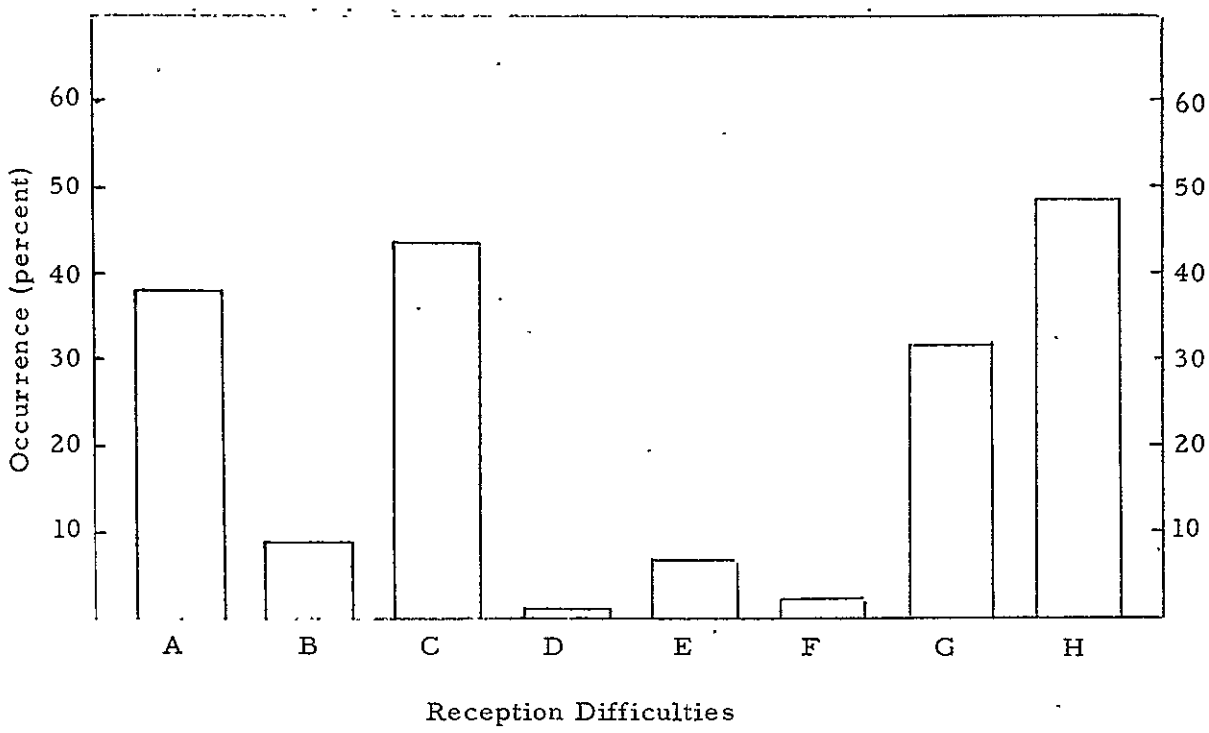


Figure 7-2. Received Grey Scale Steps (May)



A - Interference - Visible patterns appearing on chart format as a result of external signal sources or internally generated beat frequencies.
B - Bleeding - Smearing and presentation on white areas by black.
C - Signal plus noise-to-noise - White or black streaks on chart, uniformity of tonal shades, snow effect.
D - Distortion - Large scale geometric deviation from time pattern.
E - Skew - Deviation of a vertical line from a vertical normal. Test limit - 1/4" in 8".
F - Multi-Image - The multiple chart reproduction (ghosts) caused by multiple path transmission or reflection.
G - Jitter - Periodic irregularities on lines and patterns.
H - Spin Modulation - Noise interference apparently originating in the spacecraft and near the frequency of the spin rate.

Figure 7-3. WEFAX Experiment facsimile reception difficulties occurring at 20 APT receiving stations during May 1967. 273 WEFAX Test Charts evaluated.

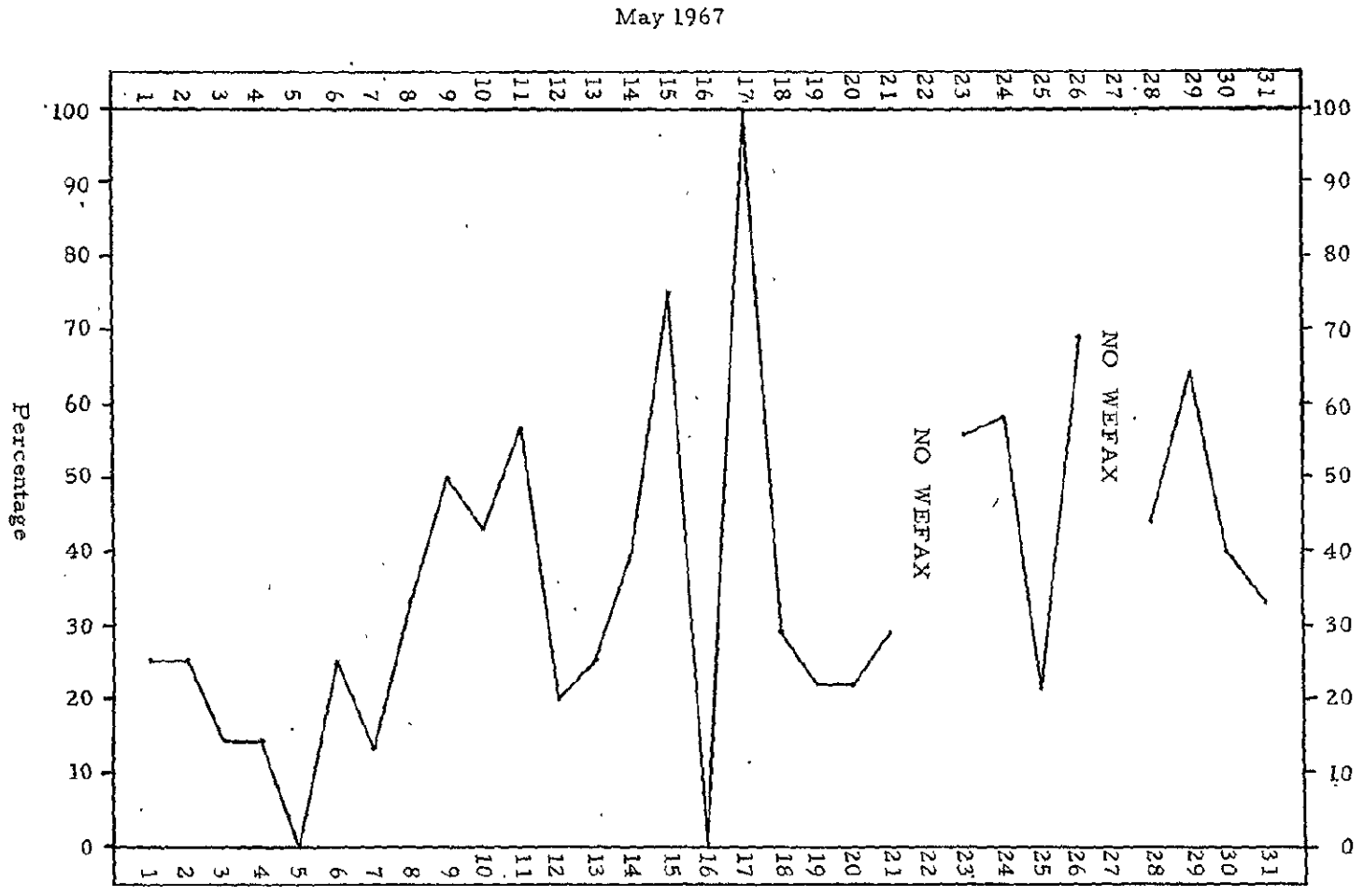


Figure 7-4. Interference Reported During May.

of stations submitting data for evaluation. Many of the May comments from the stations (Table 7-2) indicate problems in the received signal from the spacecraft. Other comments indicate the operational usability of the WEFAX system.

Special test transmissions of digitized spin scan camera pictures were conducted from GSFC thru Rosman on 4 and 5 May. There appear to be no significant problems in this method of transmission of SSCC pictures over WEFAX. The only difficulty is in getting the digitized signal to GSFC or Suitland where it can be processed and put into an APT format. Special WEFAX transmissions were made on 13 and 20 May to the Boy Scouts of America. On 13 May the transmissions were of a complete day's sequence of spin scan pictures. Digitized SSCC pictures were transmitted on 20 May. Figure 7-5 is a copy of a message transmitted on 13 May to the Boy Scouts.

TABLE 7-2:

Sample Comments from Participating APT Stations
(May)

Station Location	Comment
Lake Jackson, Texas	The primary problem still appears to be interference; spin modulation was severe thru 5/12. After this date the only interference that was severe was occasional local 60Hz arcing. Signal fading occurred during most transmissions, and caused loss of some sections of pictures. The quality of the SSCC pictures appears to be worse than in the past; the contrast is usually low and resolution only fair. I hope that the digitized pictures can be used more often in the future.
Tampa, Florida	Current atmospherics apparently caused signal drop-out during transmissions. Drop-outs more noticeable in today's pix. (26 May)
Toronto, Canada	For max signal, had to move antenna from 257° azimuth to 282°. (06/0900Z) Solar flare activity? Short bursts of noise, or signal fading due flare activity. (26/0530Z)
Aberdeen, South Dakota	Long period fading 0530-0555Z and 0900-1000Z with some spin fading (100 rpm) 0900-1000Z. Auroral activity visible from this station 0530 to 0800Z. (29 May)
Point Mugu, California	Phasing problems noted in 90% of all cloud pictures received --- appears to be a synchronization problem.
Fuchu, Japan	The ESSA-3 pictures showing the Indian Ocean area were particularly useful from 16-18 May as they showed a tropical cyclone ..... On 18 May the ESSA-3 pictures showed that the storm had suddenly moved northward, in fact several degrees north of its storm bulletin location.

Comments from Stations (cont)

Kunia, Hawaii	The standard analysis and prognosis charts from NMC are duplication of routine land line facsimile. These have had limited use in our operations. However, the quality of WEFAX chart reception is as good as that via land line. This verifies the feasibility of this system for weather communications. The Spin-Scan pictures received in May were quite good and quite useful. Their usefulness for tropical areas and the southern hemisphere has been outstanding for our purposes ..... The pictures, when received several days in a row, have definitely been used. The nephanalyses of the tropics and the southern hemisphere are used operationally. These nephanalyses have, at times, been received at 0900Z which is several hours before the normal landline facsimile transmission time of about 1400Z. These nephanalyses greatly augment our ESSA APT pictures and the sparse conventional data from 20N to 20S across the Pacific.
Anchorage, Alaska	This is the largest total of material received here since the start of the experiment. The direct transmission of charts from Mojave were the finest quality of facsimile we have ever seen.

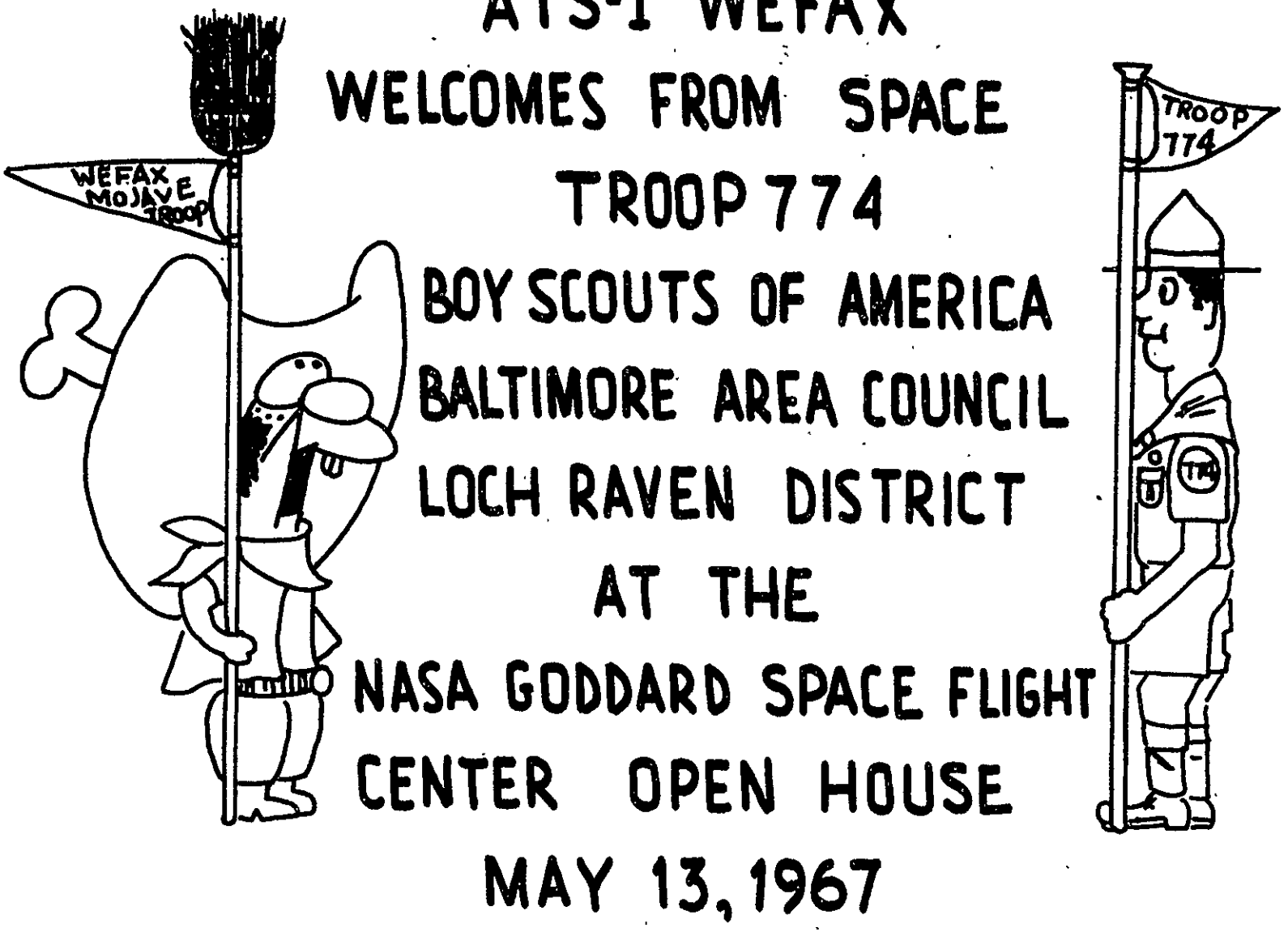


Figure 7-5. WEFAX Message to Boy Scouts.

SECTION 8

JUNE EVALUATION

WEFAX transmissions were made daily during June, and 21 participating stations submitted data for evaluation. The special WEFAX data collection period was from 27 thru 30 June, and data were received from 18 stations during this period.

The quality of reception of weather charts and satellite pictures by the various participating stations during June is depicted in Table 8-1. The weather charts received continued to be of excellent or good quality at least 70% of the time, and in the unusable category less than 5% of the time. The quality of satellite picture reception dropped below 70% for the first time since January, with 66% in the excellent or good category. Reception during June was poorer for those stations with lower antenna elevation angles. Figure 8-1 shows the correlation of the antenna elevation angle and the percentage of excellent or good receptions. The average number of grey scale steps discernible on the WEFAX test chart continued to be relatively good during June; the averages for 20 stations are shown in Figure 8-2.

Of the various reception difficulties depicted in Figure 8-3, low signal-to-noise ratio was the prevalent problem during June, occurring in 45% of the charts evaluated. The spin modulation type of noise interference continued to decrease to 28% in June, from 49% in May and 60% in April. The occurrence of interference continued to be a problem in June; the daily occurrence is shown in Figure 8-4. Comments from some of the participating stations are listed in Table 8-2

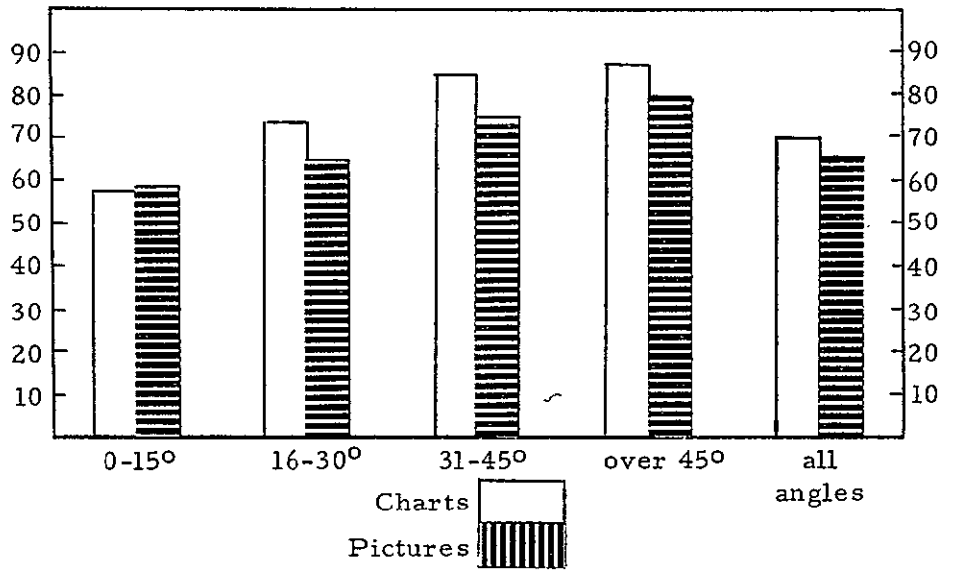
WEFAX multiple access tests were conducted on 12 and 13 June. The objective was to test the multiple access capability of the ATS-1 VHF transponder for WEFAX transmissions. Two facsimile signals were transmitted simultaneously to the spacecraft from separate sources at plus 25 kHz and minus 25 kHz from the center frequency (149.22 MHz). The Mojave transmitter was set to plus 25 kHz, so

TABLE 8-1

Classification of WEFAX Receptions of
Weather Charts and Satellite Pictures
(June 1967)

APT Receiving Stations	Weather Charts					Satellite Pictures				
	Exc	Good	Fair	Poor	Unusable	Exc	Good	Fair	Poor	Unusable
GSFC, Maryland	41	108	40	23	5	34	43	41	6	2
Aichi, Japan	0	36	55	35	9	0	36	16	22	2
Toronto, Canada	25	85	56	39	26	15	45	28	19	9
Fuchu, Japan	30	71	68	35	16	26	39	33	5	2
Tokyo, Japan	0	10	8	0	0	0	11	5	10	0
Howard AFB, C.Z.	10	20	5	2	0	1	1	0	0	0
Melbourne, Australia	22	135	9	0	0	0	72	15	6	0
Tampa, Florida.	8	4	1	1	1	17	0	0	0	4
Nashville, Tenn.	0	8	1	2	0	0	5	4	8	4
Guam, Marianas	53	68	44	10	4	23	13	28	11	1
Aberdeen, S.D.	0	7	10	7	9	0	1	9	6	14
Anchorage, Alaska	91	99	19	3	1	92	6	14	1	1
Sulphur Springs, Tex.	0	3	3	0	0	0	5	0	0	0
Lake Jackson, Texas	5	7	12	2	0	9	22	2	6	0
Christchurch, N.Z.	2	2	0	0	0	5	2	1	0	0
Mojave, California	114	95	12	2	13	80	22	9	6	8
San Francisco, Calif.	1	11	2	2	3	4	3	3	4	3
Pt. Mugu, California	6	4	2	4	1	7	6	4	3	2
Wake Island, Pacific	5	0	1	0	0	4	0	1	0	0
Kunia, Hawaii	38	90	20	15	3	34	34	5	20	9
Papeete, Tahiti	104	106	5	1	0	62	51	7	4	0
TOTALS	555	969	373	183	91	413	417	225	137	61
	(26%)	(45%)	(17%)	(8%)	(4%)	(33%)	(33%)	(18%)	(11%)	(5%)

Percentage of Excellent or Good Receptions of
WEFAX by Elevation Angle Increments
(2171 charts and 1253 pictures evaluated)
(June)



WEFAX Participating Stations
(by antenna elevation angle)

Station	Antenna Elevation Angle	
GSFC, Maryland	4°	
Aichi, Japan	5°	
Toronto, Canada	5°	
Fuchu, Japan	7°	
Tokyo, Japan	8°	0° to 15°
Howard AFB, C. Z.	11°	
Melbourne, Australia	11°	
Tampa, Florida	11°	
Nashville, Tenn.	13°	
Guam, Marianas	16°	
Aberdeen, S. Dakota	18°	
Anchorage, Alaska	21°	
Sulphur Springs, Tex.	21°	16° to 30°
Lake Jackson, Texas	22°	
Christchurch, N. Z.	27°	

Station	Antenna Elevation Angle	
Mojave, California	36°	
San Francisco, Calif.	37°	
Pt. Mugu, California	38°	31° to 45°
Wake Island, Pacific	38°	
Kunia, Hawaii	65°	
Papeete, Tahiti	68°	Over 45°

Figure 8-1. Percentage of Good or Excellent Receptions (June)

Average Grey Scale Steps of
Receiving Stations (June)

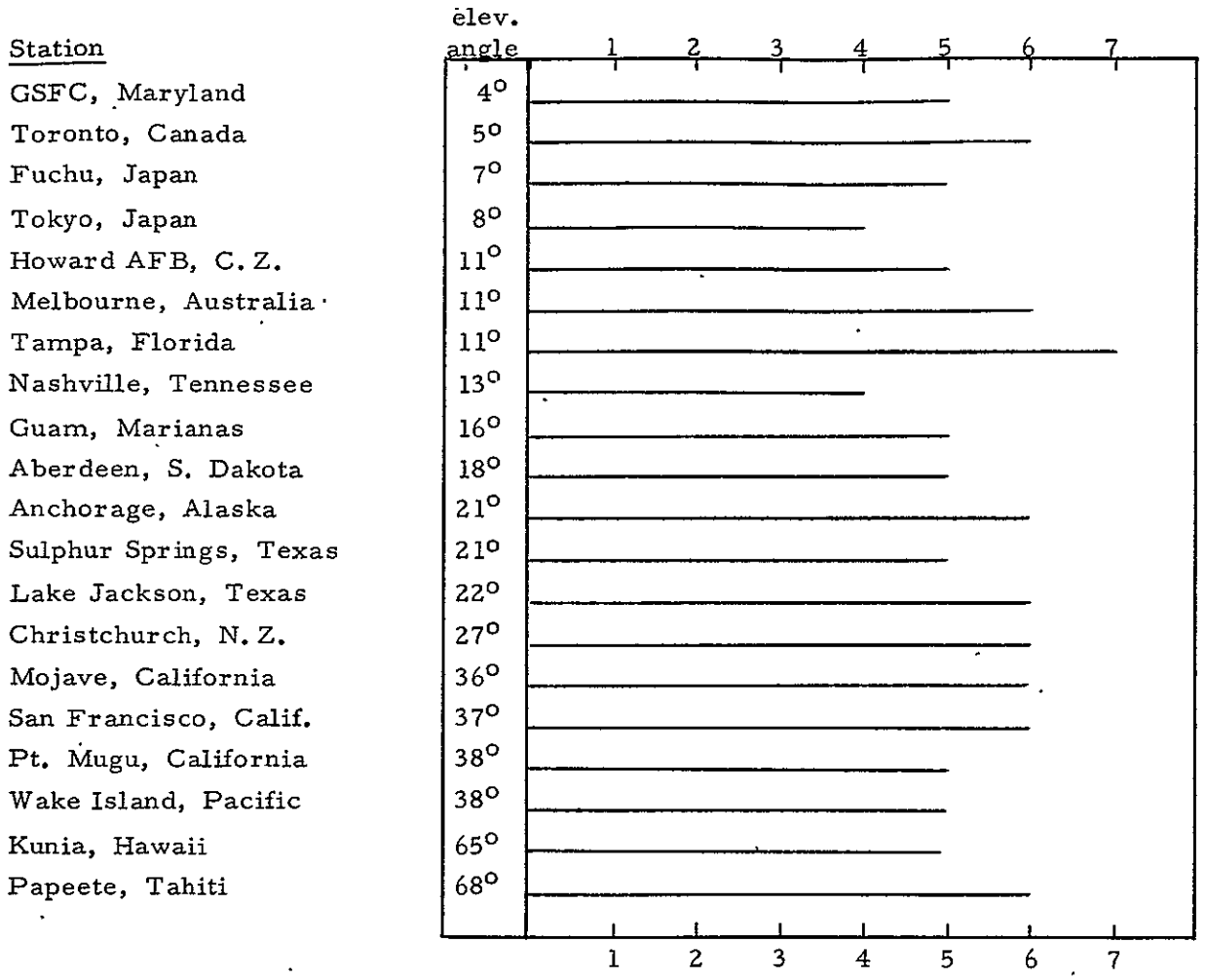
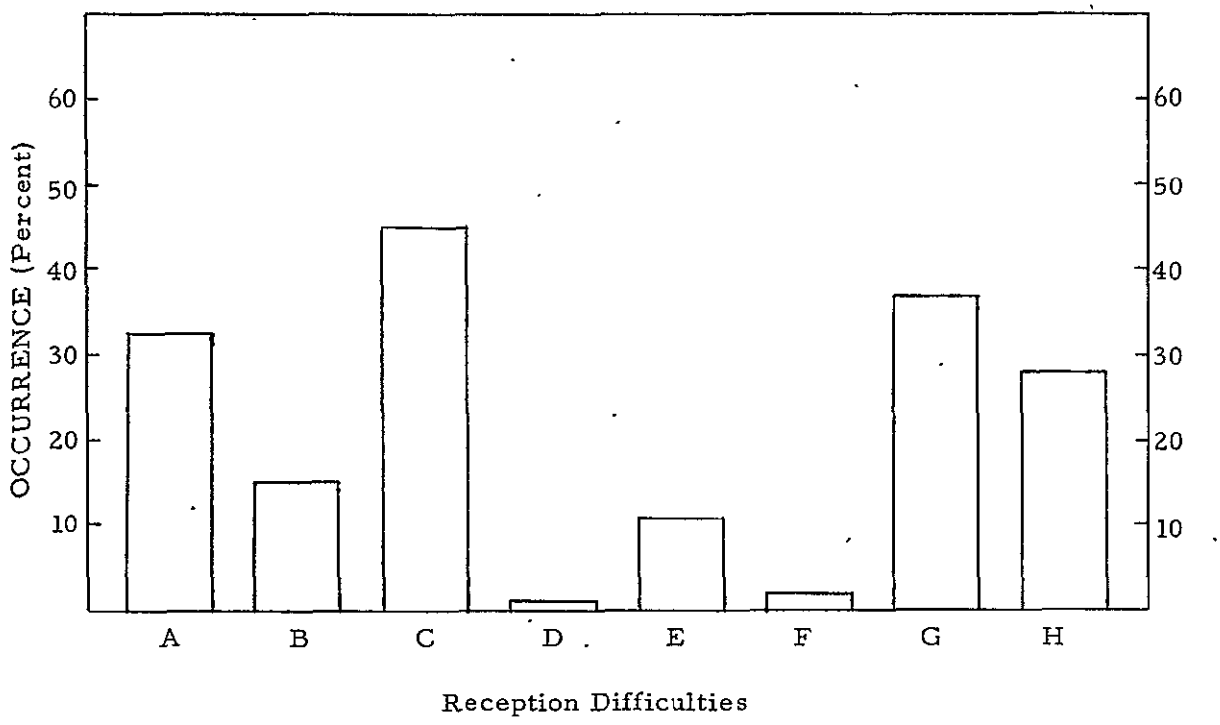


Figure 8-2. Received Grey Scale Steps (June)



A - Interference - Visible patterns appearing on chart format as a result of external signal sources or internally generated beat frequencies.
B - Bleeding - Smearing and presentation on white areas by black.
C - Signal plus noise-to-noise - White or black streaks on chart, uniformity of tonal shades, snow effect.
D - Distortion - Large scale geometric deviation from time pattern.
E - Skew - Deviation of a vertical line from a vertical normal. Test limit - 1/4" in 8".
F - Multi-Image - The multiple chart reproduction (ghosts) caused by multiple path transmission or reflection.
G - Jitter - Periodic irregularities on lines and patterns.
H - Spin Modulation - Noise interference apparently originating in the spacecraft and near the frequency of the spin rate.

Figure 8-3. WEFAX Experiment facsimile reception difficulties occurring at 21 APT receiving stations during June 1967. 306 WEFAX Test Charts evaluated.

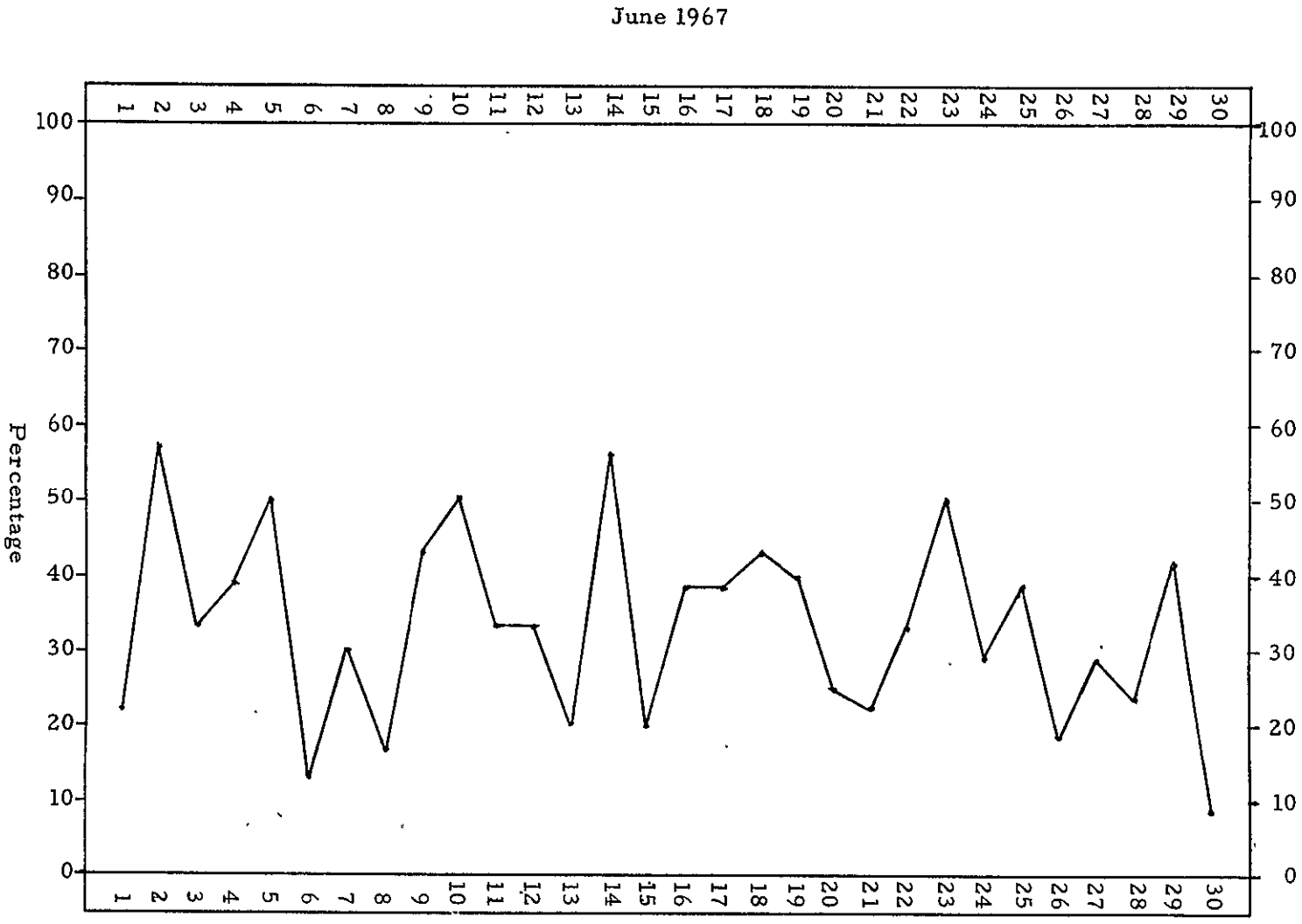


Figure 8-4. Interference Reported During June.

TABLE 8-2

Sample Comments from Participating APT Stations
(June)

Station Location	Comment
Melbourne, Australia	We regret the exclusion of the four-part SSCC Pix for most of the June transmissions. These were being used regularly by the analysts. The full disc pictures lack the detail that is apparent in the mosiacs. The resumption of transmission of digitized SSCC pix is anxiously awaited. The Nephanalyses are the only charts that are being used on a regular basis by our analysts. Most of the June transmissions were very clean and free from spin modulation.
Aberdeen, South Dakota	Signal levels have been so low in general that it has not been worthwhile to try and record the pictures and charts. The signal level, if good at all, characteristically declines during the transmission so that it is definitely unusable by the time the transmission ends. Signal levels also vary greatly during transmission period. We have found that the transmissions in the 2000-0400Z time periods have been most satisfactory.
Lake Jackson, Texas	During this month, there were no significant reception problems related to the ATS-1. The ESSA 5 pictures have improved. I still hope further work will be done on digitized pictures; and I am looking forward to any future multiplex tests that will be run.
Tokyo, Japan	Now, the transmission time of WEFAX is too late in the evening to receive on routine basis.
Fuchu, Japan	The nephanalysis would be more usable to us if its coverage were extended 10 degrees further north and shifted 20 to 30 degrees to the west. The 12 June special WEFAX multiplex transmissions were received. Signal strength was very low, just above the background noise level. The resulting reception was rather poor.

Comments from stations (cont)

Pt. Mugu, California	Phasing continues to be a problem at this station.
Tampa, Florida	27 June: Excellent pix and charts. Noise bursts throughout transmission, but data legible. 30 June: Worst transmission of evaluation period. Signal much too weak. Apparent atmospherics.
Kunia, Hawaii	Except for minor local interference problems, reception and chart legibility were within operational limits. As a weather facsimile transmission system, the ATS system is excellent.
Papeete, Tahiti	The broadcast hour 1030-1130 universal time suits us perfectly.

their transmissions were received on 135.625 MHz. The Rosman transmitter was set to minus 25 kHz; their transmissions were received on 135.575 MHz.

Data from the multiple access tests conducted on 12 and 13 June were received from 12 stations. Results from the various stations were similar, as can be seen in Figures 8-5 and 8-6. Figure 8-5 is a copy of a portion of the 12 June test as received at GSFC, and shows the reception of both frequencies. Copies of samples from 4 stations are shown in Figure 8-6, with a portion of each frequency received.

The received transmissions exhibited a degraded signal-to-noise ratio, and crosstalk interference was evident. The multiple access mode of transmission will give usable data, but of very low quality. The quality would be highly dependent on the sensitivity and selectivity of the APT ground receiver. Because of the limited number of channels available with this technique, and the degradation experienced during the preliminary evaluation tests, it was decided to abandon this approach for the more promising communications technique utilizing the VHF multiplex facilities of the ATS-1.

On 30 June a test was conducted to demonstrate the feasibility of utilizing the ATS-1 VHF multiplex communications link for WEFAX. At Mojave, Multiplex Modulation (MUX) equipment was used to both transmit and receive 3 channels of data. The results were extremely encouraging, with reception on channel 1 and channel 2 of excellent quality. Reception on channel 3 was classified as only fair because of noise pattern interference; eventually, however, this was almost entirely eliminated. The results of this test indicated that a fully simulated WEFAX transmission should be performed utilizing two separate sites, each containing its own MUX/deMUX equipment.

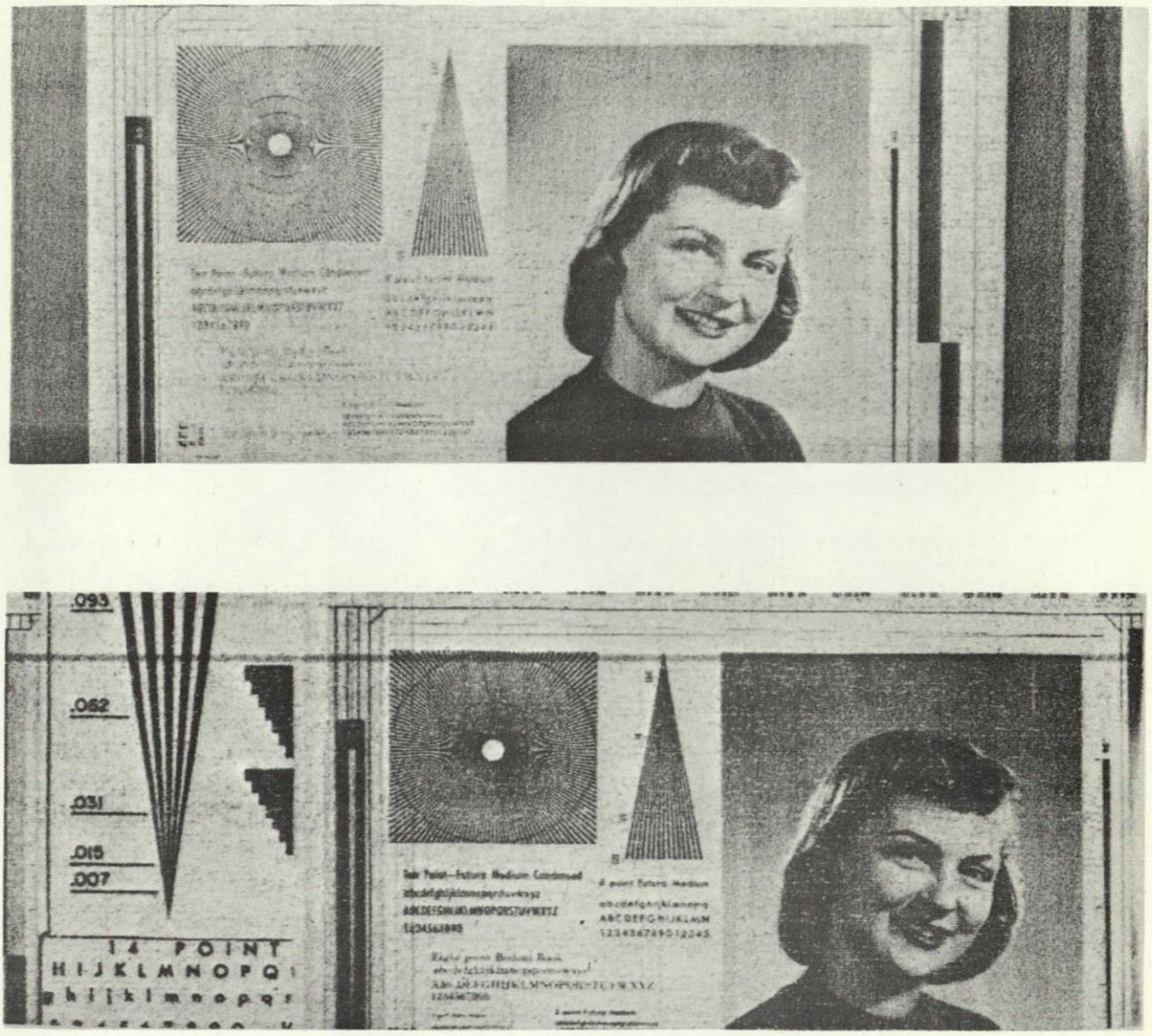
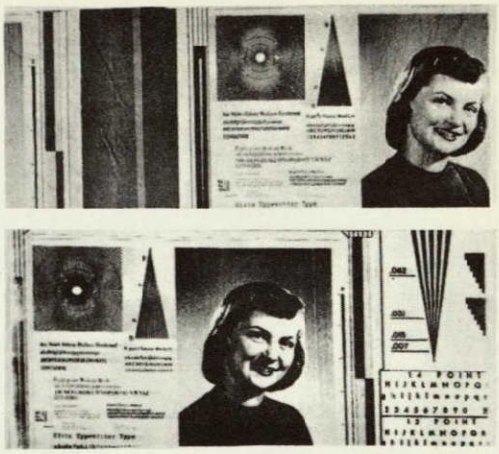
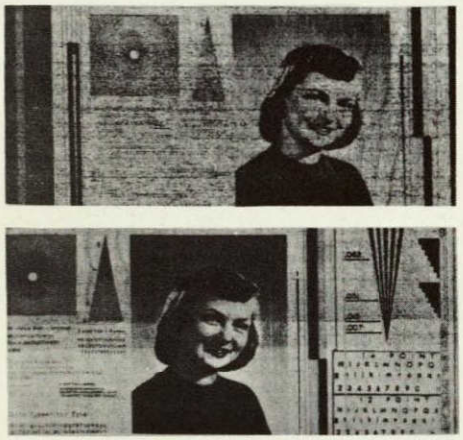


Figure 8-5. Multiple Access Reception at GSFC on 12 June. The upper portion shows the reception on 135.575 MHz and the lower portion the reception on 135.625 MHz.

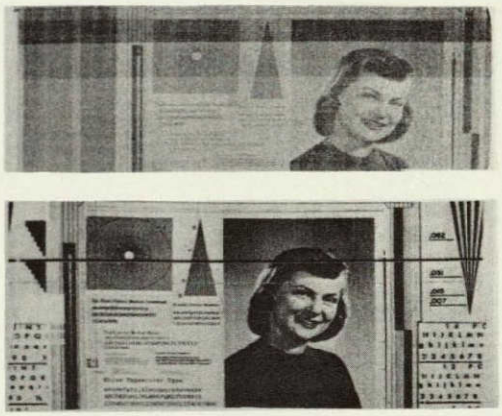
TORONTO



PAPEETE



SULPHUR SPRINGS



COLORADO SPRINGS

Figure 8-6. Samples of 12 June Multiple Access Reception. For each station, the upper portion depicts the reception on 135.575 MHz and the lower portion 135.625 MHz.

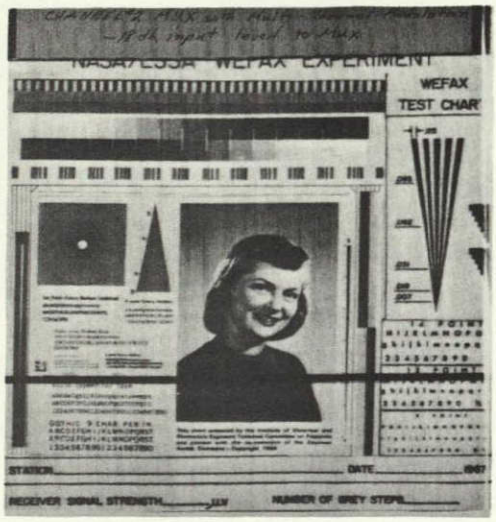
The following multiplex test was conducted in July, but it is included at this point in the text.

A WEFAX multiplex test was conducted on 18 July. Transmissions were made from Rosman, utilizing 3 channel MUX equipment, and Mojave received the transmissions using corresponding deMUX equipment. The transmissions were also received at GSFC, but without the use of deMUX equipment. Channel 1 used the standard subcarrier, channel 2 was 8 kHz above, and channel 3 was 12 kHz above. Figure 8-7 is a copy of the reception at Mojave, showing a copy of the reception on channel 1 without the use of deMUX equipment, and also the reception on each of the three channels using deMUX equipment.

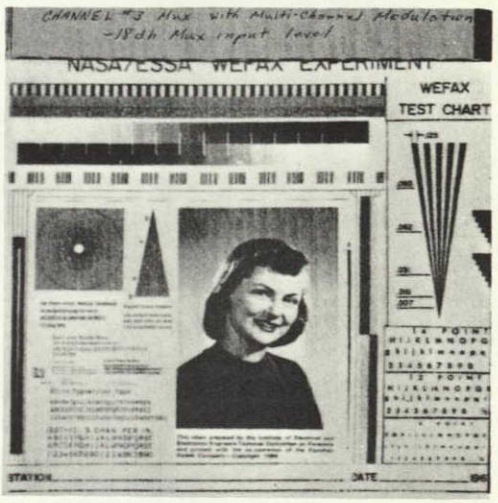
Excellent reception was obtained for all three channels with the deMUX equipment. An interference (crosstalk) pattern appeared on channel 1 when the deMUX equipment was not used. This problem will have to be eliminated so that stations without deMUX equipment will be able to receive good copy on channel 1. Preliminary evaluation of the data indicates that the probable cause was crosstalk. The use of a low pass filter having a bandwidth of 3 kHz reduced some of the interference, but the general quality of the received transmission was still poor. Extensive closed loop tests will be conducted in the near future to isolate and rectify this problem. Before utilizing the MUX mode of transmission for WEFAX, this problem must be eliminated.

NO deMUX

CHANNEL 1



CHANNEL 2



CHANNEL 3

Figure 8-7. Multiplex Reception at Mojave on 18 July.

SECTION 9

JULY EVALUATION

During the month of July, WEFAX transmissions were conducted for one hour each day. Data were submitted for evaluation by 18 participating stations. The special WEFAX data collection period was from 18 thru 22 July, and data were received from 17 stations during this period.

The quality of reception of weather charts and satellite pictures by the various participating stations during July is shown in Table 9-1. An improvement was very evident in the quality of reception of satellite pictures. The percentage of satellite pictures in the excellent or good categories increased from 66% in June to 75% in July. However, the quality of reception of the weather charts decreased in the excellent or good categories from 70% in June to 67% in July. Part of this decrease can be attributed to the change to smaller weather charts during the latter part of the month. Figure 9-1 shows the correlation between the antenna elevation angle and the percentage of excellent or good receptions. The average number of grey scale steps discernible on the WEFAX test chart improved during July; the averages for 18 stations are shown in Figure 9-2. There was an increase of at least one grey scale step at 10 stations and a decrease at only 2 stations.

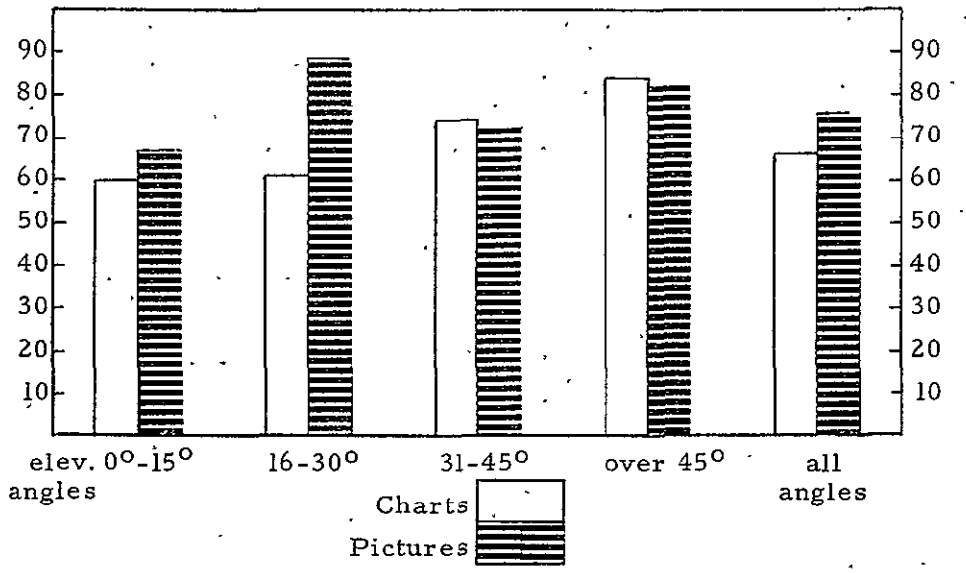
Reception difficulties were significantly reduced as depicted in Figure 9-3. Four of the difficulties showed an appreciable decrease and only two showed a minor increase. The low signal-to-noise ratio continued to be a major problem in July, though it did decrease from 45% in June to 38% in July. The occurrence of jitter increased from 37% in June to 40% in July; however, the degree of jitter has been small and it does not materially affect the legibility of the charts and pictures. The spin modulation type of noise interference did not occur during July. The noise dissappeared during the latter part of June even though no specific corrective action

TABLE 9-1

Classification of WEFAX Receptions of
Weather Charts and Satellite Pictures
(July 1967)

APT Receiving Stations	Weather Charts					Satellite Pictures				
	Exc	Good	Fair	Poor	Unusable	Exc	Good	Fair	Poor	Unusable
GSFC, Maryland	106	63	9	1	4	111	68	34	0	1
Aichi, Japan	0	25	38	55	2	0	55	53	58	11
Toronto, Canada	34	61	31	24	15	25	104	31	16	2
Fuchu, Japan	17	82	42	22	13	31	87	55	15	8
Howard AFB, C. Z.	6	16	8	0	0	0	1	0	0	0
Melbourne, Australia	4	77	34	9	5	7	156	10	2	0
Tampa, Florida	0	2	6	1	1	9	10	2	4	9
Nashville, Tennessee	0	2	2	8	3	0	8	6	8	7
Guam, Marianas	5	8	11	0	10	6	17	8	0	0
Aberdeen, S. Dakota	5	20	37	9	8	14	51	9	6	3
New Orleans, La.	3	2	0	0	0	0	7	0	0	0
Anchorage, Alaska	98	9	8	1	5	206	7	7	0	0
Lake Jackson, Texas	6	4	9	0	4	12	44	10	1	0
Mojave, California	121	58	5	0	6	153	48	6	4	0
San Francisco, Calif.	3	9	14	8	2	0	3	25	12	21
Pt. Mugu, California	11	28	23	10	11	29	17	5	3	22
Kunia, Hawaii	43	75	6	21	7	78	76	15	28	18
Papeete, Tahiti	80	61	6	4	4	88	101	16	1	0
TOTALS	542 (32%)	602 (35%)	289 (17%)	173 (10%)	100 (6%)	769 (35%)	860 (40%)	292 (13%)	158 (7%)	102 (5%)

Percentage of Excellent or Good Receptions of
WEFAX by Elevation Angle Increments
(1706 charts and 2181 pictures evaluated)
(July)



WEFAX Participating Stations
(by antenna elevation angle)

Station	Antenna Elevation Angle	
GSFC, Maryland	4°	
Aichi, Japan	5°	
Toronto, Canada	5°	
Fuchu, Japan	7°	
Howard AFB, C. Z.	11°	0° to 15°
Melbourne, Australia	11°	
Tampa, Florida	11°	
Nashville, Tenn.	13°	
Guam, Marianas	16°	
Aberdeen, S. Dakota	18°	
New Orleans, La.	18°	16° to 30°
Anchorage, Alaska	21°	
Lake Jackson, Texas	22°	

Station	Antenna Elevation Angle	
Mojave, California	36°	
San Francisco, Calif.	37°	31° to 45°
Pt. Mugu, California	38°	
Kunia, Hawaii	65°	Over 45°
Papeete, Tahiti	68°	

Figure 9-1. Percentage of Good or Excellent Receptions (July)

Average Grey Scale Steps of
Receiving Stations (July)

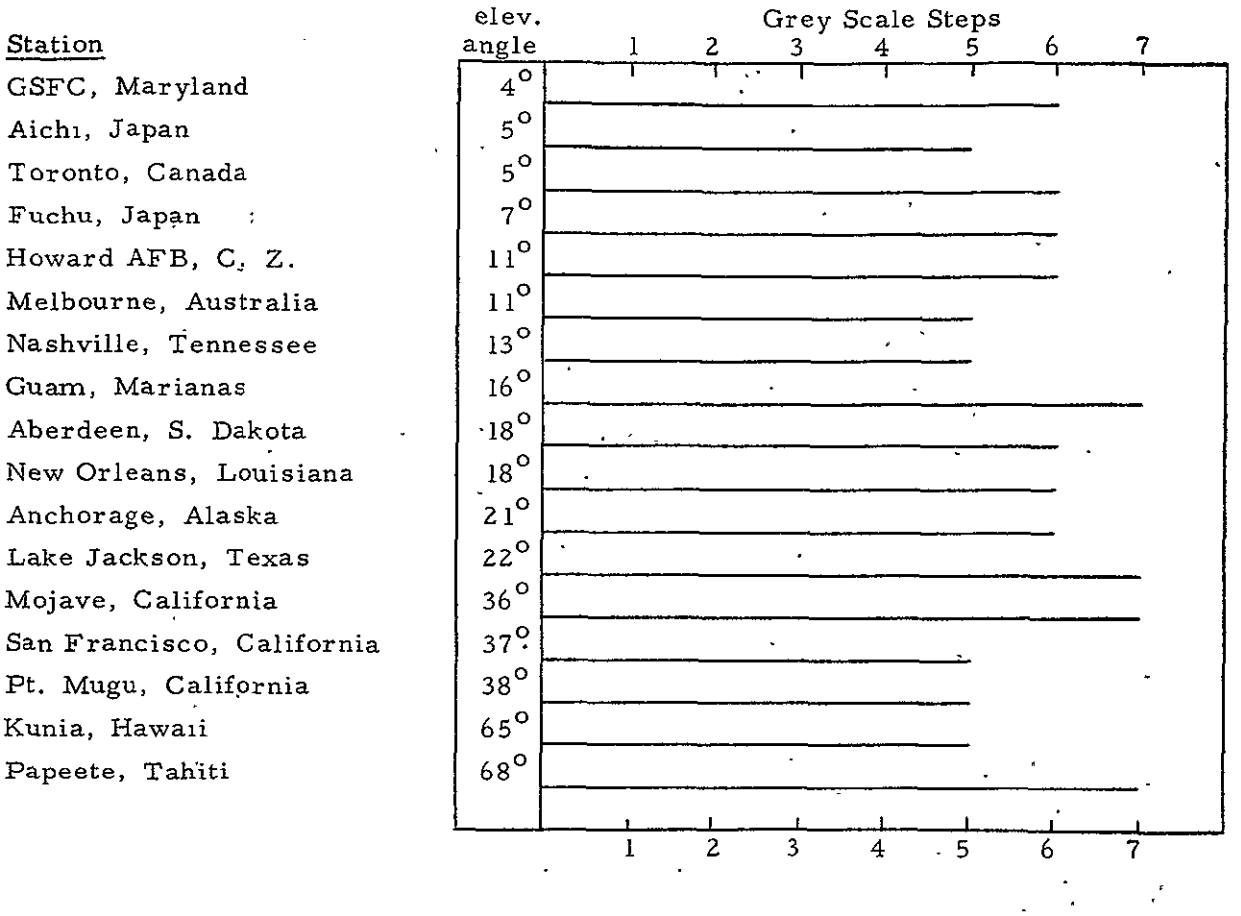
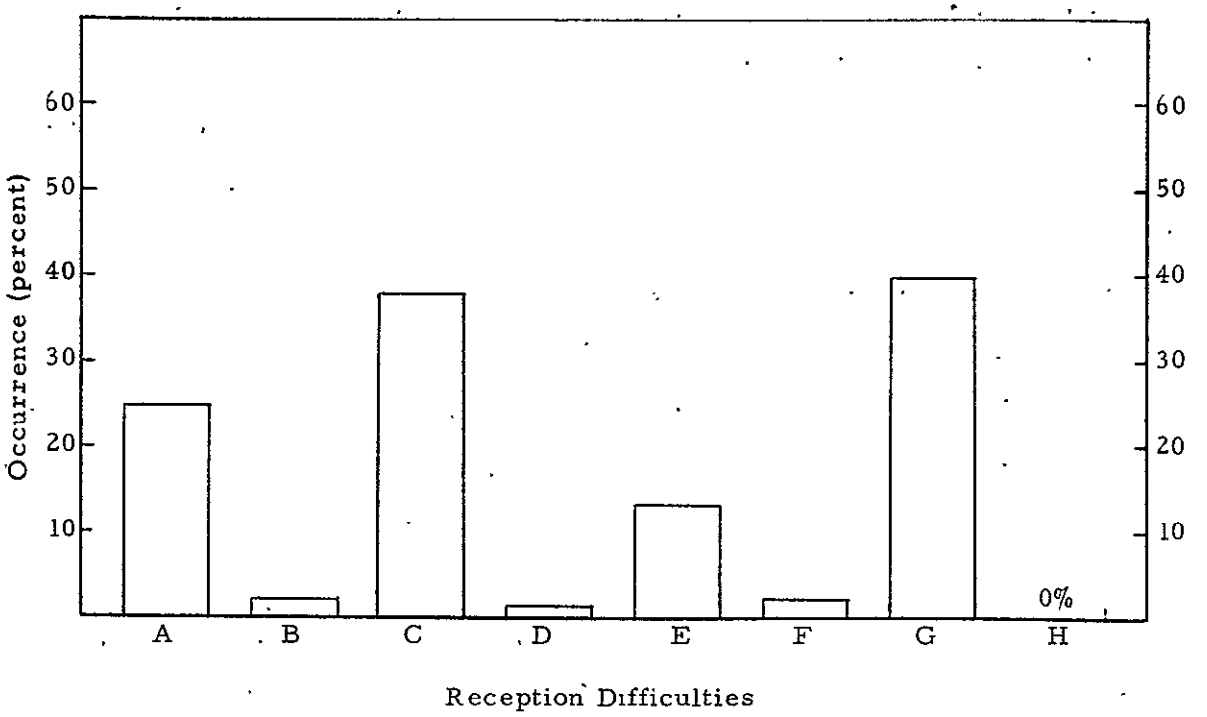


Figure 9-2. Received Grey Scale Steps (July)



A - Interference - Visible patterns appearing on chart format as a result of external signal sources or internally generated beat frequencies.
B - Bleeding - Smearing and presentation on white areas by black.
C - Signal plus noise-to-noise - White or black streaks on chart, uniformity of tonal shades, snow effect.
D - Distortion - Large scale geometric deviation from time pattern.
E - Skew - Deviation of a vertical line from a vertical normal. Test limit - 1/4" in 8".
F - Multiple-Image - The multiple chart reproduction (ghosts) caused by multiple path transmission or reflection.
G - Jitter - Periodic irregularities on lines and patterns.
H - Spin Modulation - Noise interference apparently originating in the spacecraft and near the frequency of the spin rate.

Figure 9-3. WEFAX Experiment facsimile reception difficulties occurring at 18 APT receiving stations during July 1967. 263 WEFAX Test Charts evaluated.

was taken to eliminate the spin modulation. The occurrence of interference decreased from 32% in June to 25% in July; this is the lowest percentage since the beginning of the experiment. Figure 9-4 shows the daily occurrence of interference as a percentage of the number of stations submitting data for evaluation. Comments from some of the participating stations are listed in Table 9-2. Many of the comments indicate the outstanding usefulness of the ESSA 5 mosaics.

A WEFAX multiplex test was conducted on 18 July. Transmissions were made from Rosman, utilizing 3 channel MUX equipment and Mojave received the transmissions using corresponding deMUX equipment. Channel 1 used the standard subcarrier, channel 2 was 8 kHz above, and channel 3 was 12 kHz above. Figure 9-5 is a copy of the reception at Mojave, showing a copy of the reception on channel 1 without the use of deMUX equipment and also the reception on each of the three channels using deMUX equipment.

Excellent reception was obtained for all three channels with the deMUX equipment. An interference (crosstalk) pattern appeared on channel 1 when the deMUX equipment was not used. This problem will have to be eliminated so that stations without deMUX equipment will be able to receive good copy on channel 1. Preliminary evaluation of the data indicates that the probable cause was crosstalk. The use of a low pass filter having a bandwidth of 3 kHz reduced some of the interference, but the general quality of the received transmission was still poor. Extensive closed loop tests will be conducted in the near future to isolate and rectify this problem. Before utilizing the MUX mode of transmisssion for WEFAX, this problem must be eliminated.

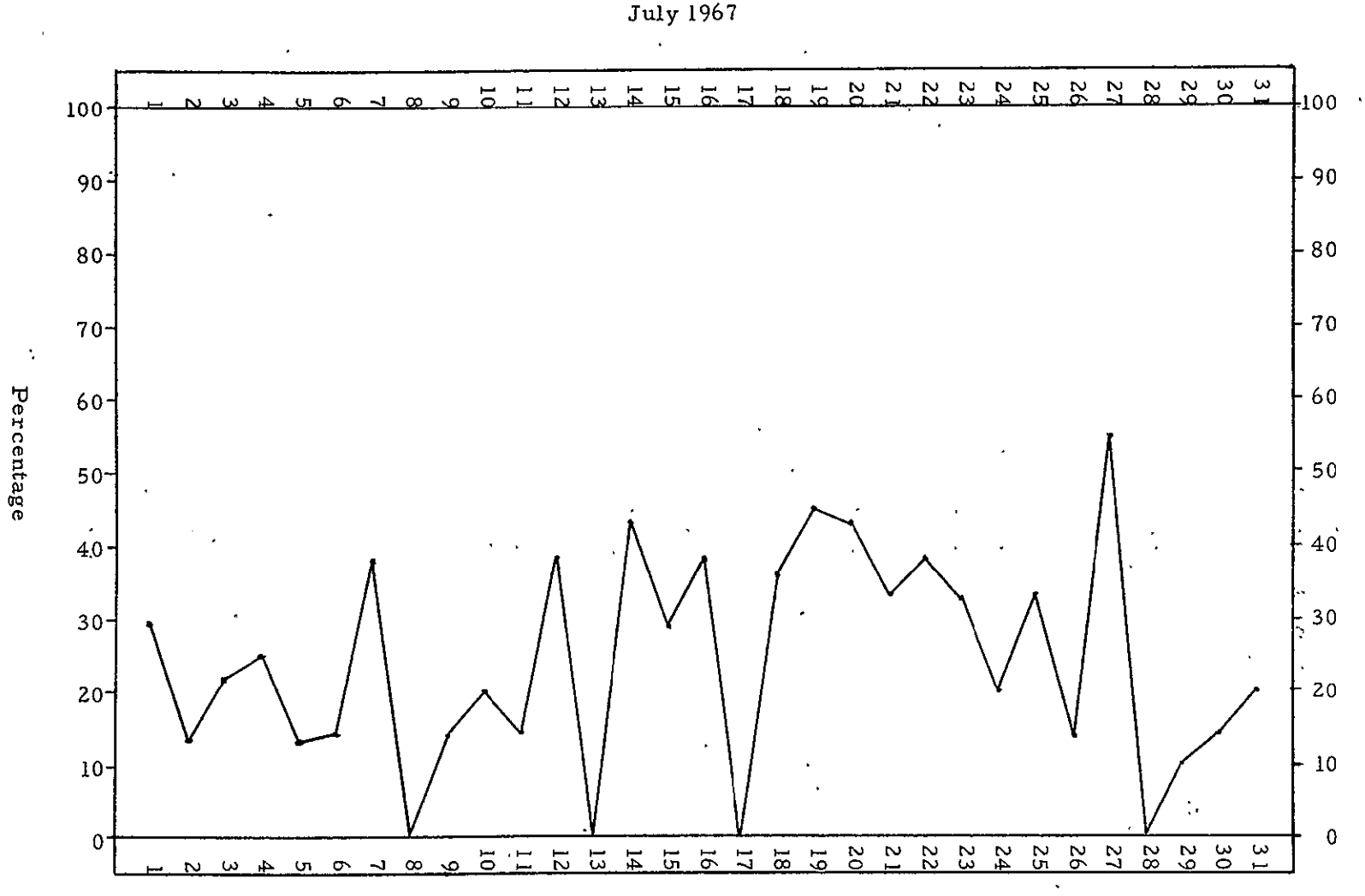


Figure 9-4. Interference Reported During July.

TABLE 9-2

Sample Comments from Participating APT Stations
(July)

Station Location	
Toronto, Canada	The new ESSA mosaic presentation: we have had no trouble in receiving these pictures and the results have generally been of usable or better quality.
Fuchu, Japan	The complete mosaics were of great use to the forecasters in locating upper air features which were not apparent from the sparse data received The mosaics were transmitted over the facsimile network.
Tampa, Florida	Some days of evaluation period very good, others very poor. Signal loss on some days, phase problems on others.
Lake Jackson, Texas	The ESSA pictures continued excellent quality and the SSCC pics improved. The ESSA 5 mosaics were quite good and easy to "put together".
Pt. Mugu, California	The smaller size charts are not quite as legible as previous larger ones, particularly when interference in reception is experienced. The presentation of ESSA 5 cloud pictures on a mercator grid as received on 25 July is useful, but it is recommended that latitude identification be moved closer to the center of the pictures.
Kunia, Hawaii	Reception was generally good during July. There did seem to be a pattern of degrading interference on every second to third day's transmission. We have ascribed this interference or noise to local sources. However, a check with Fuchu, Japan, shows that they experienced degraded reception on the same days that we did. This leads us to suspect atmospheric sources or transmitter sources of the noise. The ESSA 5 pictures and the recent ESSA 5 digitized mosaics have been of tremendous benefit to our operations. These pictures effectively extend our APT coverage and allow us to provide much better support..... Operational use of the tropical strip (35N to 35S) should provide many interesting new conclusions regarding tropical meteorology. For the first time, people in the field have access to daily cloud pictures of the tropical Pacific.
Aberdeen, South Dakota	New ESSA 5 mosaics are very good, particularly when accompanied by SSCC pix.

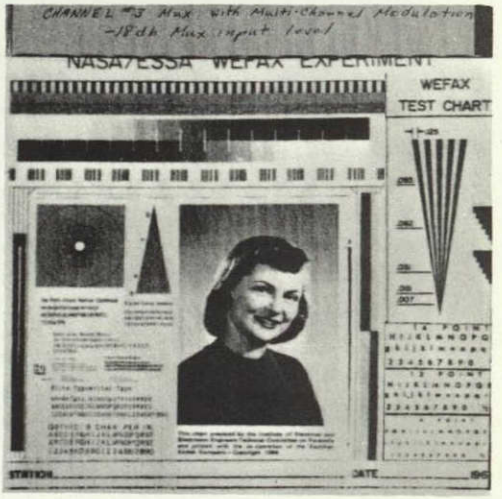
Comments from Stations (cont)

Papeete, Tahiti	We have greatly appreciated the montages (mosaic pictures) produced from the orbits of ESSA 5. On the other hand, the recent format of the maps seems to us to be far too small and interferes with the legibility of the details, given the equipment which we have to use.
Melbourne, Australia	The introduction of the ESSA 5 mosaics at the end of the month was welcomed by our meteorologists. For the first time, we are able to look at the Pacific area on a daily basis as seen from a satellite. These mosaics will be particularly useful for obtaining data from areas where there are few, if any, other observations made. The July transmissions were particularly clear and only on one occasion was data lost due to interference.

NO deMUX

CHANNEL 1

CHANNEL 2



CHANNEL 3

Figure 9-5 Multiplex Reception at Mojave on 18 July.

SECTION 10

AUGUST EVALUATION

WEFAX transmissions during August occurred daily from 1100Z to 1200Z. In addition, there were 18 special transmission periods. Data were submitted for evaluation by 20 participating stations. The special WEFAX data collection period was from 7 through 11 August, and data were received from 18 stations during this period.

A total of 2616 weather and test charts, and 2673 satellite pictures were evaluated for the August period. The quality of reception of weather charts and satellite pictures by the various participating stations during August is shown in Table 10-1. Weather chart reception classified as excellent to good decreased to 58%. This resulted from the reduced size of the charts received. The same basic chart was transmitted; however, the facsimile scanner was used in the 19 inch lens mode rather than the 11 inch lens mode. This reduced the size of the received chart to about 35% of the area of the 11 inch mode. As an example, the dimensions of a chart received on a 9 inch facsimile recorder changed from approximately 8-1/2 x 13-1/4 inches to 5 x 8 inches. The decrease in the size of letters and figures made many of them illegible, especially in the presence of some type of reception difficulty. The contours and major features of the weather charts were discernible, but the small size limited their operational usability.

The quality of reception of the satellite pictures continued to be very good, with 76% of the received pictures classified as excellent or good. Correlation between the antenna elevation angle and percentage of excellent or good receptions are shown in Figure 10-1. During August, there was a decrease in the average number of grey scale steps discernible on the WEFAX test chart. Figure 10-2 shows the grey scale steps for 20 participating stations.

Reception difficulties depicted in Figure 10-3 show some variations from the previous month. There was a significant decrease in signal-to-noise and jitter, and an appreciable increase in bleeding and multi-image. Signal-to-noise has improved over the last three months from 45% in June, to 38% in July, and to 23% in August. The spin modulation type of noise interference did not occur again in August, so it was deleted from the reception difficulties figure. There was very little change in the amount of interference noted during August. Figure 10-4 shows the daily occurrence of interference as a percentage of the number of stations submitting data

TABLE 10-1

Classification of WEFAX Receptions of
Weather Charts and Satellite Pictures
(August 1967)

APT Receiving Stations	Weather Charts					Satellite Pictures				
	Exc	Good	Fair	Poor	Unusable	Exc	Good	Fair	Poor	Unusable
Dorval, Canada	1	4	4	1	0	0	8	0	0	0
GSFC, Maryland	48	86	48	28	89	59	73	40	36	79
Aichi, Japan	0	20	7	7	0	0	26	8	12	1
Toronto, Canada	34	130	50	41	32	137	101	20	6	2
Fuchu, Japan	41	94	89	42	11	52	139	60	7	6
Tokyo, Japan	0	38	27	52	2	0	85	26	11	0
Howard AFB, C.Z.	0	14	9	0	0	0	24	12	0	0
Tampa, Florida	9	0	1	6	11	10	14	11	7	1
Nashville, Tennessee	0	11	5	5	3	0	9	13	10	5
Guam, Marianas	13	91	59	42	0	58	104	40	12	0
Aberdeen, S. Dakota	6	32	39	14	11	16	81	20	17	8
Anchorage, Alaska	101	92	57	8	0	158	69	15	2	0
Lake Jackson, Texas	13	9	12	0	0	21	50	11	0	0
Seattle, Washington	1	3	0	2	0	0	7	0	8	0
Mojave, California	174	104	35	12	2	248	38	1	3	2
San Francisco, Calif.	1	6	5	5	9	1	2	0	0	3
Pt. Mugu, California	10	18	6	1	5	10	8	0	0	22
Wake Island, Pacific	11	3	0	0	0	3	4	0	0	0
Kunia, Hawaii	55	64	54	21	54	101	78	53	16	13
Papeete, Tahiti	22	154	73	6	1	125	118	9	3	5
TOTALS	540 (21%)	973 (37%)	580 (22%)	293 (11%)	230 (9%)	999 (37%)	1038 (39%)	339 (13%)	150 (6%)	147 (5%)

Average Grey Scale Steps of
Receiving Stations (August)

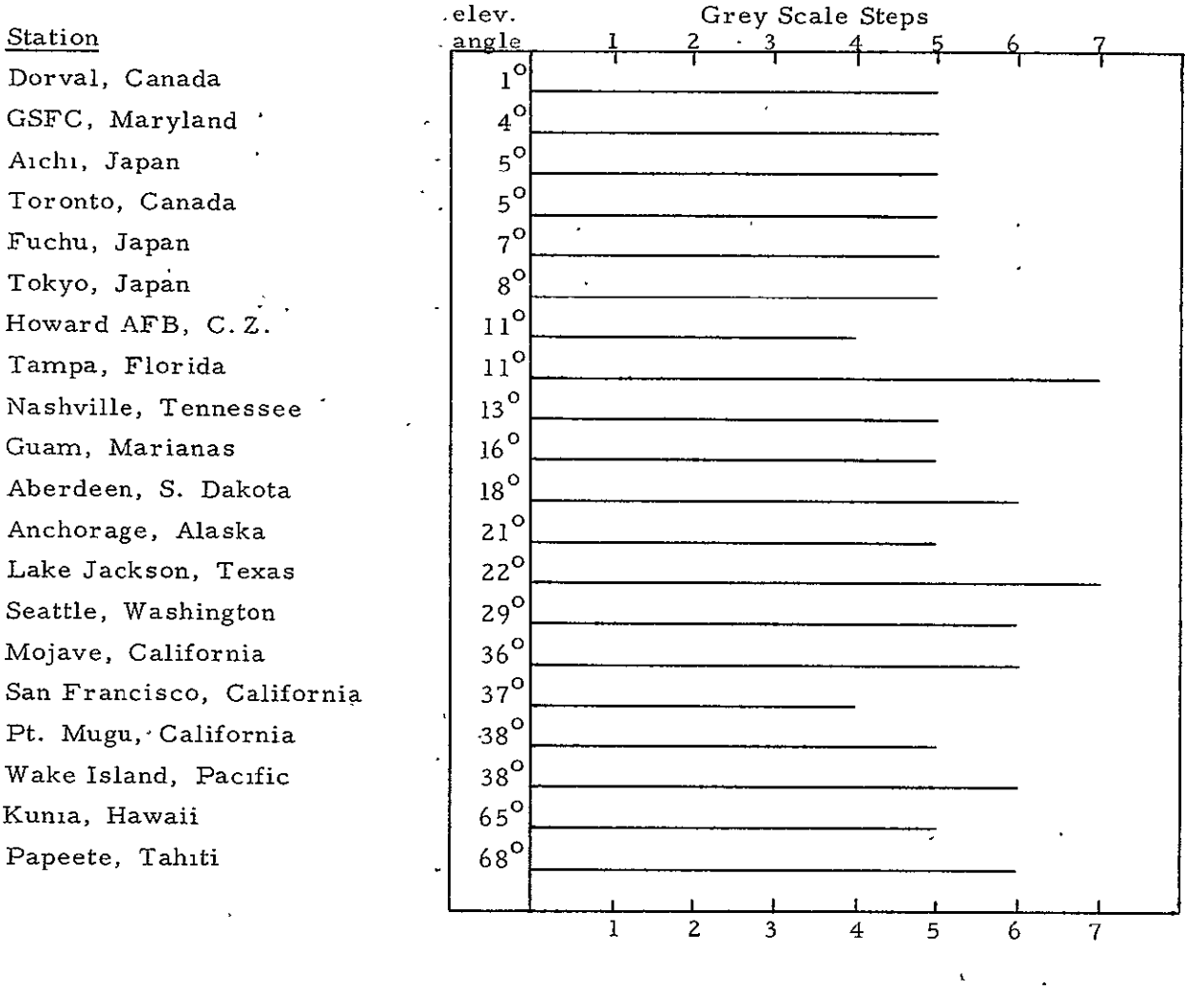
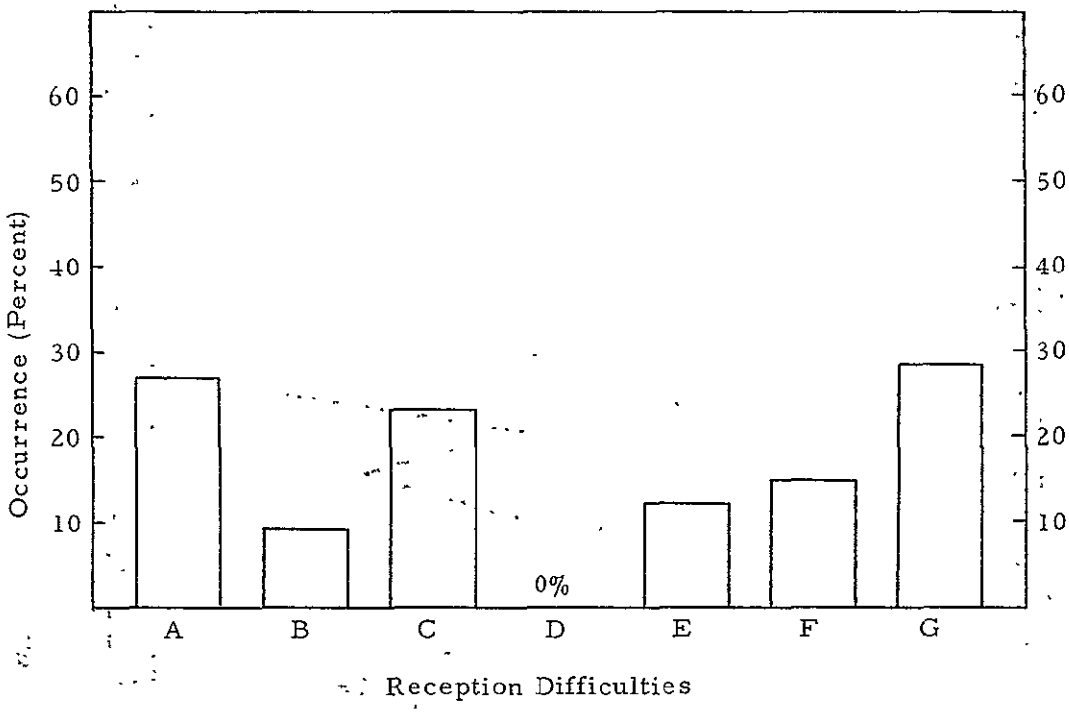


Figure 10-2. Received Grey Scale Steps (August)



A - Interference - Visible patterns appearing on chart format as a result of external signal sources or internally generated beat frequencies.
B - Bleeding - Smearing and presentation on white areas by black.
C - Signal plus noise-to-noise - White or black streaks on chart, uniformity of tonal shades, snow effect.
D - Distortion - Large scale geometric deviation from time pattern.
E - Skew - Deviation of a vertical line from a vertical normal. Test limit - 1/4" in 8".
F - Multi-Image - The multiple chart reproduction (ghosts) caused by multiple path transmission or reflection.
G - Jitter - Periodic irregularities on lines and patterns.

Figure 10-3. WEFAX Experiment facsimile reception difficulties occurring at 20 APT receiving stations during August 1967. 236 WEFAX Test charts evaluated.

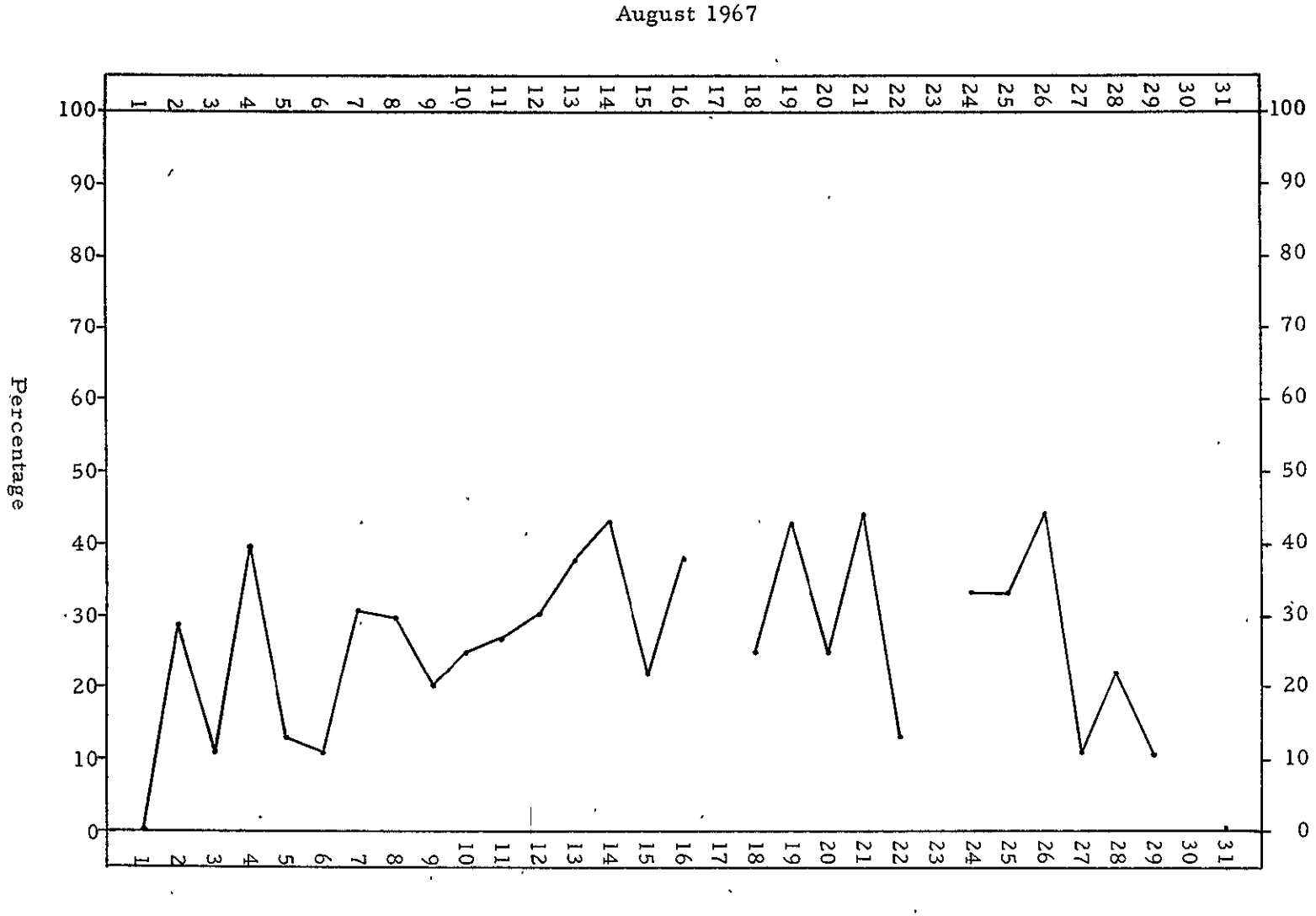


Figure 10-4. Interference Reported During August.

for evaluation. Many of the comments received from the participating stations (see Table 10-2) continue to extol the value of the ESSA 5 digitized mosaics.

There were several special WEFAX transmissions during the month of August. On 1, 3, 4, 5, 6, and 7 August, special transmissions were made to the Boy Scout World Jamboree in Farragut State Park, Idaho. Transmissions consisted of standard WEFAX data plus special weather charts and notices. Reports indicate that the WEFAX data received by the Boy Scouts were of excellent quality.

Special Multiplex tests were conducted on 10, 14, 22, 28, and 31 August. Various problems arose during these tests; therefore, more tests will need to be conducted in order to perfect this mode of transmission for WEFAX. (Subsequent tests during September were highly successful, and further investigations are being made into the multiplex mode of transmission of WEFAX data.)

Special test transmissions of digitized ATS-1 spin scan cloud camera pictures were conducted during August. Digitized SSCC tapes were processed at NESC/ESSA and transmitted over WEFAX in the APT format. Figures 10-5 through 10-8 represent reception samples of these test transmissions. In some cases, the earth disc was transmitted in nine sections; and included grids. A few transmissions were made which included only four sections of a portion of the earth disc, and did not include grids. Results of these tests indicate that excellent detail can be obtained by utilizing the digitized process. Further experimentation will be done in the computer program to adjust the tonal range so that it will be compatible with the recording characteristics of the APT ground stations. A problem also exists in adding grids to the pictures. A small inaccuracy in the ATS-1 attitude data causes a relatively large error in the grids produced by the machine techniques which were used in these tests.

TABLE 10-2

Sample Comments from Participating APT Stations
(August)

Station Location	Comment
Kunia, Hawaii	During August no serious interference, reception or acquisition problems were noted. The major interference occurs as horizontal white lines caused by complete signal loss. These give the charts/pictures a "venetian blind" appearance. We cannot overstate the value of the ESSA 5 digitalized mosaics to our forecast mission. These pictures are the greatest boon to our understanding of tropical weather systems and to our forecasting of areas not serviced by conventional data. As stated in the NASA/ESSA WEFAX Experiment Evaluation Report (p 10-2) continued effort should be made towards improving the retransmission of SSCC pictures. To this we add that the SSCC pictures received to date are of good enough quality to assist all Pacific weather agencies.
Fuchu, Japan	The ESSA 5 digital mosaic has been extremely useful in the Asiatic Weather Central. The 1100-1200Z transmission time is very helpful in the analysis of the 1200Z Surface Chart. The mosaic is most helpful also in preparing the HWD (Horizontal Weather Depiction) and nephanalysis.
Tokyo, Japan	ESSA 5 mosaic is most useful for our operational typhoon formation forecast and also for our research on tropical meteorology. We hope you will continue to transmit this mosaic data.
Anchorage, Alaska	The addition of the vertical motion prog to the program has been helpful even though its receipt has been somewhat sporadic. The total of 445 charts and pics received is the greatest number received by this station in one month.
Pt. Mugu, California	Although the "post card" size charts are usually readable, larger size charts are considered to be more readily useable operationally.
Tampa, Florida	ESSA 5 mosaics great step forward.
Nashville, Tennessee	Digitalized SSCC pictures looked good.

Comments from Stations (cont)

Lake Jackson, Texas	Chart quality has been poorer due to the small format but the charts may still be useable for most purposes. Generally the charts were too dark when the gain was set using the phase signal as the 100% white reference. Generally the signal level was strong through the month with the exception of the 10th, 11th, 17th, and 20th when severe fades were experienced and the signal level was below normal. The first two dates could have been caused by the Perseid meteor shower.

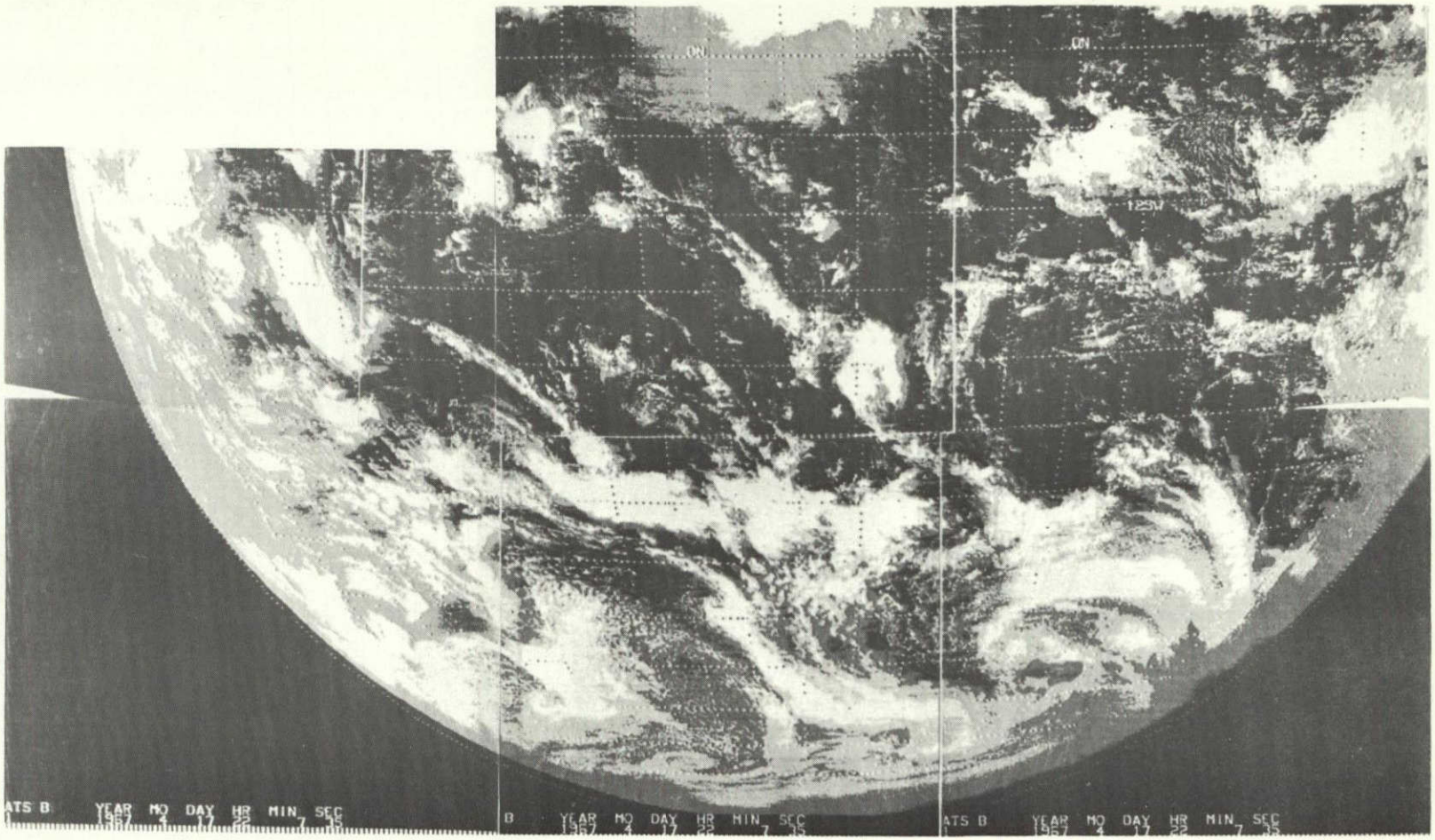


Figure 10-5. Digitized SSCC Picture Received at Tahiti on 10 August 1967. The picture is a mosaic of the 6 southern WEFAX frames of the ATS-1 SSCC picture taken at 220735Z on 17 April 1967.

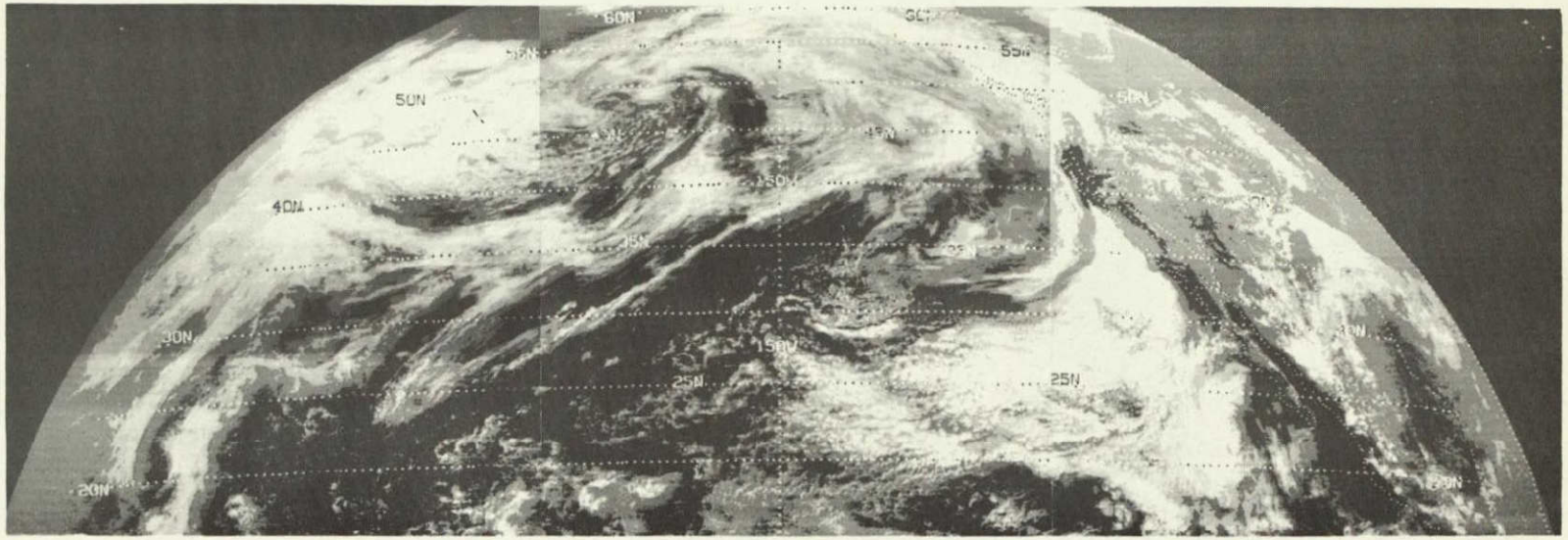


Figure 10-6. Digitized SSCC Picture Received at Toronto on 15 August 1967. The picture is a mosaic of the three northern WEFAX frames of the ATS-1 SSCC picture taken at 215159Z on 26 January 1967.

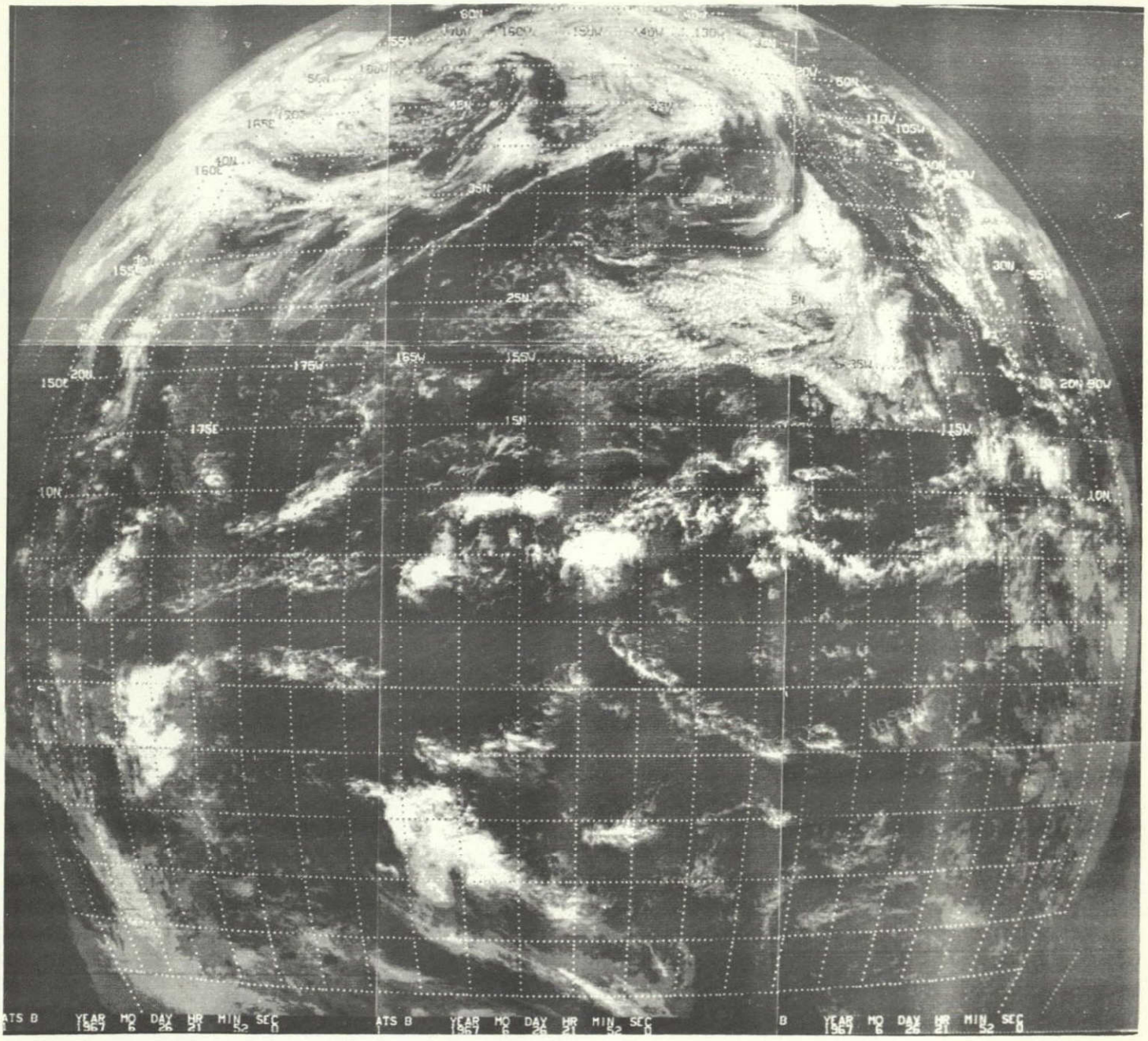


Figure 10-7. Digitized SSCC Picture Received at Lake Jackson on 17 August 1967.
The picture is a mosaic of the 9 WEFAX frames of the ATS-1 SSCC picture taken at 215159Z on 26 June 1967.

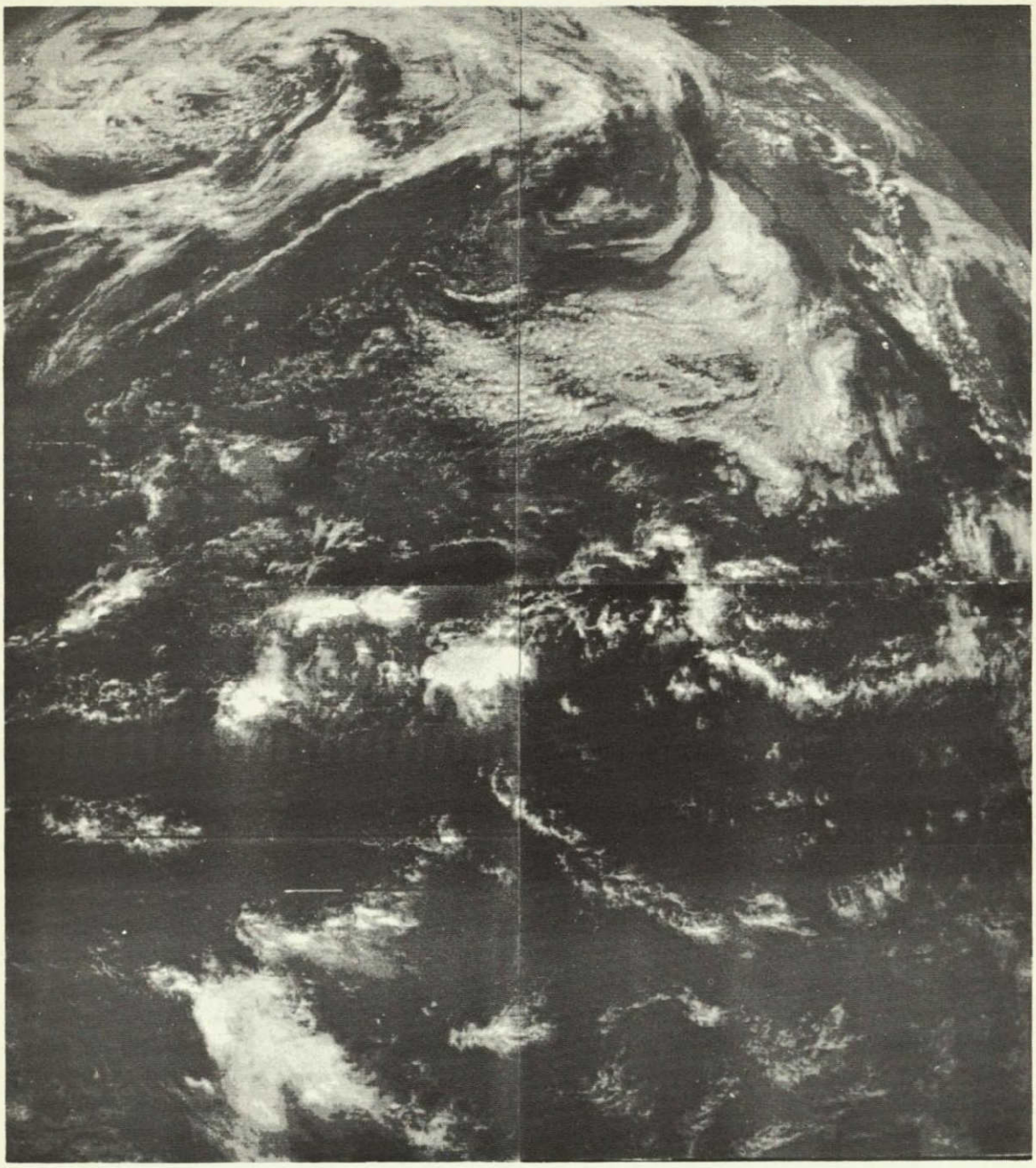


Figure 10-8. Digitized SSCC Picture Received at Lake Jackson on 22 August 1967.
The picture is a mosaic of 4 WEFAX frames of the ATS-1 SSCC picture taken at 215159Z on 26 June 1967.

SECTION 11

SEPTEMBER EVALUATION

Numerous WEFAX transmissions were performed during September. There were 88 transmission periods, including 58 special transmissions. Many of the special transmissions were of only 10 minutes duration, but they did provide an opportunity to evaluate reception at various times of the day. There were 5 transmission periods each day from 20 through 30 September.

On 5, 6, and 7 September, multiplex test transmissions were made from Mojave. Receptions were attempted on 5 September with the deMUX equipment located at ESSA, Suitland; local interference prevented acceptable reception. For the tests on 6 and 7 September, the deMUX equipment was located at GSFC. Test results on 6 September ranged from fair to poor. Reception on channel 1 was fair, but crosstalk was discernible on channels 2 and 3. Excellent reception on all three channels was obtained on 7 September. Each channel was distinctly clear with no crosstalk discernible. Good reception was also obtained on channel 1 using a 3.2 kc filter instead of deMUX equipment. Results of these tests indicate that WEFAX transmissions can be routinely made utilizing multiplex equipment. Receiving stations will need deMUX equipment to receive all channels or a suitable filter to receive data from channel 1.

Two special transmission periods on 9 September were utilized to transmit selected SSCC pictures to Hawaii for use in the recovery of BIOSATELLITE II. The pictures provided the recovery units with a full depiction of the cloud conditions in the satellite recovery area. Figure 11-1 illustrates one of the various sizes of enlargements which were transmitted.

A special ten minute daily transmission period was initiated on 12 September to provide satellite pictures of the Atlantic hurricane area. Two WEFAX frames of the ESSA 3 mosaic of the area from 40°N to 5°N latitude and 17°W to 100°W longitude were transmitted. The mosaics were intended primarily for the Miami Hurricane Forecast Center and were used to locate and track tropical disturbances and storms. Miami relayed the mosaics via cable to the U.S. Weather Bureau forecast office in San Juan, Puerto Rico.

Figure 11-2 is a copy of the 16 September transmission received at Mojave and Point Mugu.

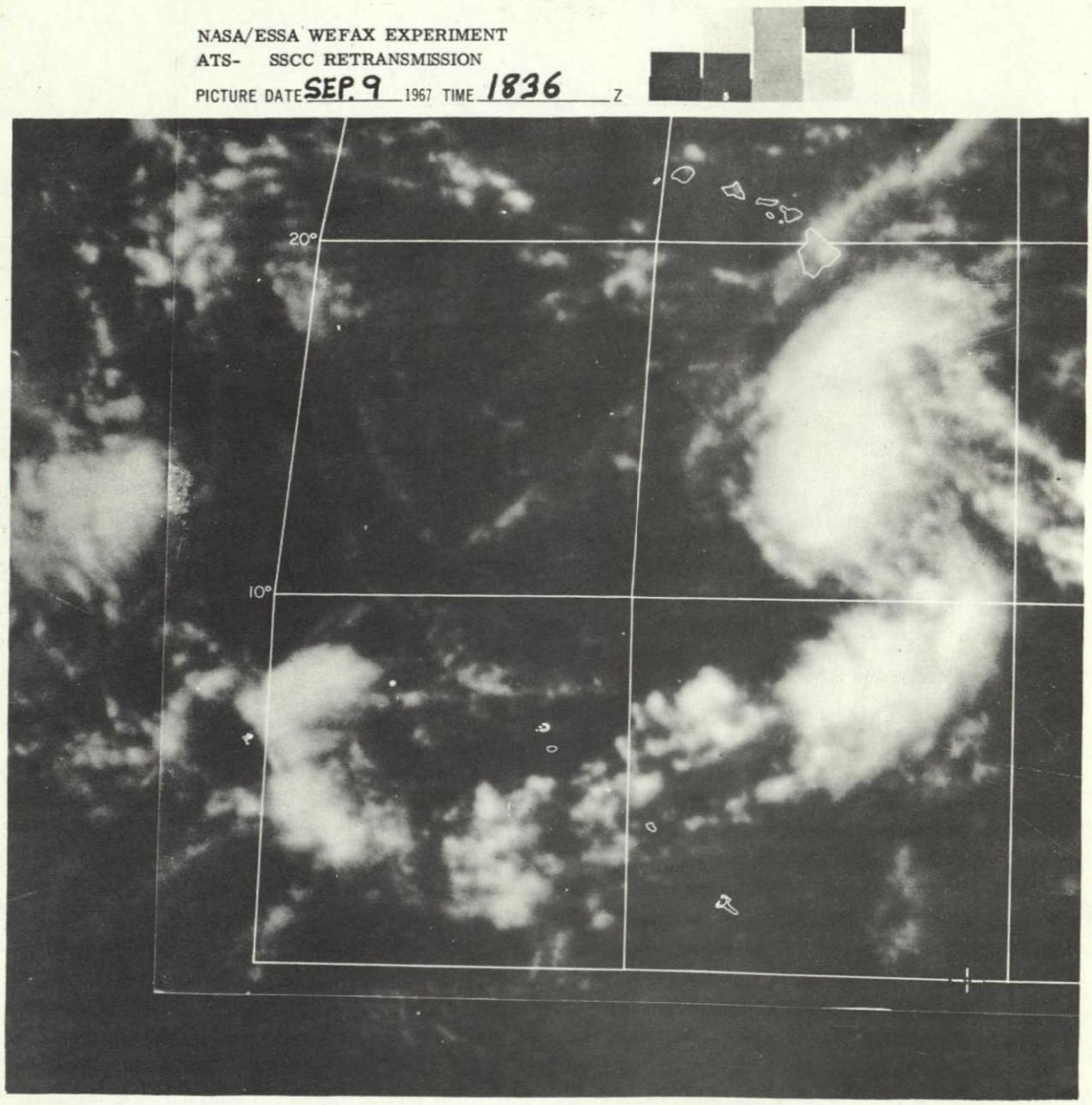
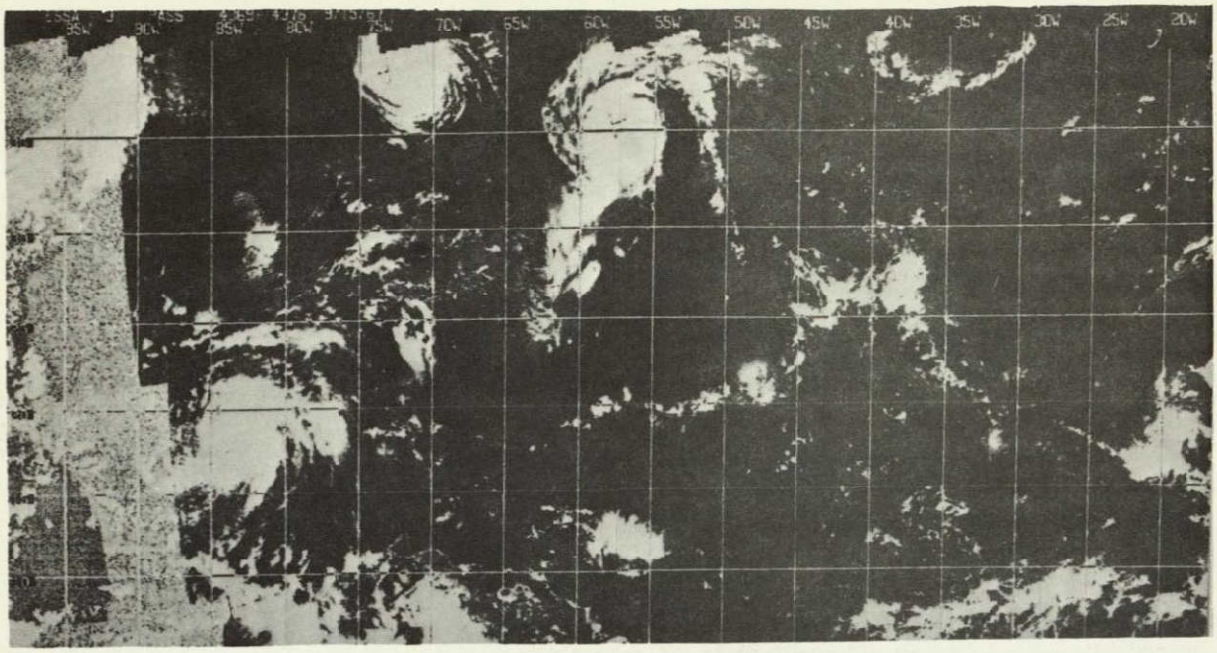
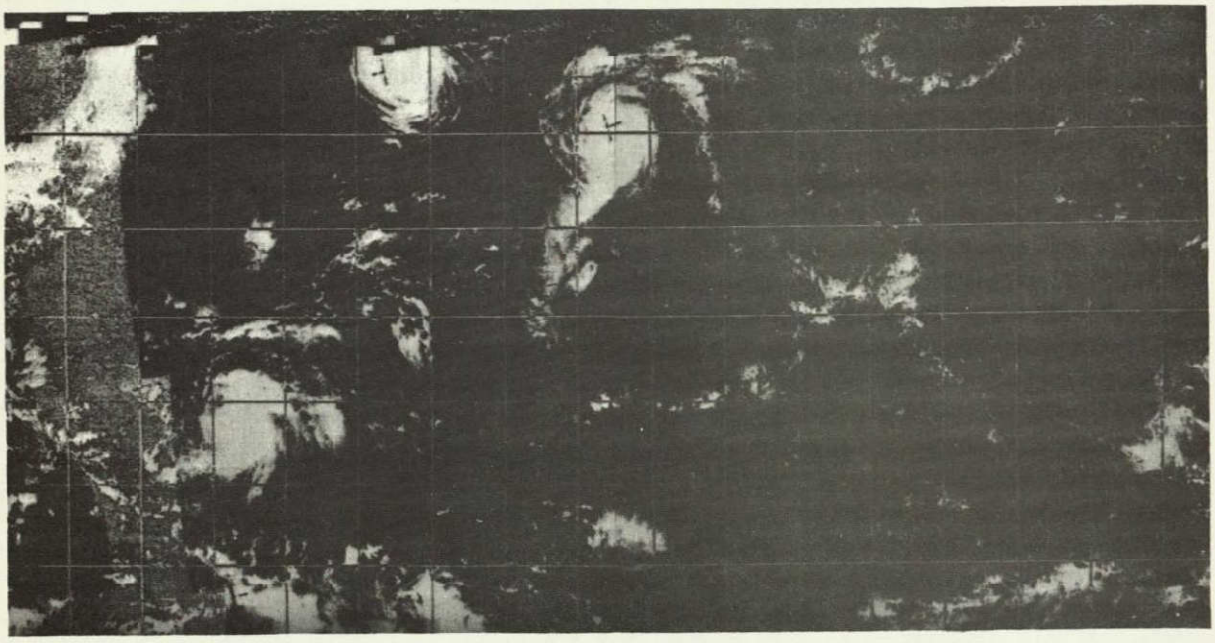


Figure 11-1. WEFAX Picture for BIOSATELLITE II Recovery.



MOJAVE RECEPTION



POINT MUGU RECEPTION

Figure 11-2. Atlantic Hurricane Mosaic Transmitted on 16 September 1967. The mosaic shows Hurricanes Beulah (18N, 83W), Chloe (35N, 58W), and Doria (38N, 72W).

On 19 September, WEFAX began operational support of a high priority Joint Task Force-8 exercise in the Central Pacific. SSCC pictures taken at approximately 1800Z, 2200Z, and 0400Z were enlarged and gridded at Mojave and transmitted over WEFAX. Each ten minute transmission consisted of two frames: two enlarged sections of the 2200Z picture, and an enlarged section and an earth disc of the 1800Z and 0400Z pictures. Figure 11-3 is a sample copy of one of these transmissions.

Data for September were submitted by 21 participating stations. Cooby Creek, near Toowoomba, Australia, submitted WEFAX data for the first time. The special WEFAX data collection period was from 5 through 9 September, and data were received from 16 stations during this period.

Data evaluated for September consisted of 2249 weather and test charts, and 3052 satellite pictures. Table 11-1 shows the quality of reception by the various participating stations. Reception of weather charts continued to be relatively poor, as only 60% were classified excellent to good and 14% were classified unusable. Chart reception was poor during the first half of the month because of the reduced size of the charts. There was a great improvement during the last half of September when the charts were returned to the standard size.

Satellite picture reception during September was outstanding. Eighty-three percent of the pictures were classified excellent (43%) or good (40%) and only 3% classified unusable. The percentage of excellent or good receptions grouped in relation to the station's antenna elevation angle is shown in Figure 11-4. There was very little change in the average number of grey scale steps discernible on the WEFAX test chart. Figure 11-5 shows the average grey scale steps for each of the 19 participating stations. Some comments received from participating stations are listed in Table 11-2. Many comments reflect the usefulness of the ESSA 3/5 mosaics. Copies of ESSA 3 mosaics received at Toronto are shown in Figure 11-6. The 16 September mosaic was recorded on a photo facsimile recorder and the 19 September on a paper facsimile recorder.

Reception difficulties depicted in Figure 11-7 show only minor variations from the previous month. Occurrence of signal-to-noise increased by 3%; multi-image and jitter decreased by 5% and 3%, respectively. The percentage of occurrence of interference during September was the same as August. Figure 11-8 shows the daily occurrence of interference as a percentage of the number of stations submitting data for evaluation.

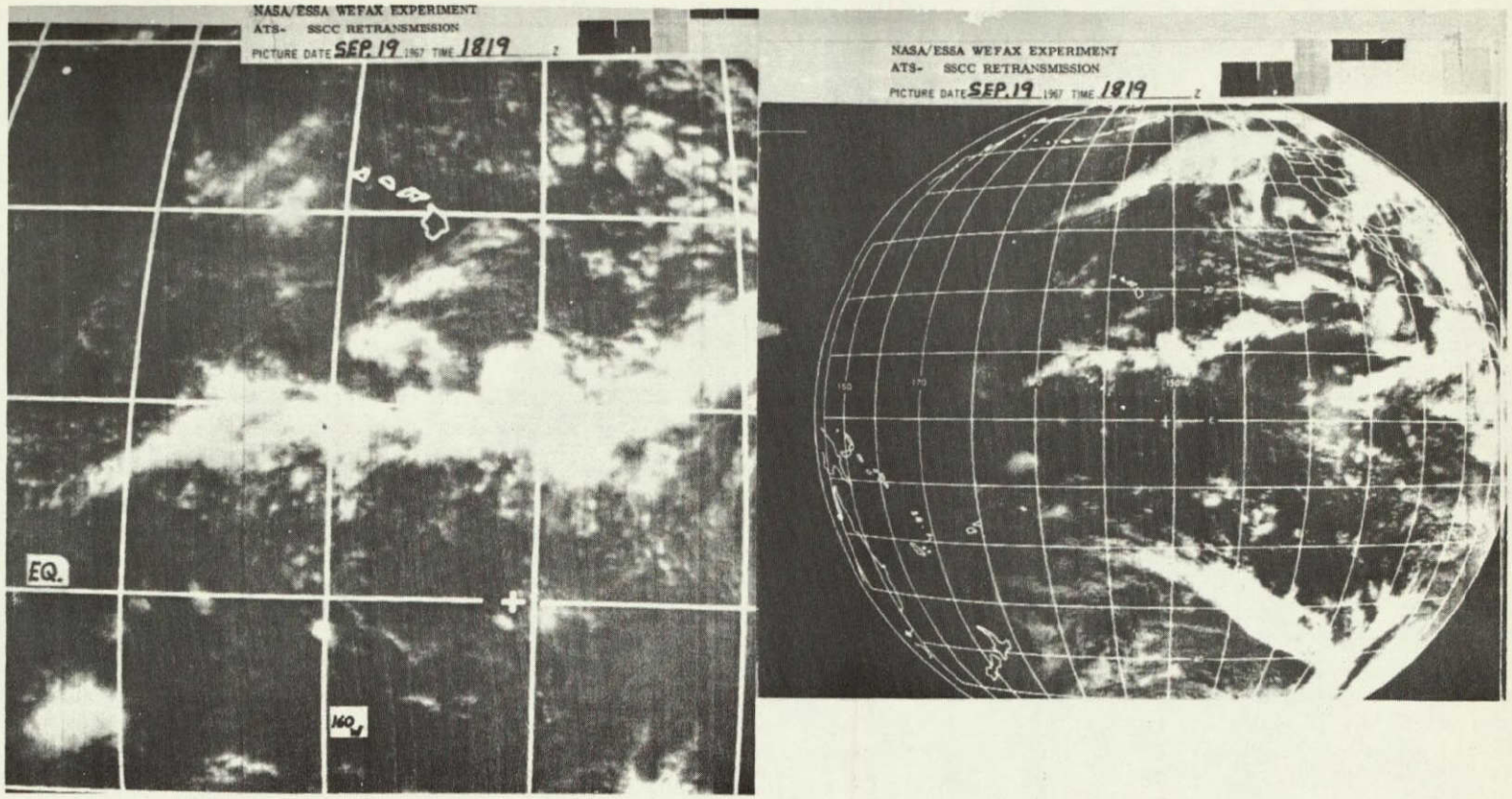


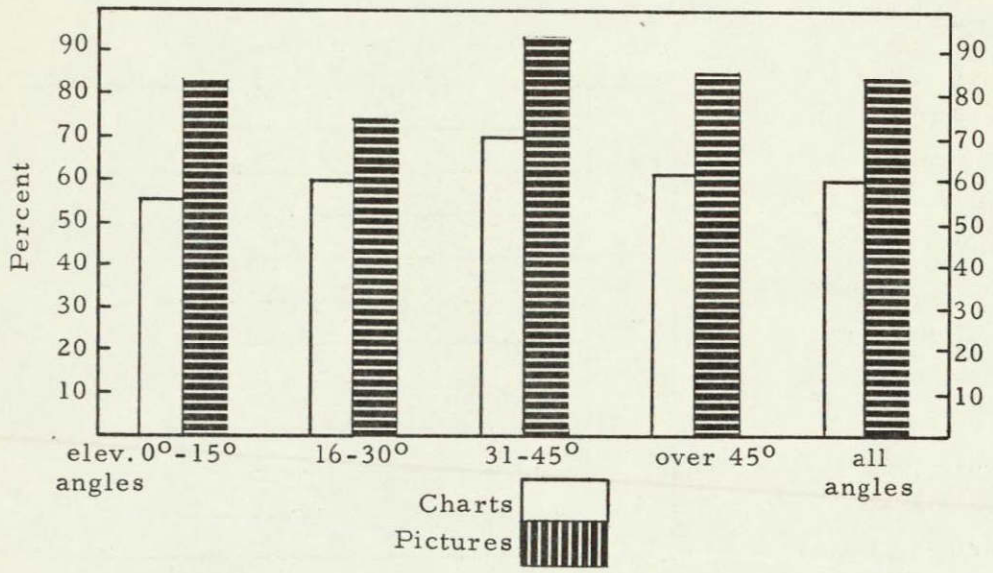
Figure 11-3. JTF-8 WEFAX Transmission Received at Mojave at 2050Z 19 September 1967.

TABLE 11-1

Classification of WEFAX Receptions of
Weather Charts and Satellite Pictures
(September 1967)

APT Receiving Stations	Weather Charts					Satellite Pictures				
	Exc	Good	Fair	Poor	Unusable	Exc	Good	Fair	Poor	Unusable
GSFC, Maryland	80	63	36	13	32	140	132	39	5	15
Toronto, Canada	31	38	26	22	38	109	88	12	6	1
Fuchu, Japan	20	78	48	16	34	31	182	50	9	4
Tokyo, Japan	0	88	14	42	30	0	191	23	1	10
Miami, Florida	2	1	1	0	0	0	0	0	0	0
Melbourne, Australia	87	83	22	0	31	166	93	40	1	10
Tampa, Florida	0	0	1	12	0	1	5	5	6	6
Nashville, Tennessee	0	0	0	22	0	1	9	0	0	0
Guam, Marianas	10	84	52	13	28	15	74	62	27	7
Aberdeen, S. Dakota	0	1	5	8	11	0	6	5	0	14
Toowoomba, Australia	0	13	2	0	0	2	18	6	0	0
Anchorage, Alaska	77	63	28	17	17	139	95	24	6	1
Sulphur Springs, Texas	3	1	0	0	0	0	0	0	0	0
Lake Jackson, Texas	7	10	3	4	0	25	20	5	1	0
Petersen Field, Colo.	7	2	3	0	0	23	3	1	0	0
Christchurch, N. Z.	11	10	2	1	2	18	12	7	0	0
Mojave, California	116	68	12	16	22	262	72	8	10	10
San Francisco, California	3	3	1	0	0	1	0	0	0	0
Point Mugu, California	41	33	32	7	24	159	5	0	0	11
Kunia, Hawaii	37	60	36	30	17	64	103	36	6	8
Papeete, Tahiti	55	70	14	10	36	167	96	15	11	1
TOTALS	587 (26%)	769 (34%)	338 (15%)	233 (11%)	322 (14%)	1323 (43%)	1203 (40%)	338 (11%)	89 (3%)	98 (3%)

Percentage of Excellent or Good Receptions of
WEFAX by Elevation Angle Increments
(2249 charts and 3052 pictures evaluated)
(September)



WEFAX Participating Stations
(by antenna elevation angle)

Station	Antenna Elevation Angle		Station		
GSFC, Maryland	4°		Mojave, California	36°	
Toronto, Canada	5°		San Francisco, Calif.	37°	31° to 45°
Fuchu, Japna	7°		Pt. Mugu, California	38°	
Tokyo, Japan	8°				
Miami, Florida	10°	0° to 15°	Kunia, Hawaii	65°	
Melbourne, Australia	11°		Papeete, Tahiti	68°	Over 45°
Tampa, Florida	11°				
Nashville, Tennessee	13°				
Guam, Marianas	16°				
Aberdeen, S. Dakota	18°				
Toowoomba, Australia	20°				
Anchorage, Alaska	21°				
Sulphur Springs, Texas	21°	16° to 30°			
Lake Jackson, Texas	22°				
Petersen Field, Colo.	26°				
Christchurch, N. Z.	27°				

Figure 11-4. Percentage of Good or Excellent Receptions (September).

Average Grey Scale Steps of
Receiving Stations (September)

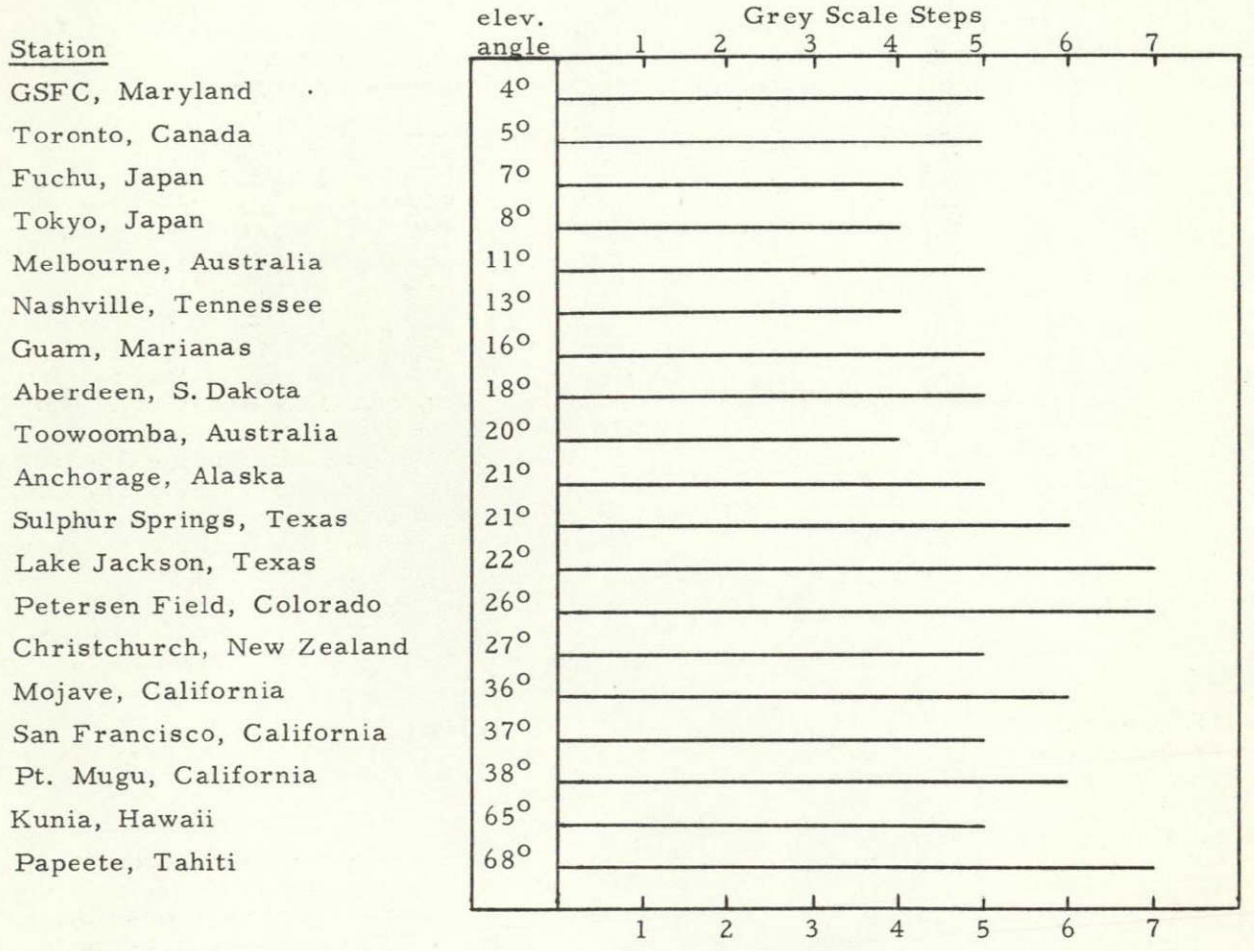


Figure 11-5. Received Grey Scale Steps (September).

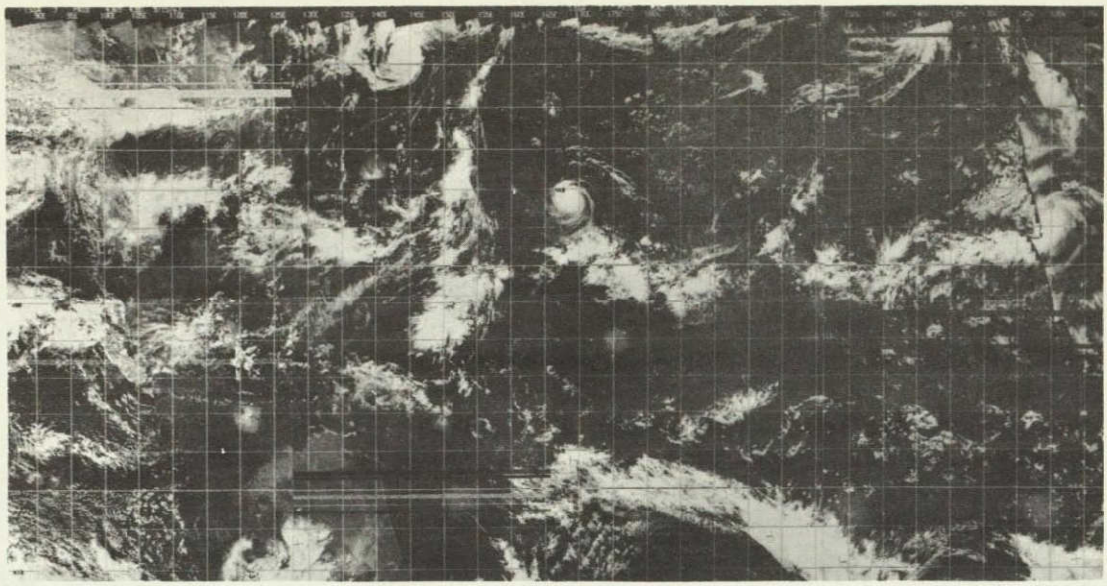
TABLE 11-2

Sample Comments from Participating APT Stations
(September)

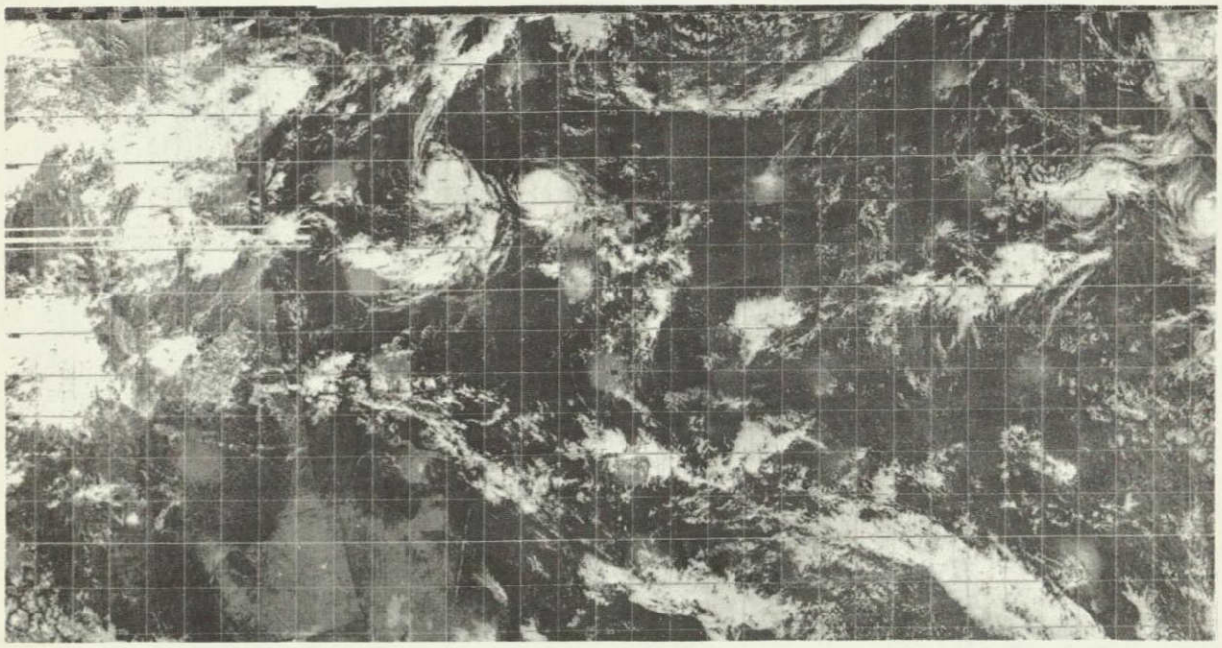
Station Location	Comment
Melbourne, Australia	The resumption of the large weather charts on the 17/1100Z transmission was most welcome. The composite nephanalyses and 500 MB tropical streamline function charts are extremely useful in this area. The Bureau's Regional Office at Darwin is now receiving the 1100Z WEFAX transmission in real time, remoted from our tracking station at Werribee near Melbourne. Most of the reports from Darwin show that ESSA mosaics are being used regularly, particularly to locate tropical disturbances in Darwin's area of responsibility. The results from Cooby Creek ATS and from Melbourne APT appear to be very similar, discounting different setting-up levels at the two stations. Both stations use Muirhead D-900Z paper facsimile machines. The signal to noise ratio on the Cooby data appears to be better than on the Melbourne data. This may be caused by the fact that Cooby is using a 22 db gain antenna to receive the WEFAX, whereas the Melbourne antenna gain is around 10 db. However, even with the additional antenna gain at Cooby, no data appears to have been lost on the Melbourne recordings and we consider that the present APT tracking station in Melbourne is quite adequate for WEFAX reception. The TBUS 3 and mailed weekly WEFAX schedules continue to be received regularly and are quite satisfactory.
Kunia, Hawaii	The daily SSCC pictures have been invaluable to our forecasting mission. The "global" pictures provide the synoptic scale of features, while the enlargements of the Central Pacific provide a sub-synoptic scale of view. Several accurate forecasts have been made using the SSCC pictures in conjunction with ESSA 2/ Nimbus 2 pictures, aircraft reconniaissance reports and conventional data. The ESSA 3/5 digitalized mosaics continue to provide us with very useful information. These cloud pictures enhance our analysis of the data void Pacific Ocean above and below the equator. We have experienced a minimum of interference in September compared to other months. The WEFAX system has proven to be quite an asset to our operations. The special transmissions have provided an example of how much help operational use of the system can be.

Comments from Stations (cont)

Toronto, Canada	Special transmissions of Atlantic hurricane coverage were very good; well received by forecasters here.
Fuchu, Japan	The ESSA 3 digital mosaics have been tremendously useful in the Asiatic Weather Central this past month. The mosaic has been extremely beneficial in giving an "over all" look at typhoons during this past season. We suggest that emphasis continue to be given the tropical nephanalysis making it a regularly scheduled item.
Tokyo, Japan	The 500 MB TROP Streamline, ESSA 3 mosaic, and ATS whole disc SSCC picture which are scheduled at 11Z transmission furnish the information for our study on tropical meteorology.
Tampa, Florida	Most of ESSA mosaic was fair to good on all days.
Lake Jackson, Texas	The most severe problem this month has been signal fading. Most transmissions have had periodic fades to below the noise; this problem has grown more severe near the end of the month. The period of the fade is usually quite long (around 20 minutes) so some 10 minute transmissions are lost while others have been quite good. The Atlantic mosaics have been quite good.
Papeete, Tahiti	Photos ESSA 3 and ESSA 5 very widely broadcast after assemblage to the user airline companies. The material is highly valued. Broadcast hour (1100 to 1200 UT) is satisfactory.

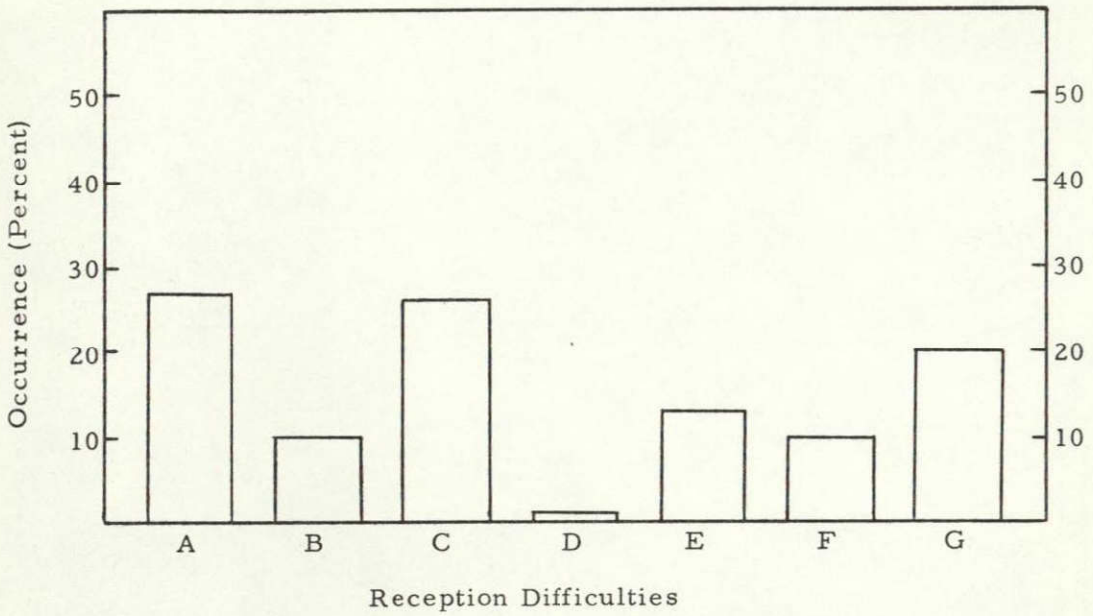


16 SEPTEMBER PHOTO FACSIMILE



19 SEPTEMBER PAPER FACSIMILE

Figure 11-6. ESSA 3 Pacific Mosaics Received at Toronto.



A - Interference - Visible patterns appearing on chart format as a result of external signal sources or internally generated beat frequencies.
B - Bleeding - Smearing and presentation on white areas by black.
C - Signal plus noise-to-noise - White or black streaks on chart, uniformity of tonal shades, snow effect.
D - Distortion - Large scale geometric deviation from time pattern.
E - Skew - Deviation of a vertical line from a vertical normal. Test limit - 1/4" in 8".
F - Multi-Image - The multiple chart reproduction (ghosts) caused by multiple path transmission or reflection.
G - Jitter - Periodic irregularities on lines and patterns.

Figure 11-7. WEFAX Experiment facsimile reception difficulties occurring at 19 APT receiving stations during September 1967. 244 WEFAX Test Charts evaluated.

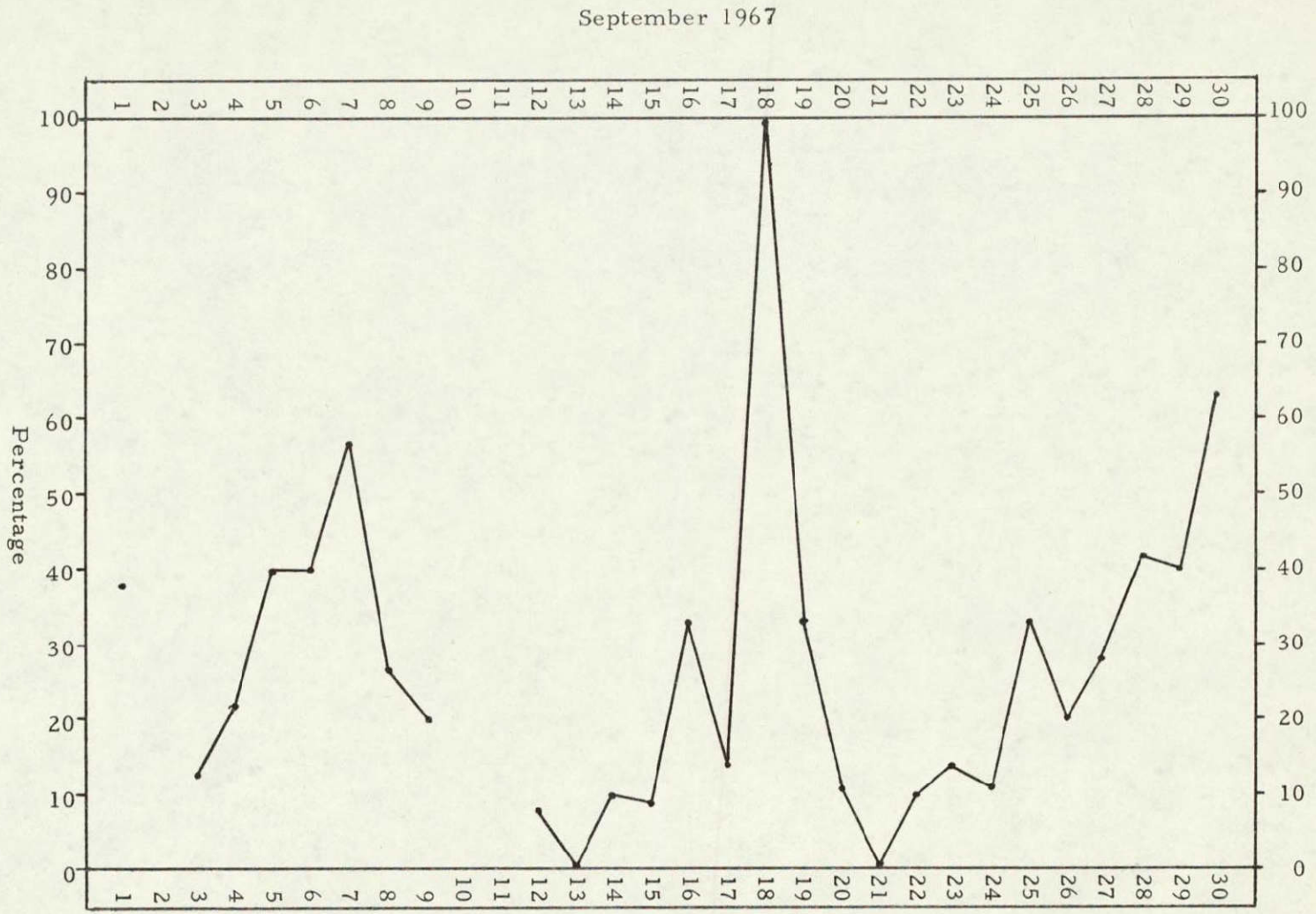


Figure 11-8. Interference Reported During September.

SECTION 12
OCTOBER EVALUATION

There were 95 WEFAX transmission periods during October, 67 of which were classified as special. Many of the 67 special WEFAX transmission periods were of 10 minutes duration or less. Except for 25 October, there was at least one transmission each day. The regular one hour WEFAX transmission period was reduced to 35 minutes starting on 26 October.

JTF-8 support, which began on 19 September, continued through 10 October. The outstanding value of WEFAX data is indicated by the following comments received from the JTF-8 weather support element:

- The satellite information received from ATS-1 was an invaluable tool used to prepare forecasts in support of the recent JTF-8 exercise. Satellite pictures ..... provided an excellent source of continuity on major cloud features. During the exercise, several tropical systems were tracked and progged based on satellite information.
- The 2200Z enlargements of the Spin Scan Camera (SSC) pictures were used for a close look at the areas of interest and as a gap filler between APT pictures received from the ESSA 2 and Nimbus 2 satellites. Perhaps the best use of the SSC enlargements was for briefing purposes. Streamline analyses and weather reconnaissance reports were directly superimposed on the SSC pictures and allowed depiction of the current synoptic situation.
- The Central Pacific Forecast Center used the SSC pictures extensively to brief weather reconnaissance aircraft on exact areas in which more detailed cloud information was needed. The combination of the coverage from the SSC pictures and actual weather reconnaissance reports gave the forecaster a complete three dimensional picture of the cloud patterns over the areas of interest.
- Though not as timely as the SSC and APT, the ESSA 5 digital mosaics provided an excellent look at the broad scale patterns. ..... these mosaics were televised daily by remote television cameras in the weather central and received on screen in the JTF-8 command post. Extremely favorable comments were received from the entire JTF-8 staff on the display brilliance of these mosaics.
- Our forecasts relied heavily on satellite information. The operational decisions based on these forecasts resulted in considerable savings of time, money and manpower. The weatherman's contribution to this exercise was greatly enhanced by the use of SSC and APT pictures.

Transmissions of ESSA 3 digitized mosaics of the southern hemisphere and Indian Ocean areas began on 10 October. Three WEFAX frames, in a polar stereographic projection, cover portions of Antarctica, the southern Pacific Ocean, and the southern Indian Ocean. Figure 12-1 is an example of two frames of a southern hemisphere mosaic. Two additional WEFAX frames cover the area from about 40°N to 27°S latitude and 52°E to 93°E longitude in a Mercator projection. These

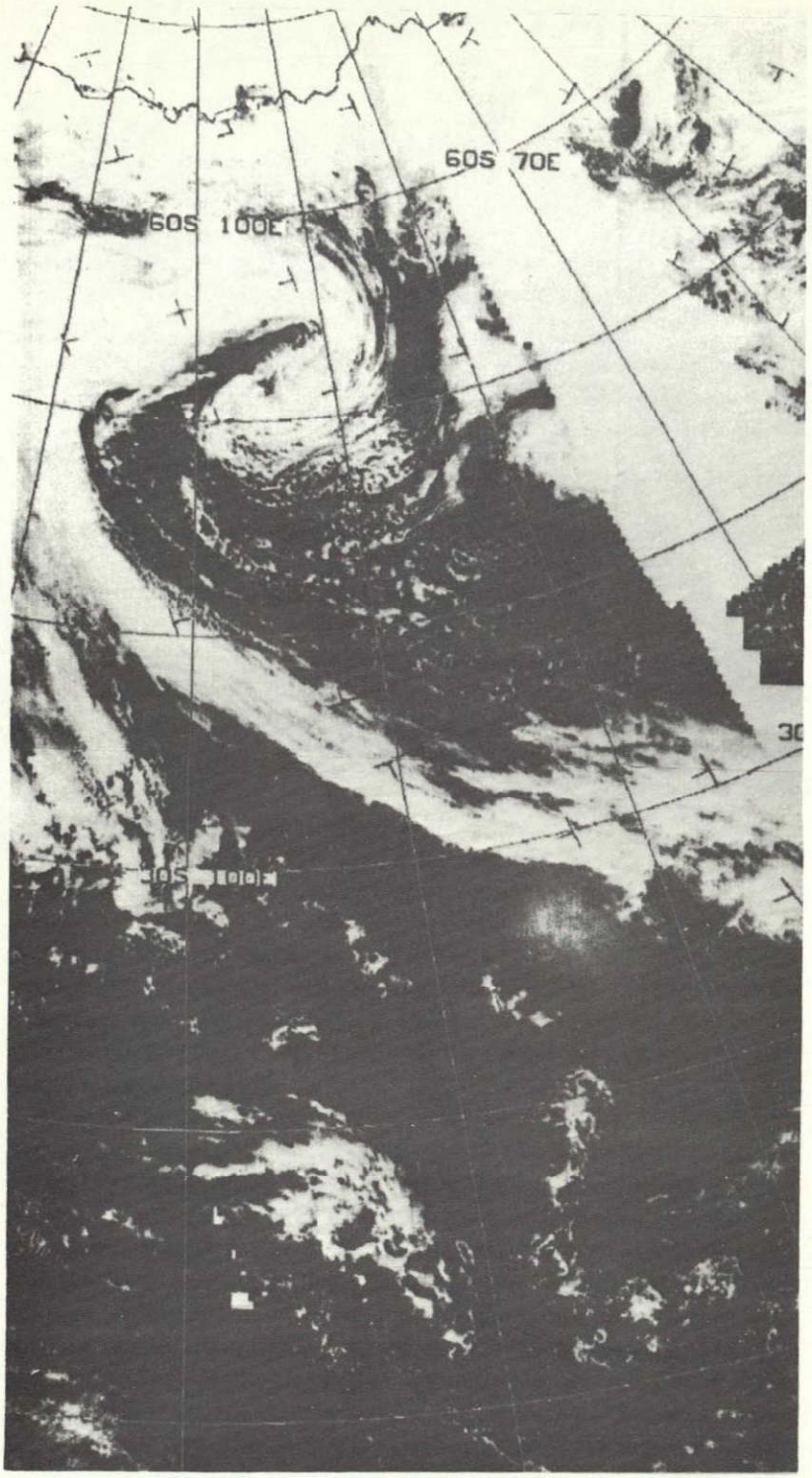


Figure ~~12-1~~ 70 Two frames of a Southern Hemisphere mosaic. Received at Mojave on 30 October 1967.

two frames can be joined to the Pacific mosaic which is transmitted during the regular WEFAX transmission period.

Some of this new information is being used for the annual Antarctic re-supply missions. In addition to the technical evaluation of the receptions, the transmitted data provide much needed information to some of the participating stations. Some comments received from meteorologists in Melbourne, Australia were:

- Excellent - enables detailed analysis in area of vital importance to us and is used operationally for 12Z chart.
- Excellent - these pictures continue to give essential information in important areas which are devoid of conventional observations.
- Excellent - these pictures assisted the analyst to position frontal systems, and also confirmed the existance of a front, about which very little was known prior to receipt of pictures - in short, the pictures were of tremendous value.

A special test transmission was performed on 4 October utilizing the real time APT signal from the Nimbus II meteorological satellite. The Mojave APT station received the Nimbus II APT signal and relayed it to the Mojave ATS-1 VHF transmitter for broadcast over WEFAX. Evaluation of the Nimbus II APT pictures received at various stations indicate that there was no apparent degradation caused by the relay through WEFAX. Figure 12-2 is a copy of a picture received at Mojave from Nimbus II and the same picture received at Lake Jackson after it had been relayed via ATS-1 WEFAX. The test demonstrated the feasibility of using WEFAX as a method of real time relay of APT pictures.

WEFAX support was provided to NASA Ames Research Center for solar observation research flights on 19 through 23 October. Enlarged sections of the ATS-1 spin scan cloud camera pictures for the area south of Hawaii were prepared and transmitted by Mojave. The pictures were used in Hawaii to program aircraft flights into cloud free areas so that a constant bearing on the sun could be maintained. Data furnished via WEFAX were of outstanding value in the planning of the flights.

WEFAX transmissions were made with the spacecraft in the half power mode from 10 through 24 October. Half power mode means that only one of the two VHF regulators in the spacecraft has been turned on. On 26 October, the standard WEFAX transmissions resumed with the spacecraft at full power, however, all special WEFAX transmissions continued at half power.

During half power transmissions, the output video from the APT receiver has a significantly reduced signal-to-noise ratio as a result of the reduced effective radiated power from the satellite . The reduced receiver output signal-to-noise results from two sources. The first source is the direct reduction in carrier-to-noise

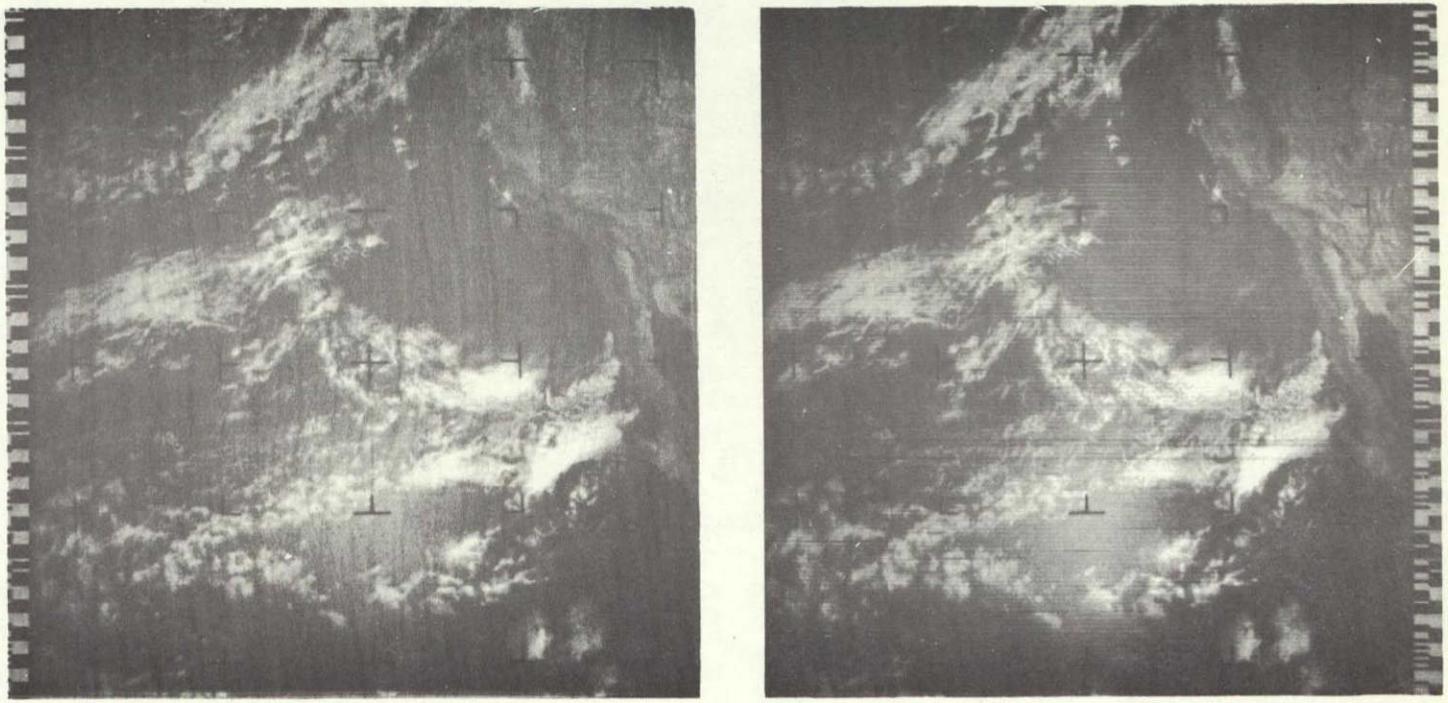


Figure ~~12-2.~~ 71 Relay of Nimbus II APT via ATS-1 WEFAX. The APT picture on the left is a copy of a picture received at Mojave direct from the Nimbus II spacecraft printed on a paper facsimile recorder. The APT picture on the right is a copy of the same APT picture received at Lake Jackson after it had been relayed via ATS-1 WEFAX and printed on photographic paper.

power received. The noise input to the receiver is fixed since it is caused by the environment of the antenna. The second source is a result of the received carrier-to-noise below the FM improvement threshold.

Measurements of the signal strength received at the Mojave APT antenna during the October 1100Z transmission periods are presented in Figure 12-3. The average signal strength received during full power transmissions was -148 dbw. During half power transmissions, the average received signal strength was -155 dbw; i.e., 7 db less.

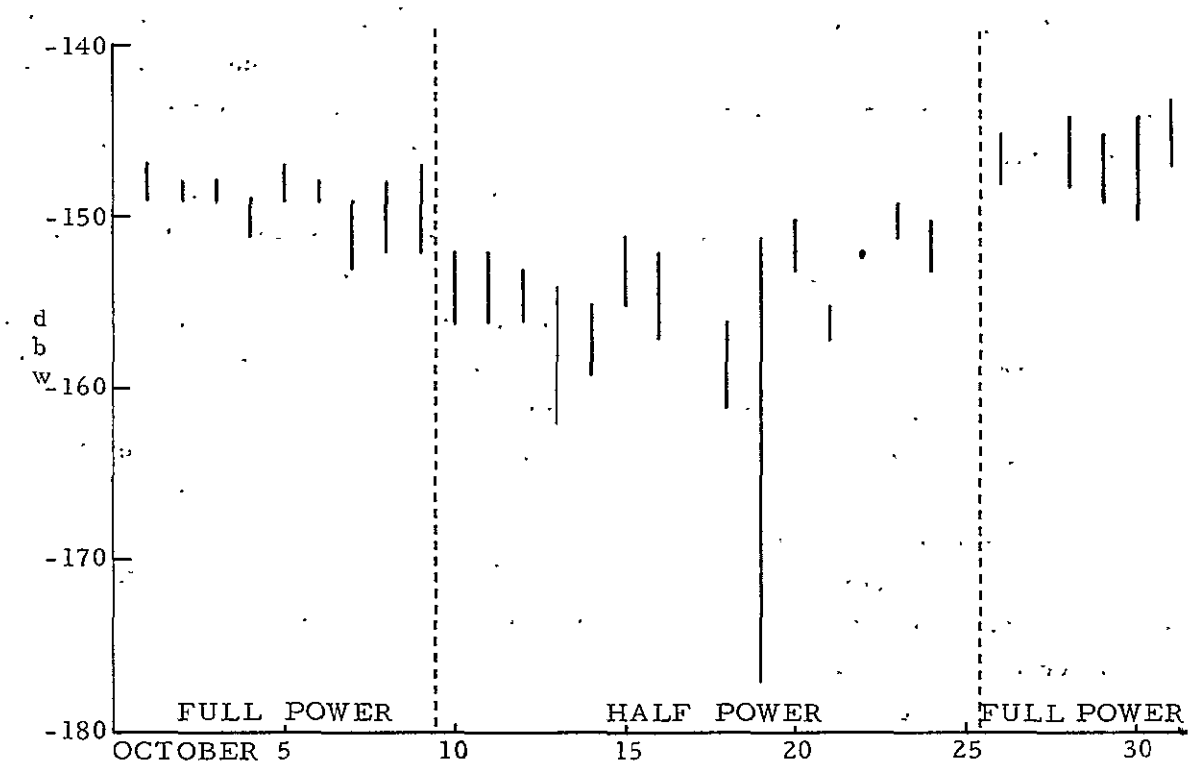


Figure 12-3. Mojave Received Signal Strength in dbw.

A comparative evaluation was made of the full and half power transmission receptions from those stations in which a differentiation was indicated. Results of the evaluation are presented in Table 12-1 as percentages of each classification category.

TABLE 12-1

Classification of Charts and Pictures
in Half Power & Full Power Modes

	Exc	Good	Fair	Poor	Unusable
Half Power	45.7	30.1	13.1	6.5	4.6
Full Power	55.7	29.1	9.9	3.6	1.6

Degradation in the half power mode is very obvious when comparing the percentages in the excellent column.

WEFAX data for October were submitted by 20 participating stations. The special WEFAX data collection period was from 2 through 6 October, and data were received from 16 stations during this period. Data evaluated for October consisted of 906 weather and test charts, and 3401 satellite pictures. Comments from participating stations about the October transmissions are quoted in Table 12-2.

Quality of reception of weather charts and satellite pictures by the various participating stations is depicted in Table 12-3. Considerable improvement was noted during October in the quality of reception of weather charts. The percentage of weather charts classified in the excellent or good categories improved from 60% in September to 72% in October. Satellite picture reception continued to be very good, with 77% of the received pictures classified as excellent or good. The percentage of excellent or good receptions grouped in relation to the station's antenna elevation angle is shown in Figure 12-4.

A comparative evaluation was made between the Mojave WEFAX uplink and downlink signals during October. Using the uplink signal as a basis, the downlink evaluation results were:

Excellent	87.4%
Good	7.7%
Fair	4.6%
Poor	0.4%
Unusable	0.0%

An investigation of the reasons for degraded receptions indicate that 56.6% were caused by low received signal strength during half power transmissions, 40.6% due to equipment malfunctions, and 2.9% resulted from an operational error.

The average number of grey scale steps discernible on the WEFAX test chart improved during October; the averages for 17 stations are shown in Figure 12-5. An increase of at least one grey scale step was noted at 11 of the stations and a decrease at only 1 station.

TABLE 12-2

Sample Comments from Participating APT Stations
(October)

Station Location	Comments
Papeete, Tahiti	The photos from ESSA 3 have been very widely disseminated to the various airlines who are tremendously appreciative of your work. As a general thing, the pictures are more appreciated than the charts (nevertheless, a dissemination of surface maps and nephanalyses over the southern hemisphere should be kept up on an equal basis).
Melbourne, Australia	The most significant development to date in the WEFAX experiment as far as this station is concerned, was the commencement on the 10th October of regular transmission of rectified ESSA 3 mercator and polar-stereographic mosaics of the South Pacific and Indian Ocean areas. Some of the comments from the meteorologists who are using these pictures include: "Excellent - enables detailed analysis in area of vital importance to us and is used operationally for 12Z chart". "Excellent - these pictures assisted the analyst to position frontal systems, and also confirmed the existance of a front about which very little was known prior to receipt of pictures". "Excellent - these pictures continue to give essential information in important areas which are devoid of conventional observations". The mosaics are giving us for the first time a detailed picture of important areas that are outside our reception range for NIMBUS and ESSA APT. We are anxious that the rectified ESSA mosaics be continued on the 1100Z and 1800Z transmissions. The cessation of regular weather chart transmission on 25 October is regretted, particularly as the 500 MB tropical streamline function chart was of great benefit to our regional office in Darwin.
Fuchu, Japan	The half power test resulted in very poor quality pictures. They were usable by our forecasters, but were not able to be transmitted via the facsimile network. The ESSA 3, ESSA 5 mosaics are the most useful tool received via WEFAX. The mosaics are used in almost every phase of the Asiatic Weather Central's operation.

Comments from Stations (cont)

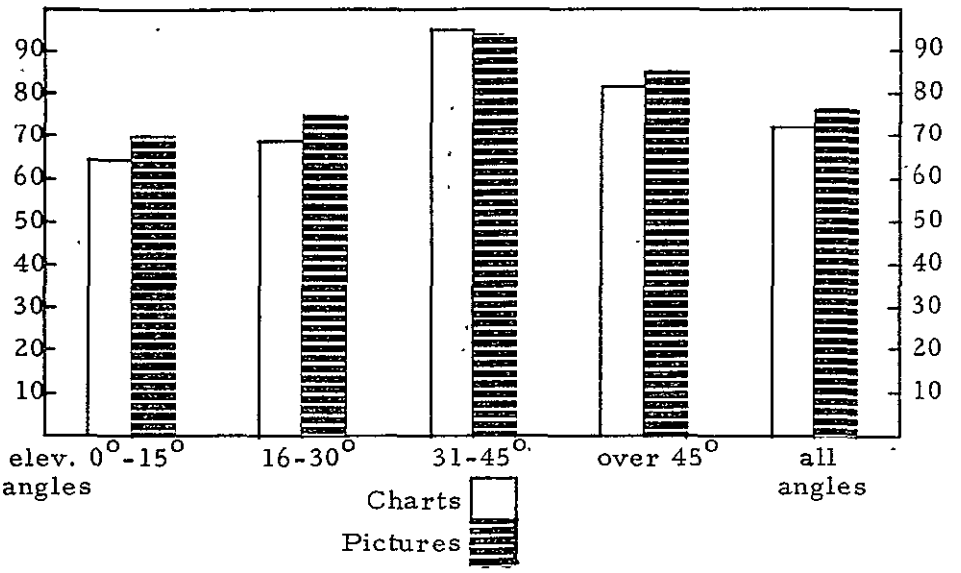
Kunia, Hawaii	All products received are useful and are becoming operational "necessities". The ESSA 3/5 mosaics save considerable forecaster time. Rather than tediously evaluating conventional data to determine cloud/weather patterns, the forecaster is presented with an immediate two dimensional view of the weather. This frees the forecaster to devote more time to prognosis rather than analysis which in the end improves our service. The transmissions at half-power definitely resulted in a degradation of our reception. Since 26 October, the reception has been excellent.
Toronto, Canada	Throughout most of October, signal levels were below the 9 to 10 microvolt optimum that has been received at frequent intervals in the past. Despite levels of 7 1/2 to 8 1/2 microvolts, the pictures were generally of good usable quality. Printed detail of weather charts, however, becomes difficult to read if levels fall below 8 1/2 microvolts. This station still suffers from radio interference marring WEFAX data, but there seems little that can be done about this.
Lake Jackson, Texas	Interference problems more severe during this month due to reduced spacecraft power after 10 October. During good receiving conditions, good to excellent pictures and charts were possible, however, the signal was usually on the borderline between severe and slight noise. Occasionally, the signal could not be heard at all. Some interference due to deep signal fades was experienced prior to 10 October. The Nimbus 2 relay of 4 October was excellent quality, however, I believe that the ESSA mosaics with grids added are of more value even though slightly delayed. The ESSA 5 pictures continue excellent quality while ESSA 3 pictures are usually good quality. Land recognition on the ESSA 3 pictures is poor but the grid has been very accurate.
Anchorage, Alaska	Deterioration in the quality of ESSA pictures has caused our technicians to make adjustments in our receiving equipment that has had an effect on the quality of some of the WEFAX pictures and charts.
Tampa, Florida	Quality of pix increase in latter parts of afternoon transmissions and in the evening. Would like to see more of ESSA 3 Atlantic and ESSA 2 Western pass relayed.
Point Mugu, California	Recommend that all charts and ESSA mosaics be annotated for latitude and longitude.

TABLE 12-3

Classification of WEFAX Receptions of
Weather Charts and Satellite Pictures
(October 1967)

APT Receiving Stations	Weather Charts					Satellite Pictures				
	Exc	Good	Fair	Poor	Unusable	Exc	Good	Fair	Poor	Unusable
GSFC, Maryland	34	53	14	2	0	139	226	52	3	1
Aichi, Japan	0	17	16	0	0	0	121	91	16	2
Toronto, Canada	12	17	8	20	5	42	81	46	14	6
Fuchu, Japan	4	23	19	16	18	8	134	105	49	26
Tokyo, Japan	0	10	26	8	0	0	73	44	9	0
Howard AFB, C. Z.	0	0	0	0	0	0	0	7	2	0
Melbourne, Australia	78	19	7	0	1	329	59	18	3	5
Tampa, Florida	8	6	3	0	0	26	21	21	14	4
Nashville, Tenn.	2	2	0	0	0	10	8	0	0	0
Guam, Marianas	4	17	10	13	1	0	25	37	40	8
Aberdeen, S. Dakota	7	11	0	0	4	16	36	4	2	9
Toowoomba, Australia	12	5	1	0	0	35	6	2	0	0
Anchorage, Alaska	47	19	9	7	1	203	39	6	18	0
Lake Jackson, Texas	5	7	3	0	0	24	30	13	4	5
Christchurch, N. Z.	0	5	9	3	1	17	30	6	1	0
Mojave, California	82	26	5	0	0	361	30	26	1	2
San Francisco, Calif.	3	0	0	0	0	3	0	0	0	0
Pt. Mugu, California	6	10	1	0	0	53	0	0	0	0
Kunia, Hawaii	21	21	10	6	3	70	65	28	6	25
Papeete, Tahiti	34	25	2	1	1	170	120	10	0	0
TOTALS	359 (40%)	293 (32%)	143 (16%)	76 (8%)	35 (4%)	1506 (44%)	1104 (33%)	516 (15%)	182 (5%)	93 (3%)

Percentage of Excellent or Good Receptions of
WEFAX by Elevation Angle Increments
(906 charts and 3401 pictures evaluated)
(October)



WEFAX Participating Stations
(by antenna elevation angle)

Station	Antenna Elevation Angle	
GSFC, Maryland	4°	
Aichi, Japan	5°	
Toronto, Canada	5°	
Fuchu, Japan	7°	
Tokyo, Japan	8°	0° to 15°
Howard AFB, C. Z.	10°	
Melbourne, Australia	11°	
Tampa, Florida	11°	
Nashville, Tennessee	13°	
Guam, Marianas	16°	
Aberdeen, S. Dakota	18°	
Toowoomba, Australia	20°	
Anchorage, Alaska	21°	16° to 30°
Lake Jackson, Texas	22°	
Christchurch, N. Z.	27°	

Station	Antenna Elevation Angle	
Mojave, California	36°	
San Francisco, Calif.	37°	31° to 45°
Pt. Mugu, California	38°	
Kunia, Hawaii	65°	
Papeete, Tahiti	68°	Over 45°

Figure 12-4. Percentage of Good or Excellent Receptions (October).

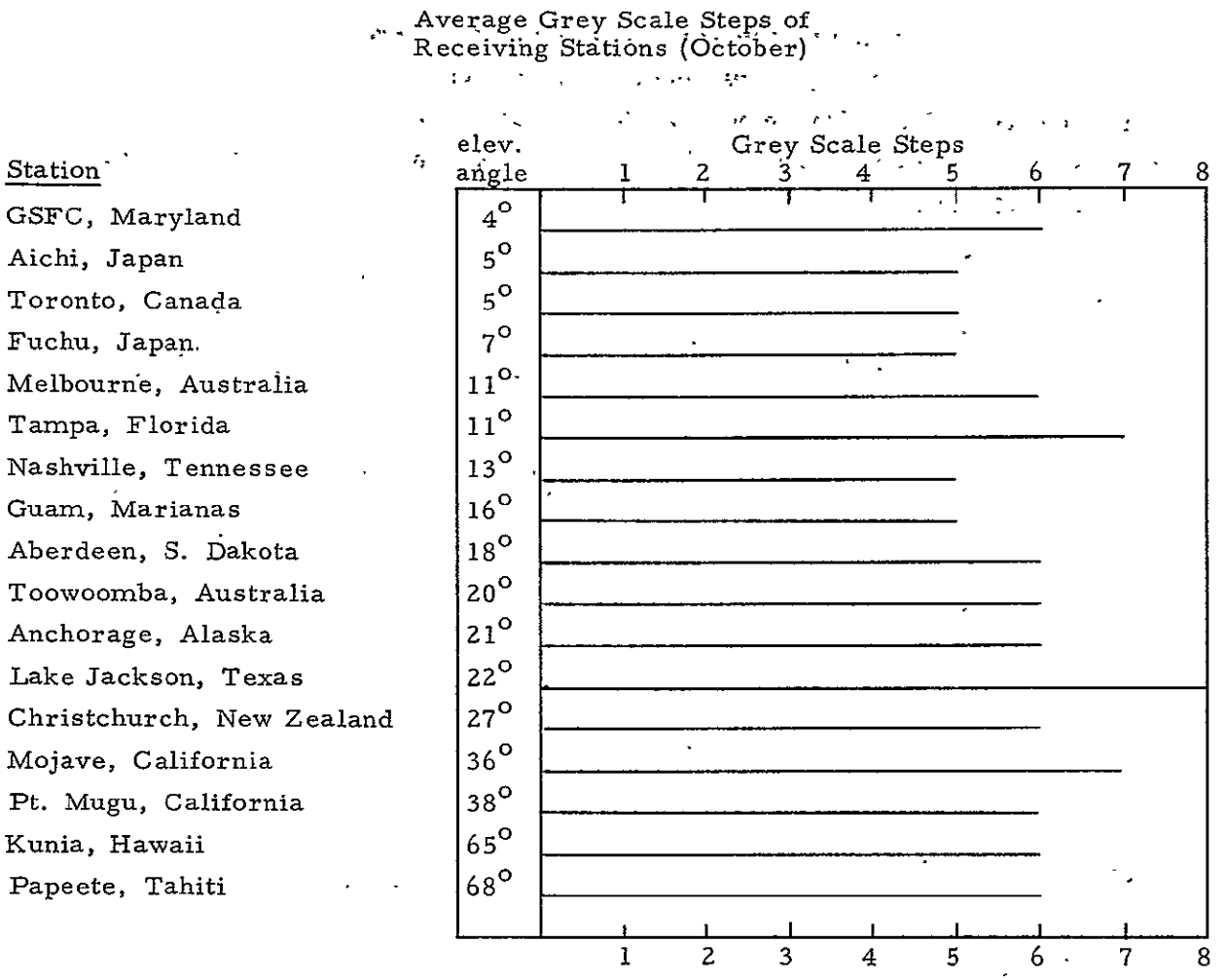


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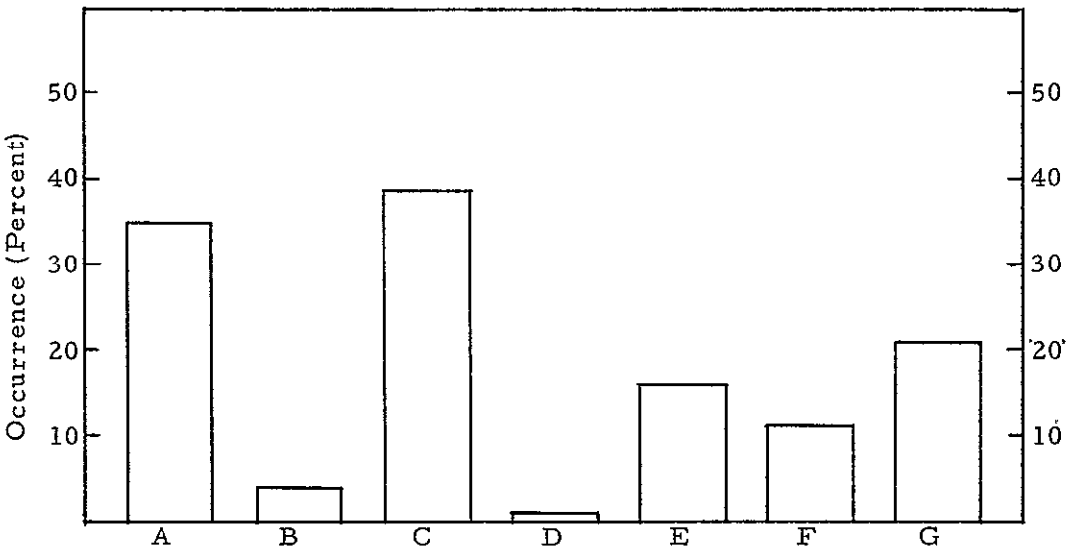
Figure 12-5. Received Grey Scale Steps (October).

75 Percentage of occurrence of major reception difficulties is shown in Figure 12-6. The effects of the half power transmissions on WEFAX receptions are indicated by the relatively high occurrence of interference and noise. Interference increased from 27% in September to 35% in October, and signal-to-noise from 26% in September to 38% in October. There were only minor variations in the other reception difficulties.



A - Interference - Visible patterns appearing on chart format as a result of external signal sources or internally generated beat frequencies.
B - Bleeding - Smearing and presentation on white areas by black.
C - Signal plus noise-to-noise - White or black streaks on chart, uniformity of tonal shades, snow effect.
D - Distortion - Large scale geometric deviation from time pattern.
E - Skew - Deviation of a vertical line from a vertical normal. Test limit - 1/4" in 8".
F - Multi-Image - The multiple chart reproduction (ghosts) caused by multiple path transmission or reflection.
G - Jitter - Periodic irregularities on lines and patterns.

Figure 12-6. WEFAX Experiment facsimile reception difficulties occurring at 18 APT receiving stations during October 1967. 151 WEFAX Test Charts evaluated.

SECTION 13

NOVEMBER EVALUATION

During November, there were 26 regular and 22 special WEFAX transmission periods. There were no WEFAX transmissions from 4 through 7 November due to the launch of ATS-3 on 5 November. Regular WEFAX transmissions were 40 minute periods until 28 November when they were increased to one hour periods. Special transmissions were of 25 minute periods and consisted of ESSA 3 digitized mosaics of the southern hemisphere and Indian Ocean areas.

Beginning on 11 November, coastal outlines were added to the ESSA 3 mosaics. One advantage of the outlines is mentioned in the comment from Fuchu AS, Japan in Table 13-1. Figure 13-1 is a copy of 4 sections of the 13 November Pacific mosaic showing the coastal outlines.

A WEFAX engineering test transmission was performed on 17 November with the ATS-3 spacecraft. A 45 minute transmission was made through ATS-3, followed by a 45 minute transmission through ATS-1. Much of the same WEFAX data were transmitted through both spacecraft so that a comparison could be made by those stations capable of receiving from both ATS-1 (150°W) and ATS-3 (48.5°W). Stations which received from both satellites reported that the ATS-3 signal was much stronger; in one case, 10 db stronger. Stations reported excellent data reception from ATS-3 and excellent to good reception from ATS-1. Stations receiving from both spacecrafts reported much better contrast in the data received from ATS-3. Figure 13-2 is a comparison of the reception from ATS-1 and ATS-3 and shows the poorer signal-to-noise ratio obtained from the ATS-1 transmission.

WEFAX data for November were submitted by 19 participating stations. The special WEFAX data collection period was from 21 through 25 November, and data were received from 11 stations during this period. Data evaluated for November consisted of 493 weather and test charts, and 1810 satellite pictures.

Quality of reception of weather charts and satellite pictures by the various participating stations is depicted in Table 13-2. Reception quality continued to improve in November; 82% of the charts and 88% of the pictures were classified in the excellent or good categories. The percentage of excellent or good receptions grouped in relation to the station's antenna elevation angle is shown in Figure 13-3.

TABLE 13-1

Sample Comments from Participating APT Stations
(November)

Station Location	Comment
Toronto, Canada	Signal levels were particularly good from 11th to 22nd November, and on 29th and 30th (during 1100 - 1200Z transmissions) Conditions were unfavorable or poor on 25th, 26th, and 27th during the 1100Z and 1835Z transmissions.
Fuchu, Japan	The geographical outlines recently added to the mosaic have greatly enhanced its use by enabling the forecasters to readily determine terrain effects against synoptic system effects. The ESSA 3 tropical mosaic is extremely useful in almost every phase of forecasting.
Guam, Marianas	Overall quality of pictures have greatly improved because of recent tube replacement and realignment of pre-amplifier. Minor interference problems still exist.
Lake Jackson, Texas	With the exception of the 23rd, 24th, 25th and 26th (1835Z), the signal level was strong throughout the month on all transmissions monitored. Most of these had no interference reported. The ESSA mosaics continue to be excellent in quality, with 88% of those printed in the excellent or good classification. The only significant problem area was the low white level on most charts as compared with the phase signal. On all charts, the gain was set on the chart white rather than the phase amplitude. This procedure usually produces excellent results, but is less reproducible than using the phase signal (as on pictures).
Kunia, Hawaii	The ESSA 3/5 equatorial Pacific montage has been received with excellent results during most of the month. The ESSA 3/5 picture mosaic is the most useful analysis tool available to us.
Papeete, Tahiti	No difficulties with acquisition, which is still excellent. The photographs from ESSA 3 continue to be very widely disseminated to the user airline companies. Reception of the Southern Hemisphere map (surface) and the Southern Hemisphere Nephanalysis is appreciated. Furthermore, photos of the Southern Hemisphere (1835-1900 UT) are being used by the Forecast Service for the section south of the 30th parallel.

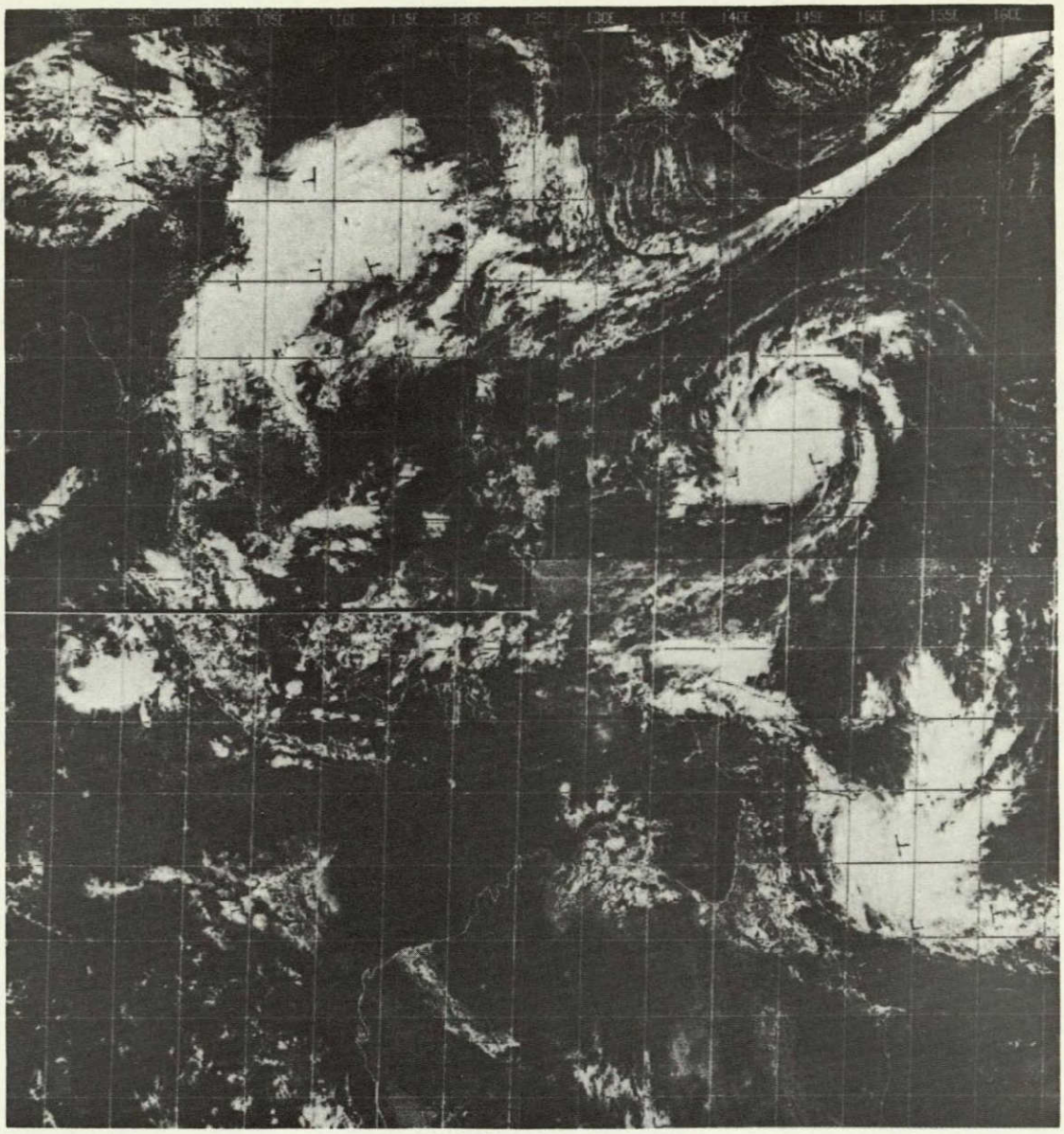
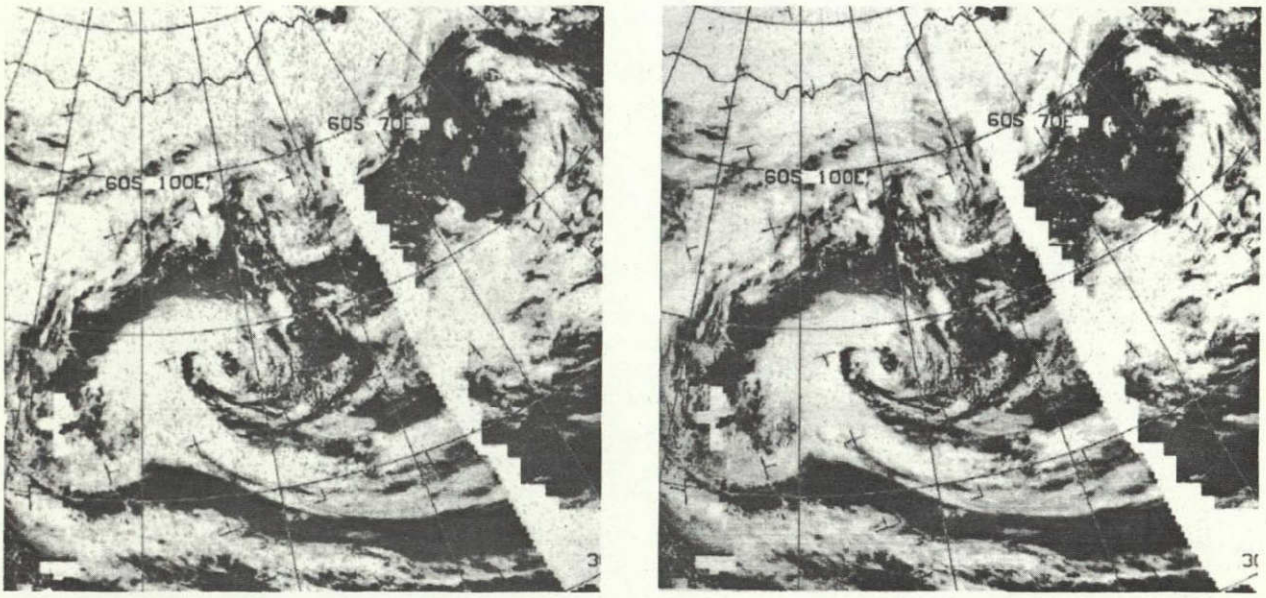


Figure 13-1. Mosaic showing coastal outlines.
Four sections of Pacific mosaic received at Mojave on 13 Nov 67.



ATS-1 ATS-3

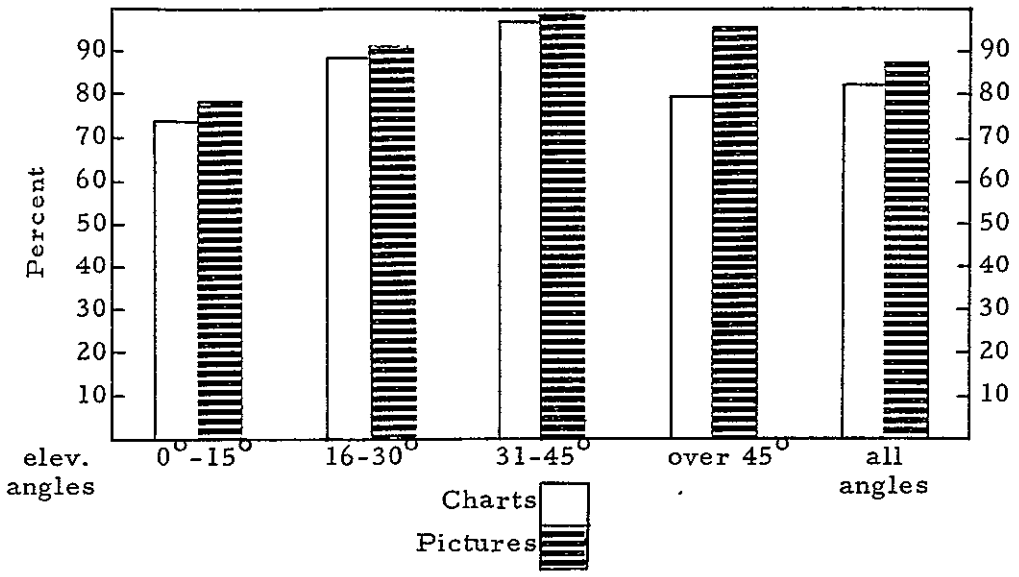
Figure 13-2. Comparison of reception from ATS-1 and ATS-3. Received at GSFC on 17 November 1967. Note the larger amount of noise in the reception from ATS-1.

TABLE 13-2

Classification of WEFAX Receptions of
Weather Charts and Spin Scan Pictures
(November)

APT Receiving Stations	Weather Charts					Satellite Pictures				
	Exc	Good	Fair	Poor	Unusable	Exc	Good	Fair	Poor	Unusable
GSFC, Maryland	28	32	5	2	0	180	64	11	3	0
Aichi, Japan	3	20	3	0	0	10	144	3	0	3
Toronto, Canada	20	22	4	5	4	119	28	9	4	8
Fuchu, Japan	1	16	25	3	4	0	99	104	21	0
Tokyo, Japan	4	1	0	0	0	5	1	0	0	0
Howard AFB, C.Z.	0	2	0	0	0	3	0	0	0	0
Kokomo, Indiana	0	0	0	0	0	0	5	8	0	0
Miami, Florida	0	0	0	0	0	0	1	0	0	0
Tampa, Florida	0	0	1	0	0	0	5	0	0	0
Guam, Marianas	1	30	3	0	0	8	110	2	0	0
Anchorage, Alaska	33	7	3	4	0	129	3	3	10	8
Lake Jackson, Texas	9	7	1	0	0	41	4	3	1	2
Mojave, California	53	14	0	1	0	243	22	0	3	0
San Francisco, Calif.	8	5	0	0	0	21	0	0	1	0
Pt. Mugu, California	1	0	1	0	0	5	0	0	0	0
Vandenberg AFB, Calif.	1	0	0	0	0	0	0	0	0	0
Kunia, Hawaii	21	17	4	2	4	73	74	9	0	0
Papeete, Tahiti	22	25	4	3	2	131	64	2	0	0
USS Ranger, Pacific	0	0	2	0	0	0	0	0	0	0
TOTALS	205 (42%)	198 (40%)	56 (11%)	20 (4%)	14 (3%)	968 (54%)	624 (34%)	154 (9%)	43 (2%)	21 (1%)

Percentage of Excellent or Good Receptions of
WEFAX by Elevation Angle Increments
(493 charts and 1810 pictures evaluated)
(November)



WEFAX Participating Stations
(by antenna elevation angle)

Station	Antenna Elevation Angle	
GSFC, Maryland	4°	
Aichi, Japan	5°	
Toronto, Canada	5°	
Fuchu, Japan	7°	
Tokyo, Japan	8°	0° to 15°
Howard AFB, C. Z.	10°	
Kokomo, Indiana	10°	
Miami, Florida	10°	
Tampa, Florida	11°	
Guam, Marianas	16°	
Anchorage, Alaska	21°	16° to 30°
Lake Jackson, Texas	22°	

Station	Antenna Elevation Angle	
Mojave, California	36°	
San Francisco, Calif.	37°	31° to 45°
Pt. Mugu, California	38°	
Vandenberg AFB, Calif.	38°	
Kunia, Hawaii	65°	
Papeete, Tahiti	68°	Over 45°
USS Ranger, Pacific	68°	

Figure 13-3. Percentage of Good or Excellent Receptions (November).

A comparative evaluation was made between the Mojave WEFAX uplink and downlink signals during November. Using the uplink signal as a basis, the downlink evaluation results were:

Excellent	98.2%
Good	0.6%
Fair	0.0%
Poor	0.0%
Unusable	1.2%

An investigation of the reasons for degraded receptions indicate that those classified as "Good" were due to a high level of noise received while the spacecraft was in the half power mode, and those classified as "Unusable" resulted from an operational error.

The average number of grey scale steps discernible on the WEFAX test charts improved during November; an increase of at least one grey scale step was noted at 4 stations whereas a decrease was observed at 1 station. The averages for 16 stations are shown in Figure 13-4.

Percentage of occurrence of major reception difficulties is shown in Figure 13-5. All seven reception difficulties decreased in November. Interference decreased from 35% in October to 27% in November, and signal-to-noise decreased from 38% in October to 33% in November. There were no cases of jitter noted during November, which represents a decrease from 21% in October.

Average Grey Scale Steps of
Receiving Stations (November)

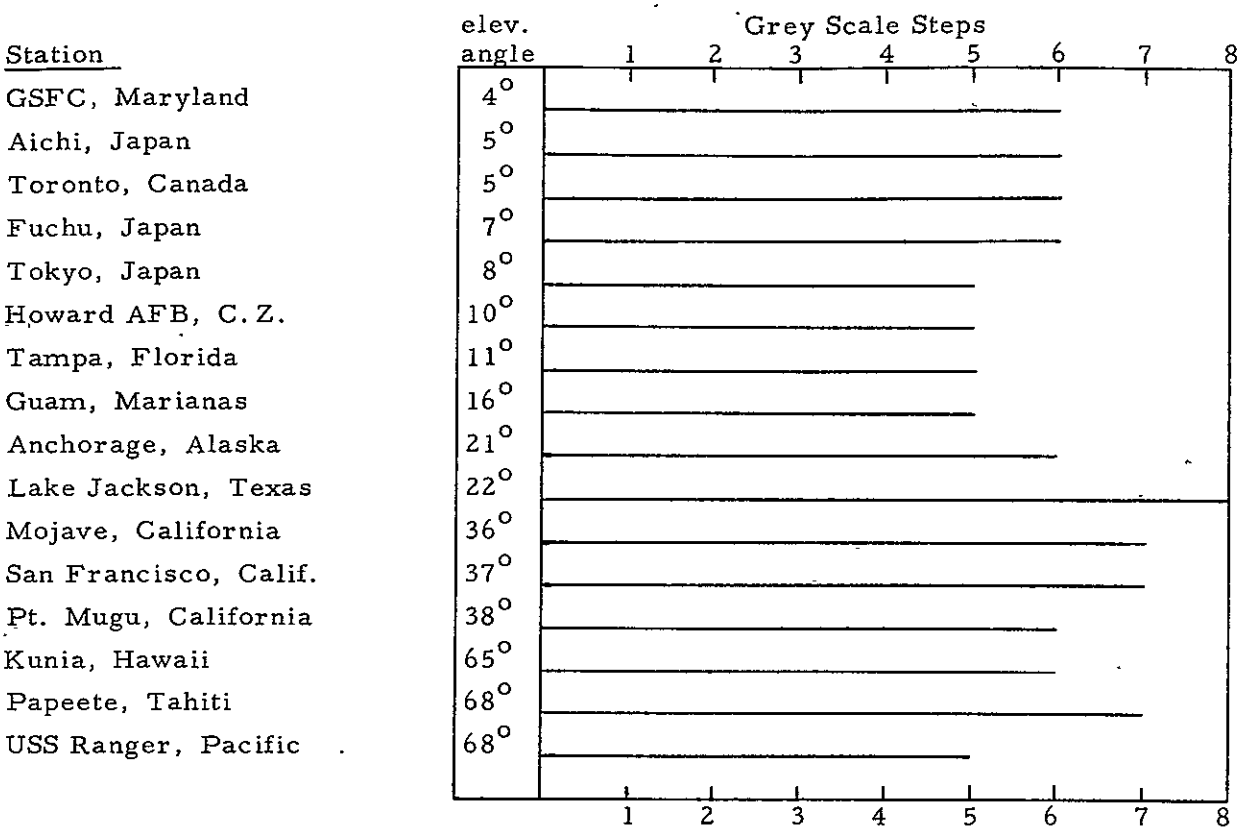
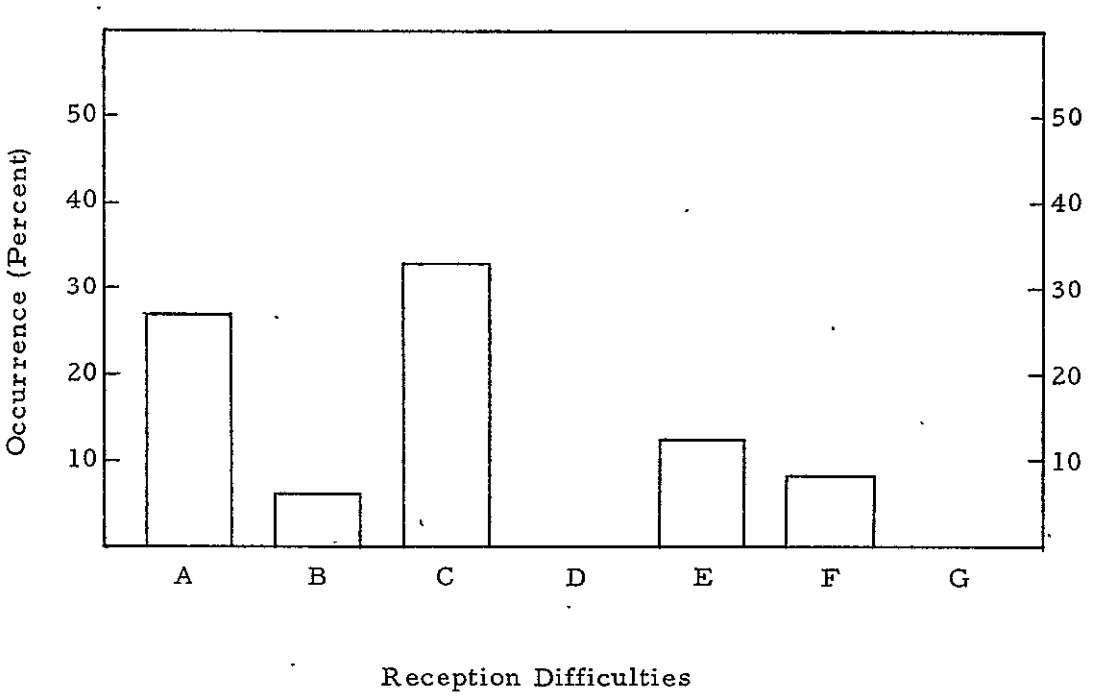


Figure 13-4. Received Grey Scale Steps (November).



A - Interference - Visible patterns appearing on chart format as a result of external signal sources or internally generated beat frequencies.
B - Bleeding - Smearing and presentation on white areas by black.
C - Signal plus noise-to-noise - White or black streaks on chart, uniformity of tonal shades, snow effect.
D - Distortion - Large scale geometric deviation from time pattern.
E - Skew - Deviation of a vertical line from a vertical normal. Test limit - 1/4" in 8".
F - Multi-Image - The multiple chart reproduction (ghosts) caused by multiple path transmission or reflection.
G - Jitter - Periodic irregularities on lines and patterns.

Figure 13-5. WEFAX Experiment facsimile reception difficulties occurring at 16 APT receiving stations during November 1967. 167 WEFAX Test Charts evaluated.

SECTION 14

DECEMBER EVALUATION

There were 74 WEFAX transmission periods during December, 44 of which were classified as special. Except for 25 December, there was at least one transmission each day.

WEFAX support was provided to a DOD Western Test Range operation from 5 through 18 December. The 1810Z SSCC full earth disc picture was gridded, enlarged and transmitted along with an enlarged area in the central Pacific Ocean.

Also during December, WEFAX provided support information for President Johnson's trip to Australia and Southeast Asia. On 20 December, a special SSCC picture was prepared and transmitted over WEFAX from Mojave for reception in Hawaii. The transmission consisted of an earth disc and enlargements of the areas from Hawaii to Samoa and from Samoa to Australia. The WEFAX pictures received in Hawaii were used to prepare the forecast and brief the crew. The pictures were then placed in the briefing folder for the Honolulu to Melbourne portion of the flight. In anticipation of the President's return flight across the Pacific, special WEFAX transmissions were conducted on 22, 23, and 24 December for receipt by certain stations in the Pacific area. On these dates, the previous day's 2230Z SSCC picture was gridded and enlarged to the 22 inch size and transmitted over WEFAX at 1100Z. Even though the President's return trip was not across the Pacific, regular WEFAX data (especially the Pacific mosaics) were used in the preparation of the flight forecasts from Melbourne to Southeast Asia.

On 7 December, the transmission format of the Southern Hemisphere mosaic was changed from 3 to 4 frames in order to give a more complete coverage of the area. Figure 14-1 is a copy of the new mosaic received at Papeete, Tahiti, on 31 December.

The first oceanographic data was transmitted over WEFAX on 8 December 1967. Sea Surface Temperature Analysis and the Combined Wave Analysis and Prognosis were the two types of charts transmitted. Charts were computer produced at the Fleet Numerical Navy Weather Facility at Monterey, California. The charts were transmitted by a computer via a computer line to a plotter at the Fleet Weather Central at Suitland, Maryland. Here the charts were given to NMC for transmission over WEFAX. Figure 14-2 is a copy of a 36 hour Sea Height Prog received at Mojave on 22 December.

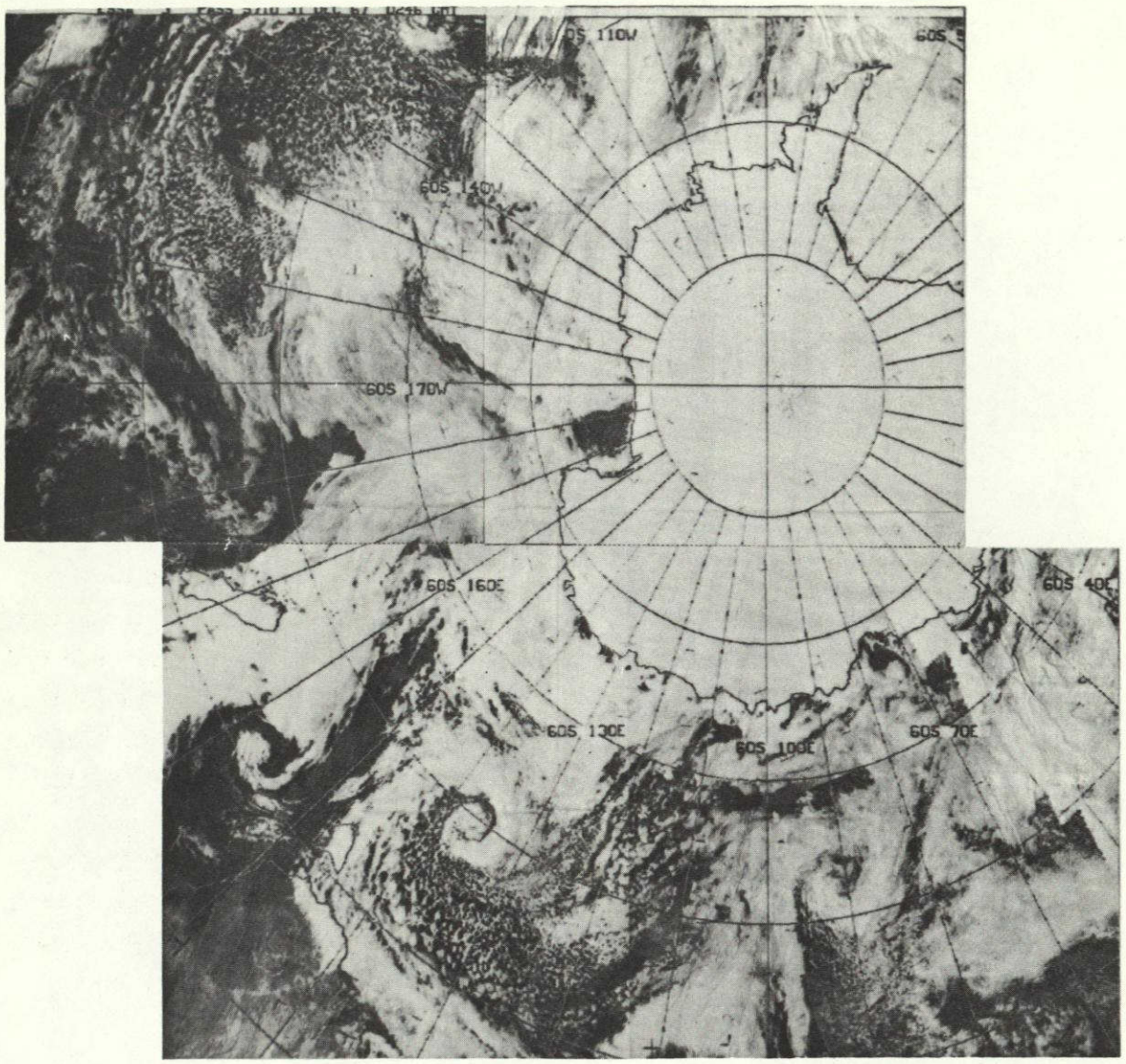


Figure 14-1. Four Section Southern Hemisphere Mosaic.
Received at Papeete on 31 December 1967.

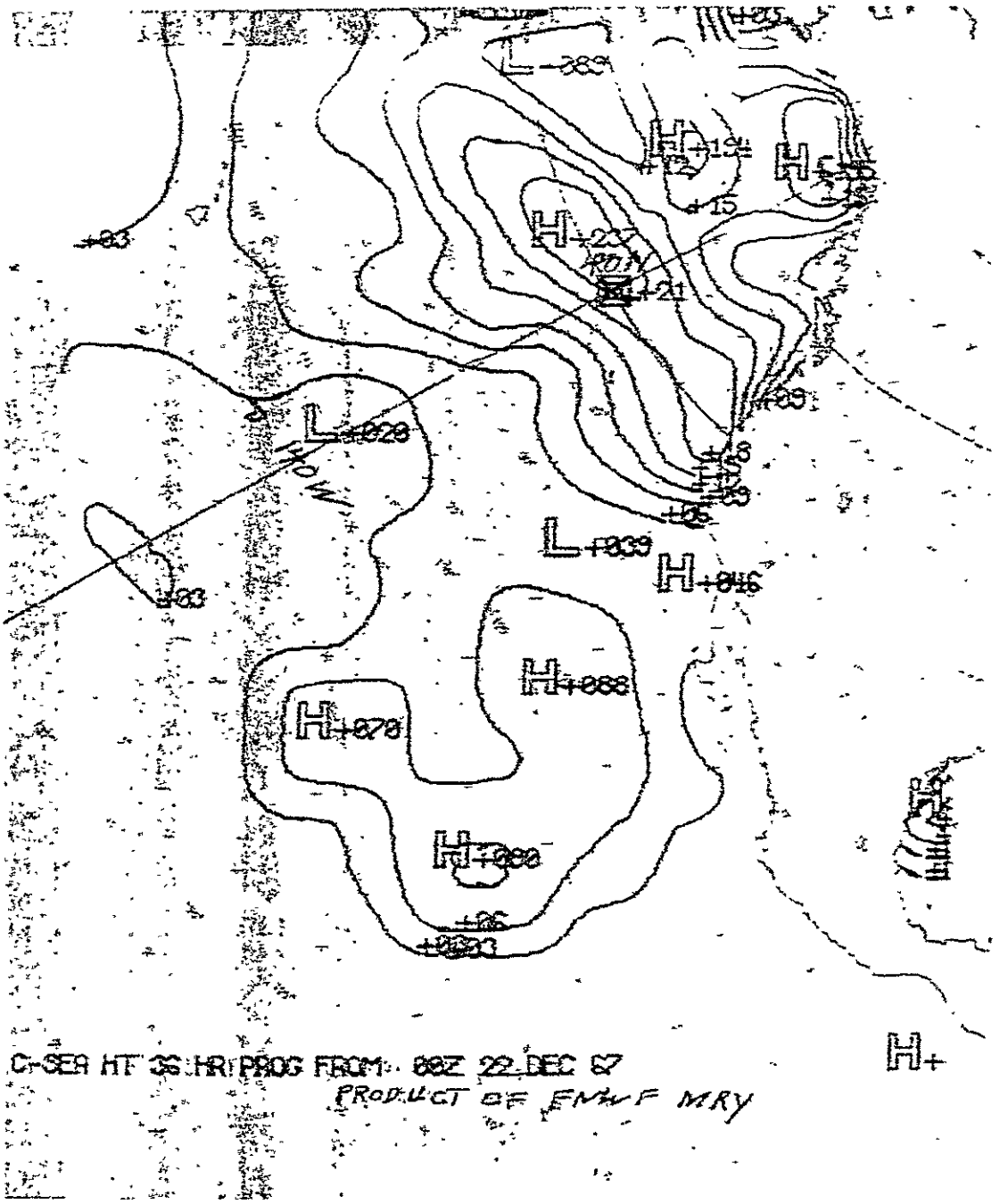


Figure 14-2. 36 Hour Sea Height Prog.
Received at Mojave on 22 December 1967.

December WEFAX data were received from 12 participating stations. The special WEFAX data collection period was from 11 through 15 December, and data for this period were received from 11 stations. Data evaluated for December consisted of 901 weather and test charts, and 2174 satellite pictures. Comments from participating stations about the December transmissions are quoted in Table 14-1.

Reception quality continued to be very good during December. Table 14-2 shows the quality of reception by the various participating stations. Seventy-five percent of the weather charts and 82% of the satellite pictures were classified as "excellent" or "good," and only 2% were classified as "unusable." The percentage of "excellent" or "good" receptions grouped in relation to the station's antenna elevation angle is shown in Figure 14-3.

The average number of grey scale steps discernible on the WEFAX test charts remained very good during December. Figure 14-4 shows the average grey scale steps for 11 participating stations. The percentage of occurrence of the seven major reception difficulties remained relatively low during December. Difficulties noted in 203 WEFAX test charts submitted from 12 stations during December are shown in Figure 14-5.

TABLE 14-1

Sample Comments from Participating APT Stations
(December 67)

Station Location	Comment
Toronto, Canada	The reception of pictures remains consistently better than that of charts, except for the IEEE Test Charts which are generally graded as "good".
Fuchu, Japan	The WEFAX ESSA 3 mosaic continues to be one of the finest products for the Asian Weather Central received via WEFAX. It is especially useful in preparing the HWD, and in analyzing the 1200Z surface chart.
Lake Jackson, Texas	December was the best month of the test at this station; there was no interference during any of the 17 regular transmissions monitored at 1600Z. Many of the 1835/1935Z transmissions did have severe fades, but only 7 were monitored. Charts were generally excellent, with 100% in the excellent or good class; 93% of the pictures printed were in this class. The ESSA mosaics are still excellent and the SSCC pictures are good to excellent.
Kunia, Hawaii	December was one of the best months for quality of reception. The ESSA 3/5 digitalized mosaics continue to be one of our most useful analysis and forecasting tools. The special spin scan pictures provided us on 19 December were given directly to the crew of the Presidential aircraft. We interpreted the clouds using latest aircraft reports and forecasts from the southern hemisphere. The cloud amounts with bases and tops were indicated directly on the Spin Scan pictures. The daily Spin Scan pictures from 20 through 24 December were used to prepare 12 hourly "no notice" forecasts of significant weather for return flights from Australia to Hickam AFB, Hawaii. ESSA 3/5 mosaics were also used for the significant weather forecast from Darwin, Australia to Thailand. These pictures, supplemented by conventional data and aircraft reports, allowed us to provide accurate and timely support for this mission. Our thanks to the ATS Coordinator and to Mojave ground station for their cooperation and assistance.
Papeete, Tahiti	Acquisition - excellent. Dissemination of the ESSA 3 photos in the form of montages of 8 photos (duplicated copies) has become operational. This documentation is considered valuable to the highest degree by the airline companies using them.

Comments from Stations (cont)

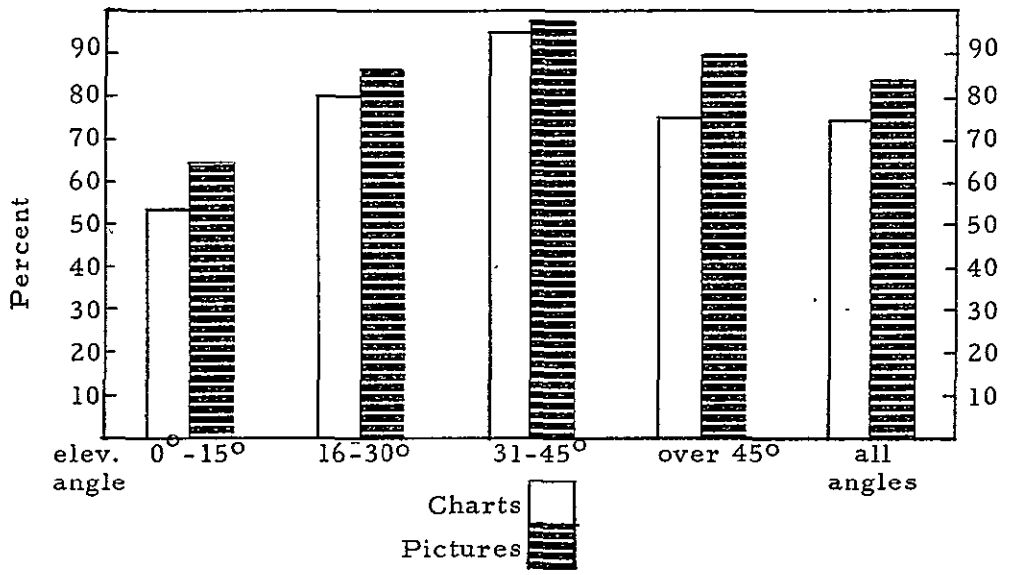
Christchurch, N. Z.	As a general evaluation, all data received at Christchurch is considered outstanding. As previously reported, limited angles, due to terrian, have prevented acquisition at McMurdo, Antarctica. Of particular value to operation (DEEP FREEZE) are the polar projection reproductions of ESSA 3 photographs ..... Delays in receipt of satellite pictures reduces the value of data for operational applications. ..... Receipt of the actual ESSA 3 photographs then permits reconstruction of analyzed charts and thereby contributes to the improved accuracy of analysis at both McMurdo and Christchurch. Additional utilization of all WEFAX is made by the New Zealand Meteorological Service, Christchurch with whom Operation DEEP FREEZE has a close working relationship. All APT and WEFAX data is made available to the Christchurch office and is transmitted by landline facsimile to Weather Wellington and Met Auckland. Picture quality permits the reliable transmission of all but NIMBUS 2 data.

TABLE 14-2

Classification of WEFAX Receptions of
Weather Charts and Spin Scan Pictures
(December)

APT	Weather Charts					Satellite Pictures				
Receiving Stations	Exc	Good	Fair	Poor	Unusable	Exc	Good	Fair	Poor	Unusable
GSFC, Maryland	18	49	10	2	0	106	96	45	13	1
Toronto, Canada	5	18	4	8	4	53	19	27	19	19
Fuchu, Japan	8	25	53	24	5	22	121	101	8	6
Tampa, Florida	1	8	6	0	0	28	21	8	4	0
Guam, Marianas	23	46	25	0	1	25	103	51	0	8
Aberdeen, S. Dakota	2	6	4	0	2	0	1	0	0	0
Anchorage, Alaska	75	32	16	2	1	225	18	1	1	1
Lake Jackson, Texas	17	8	0	0	0	28	26	3	1	0
Mojave, California	117	32	6	0	0	359	51	4	0	2
San Francisco, Calif.	2	7	3	0	0	29	4	1	1	0
Kunia, Hawaii	23	41	30	5	6	67	87	23	10	8
Papeete, Tahiti	48	60	12	1	0	194	115	10	0	0
TOTALS	339	332	169	42	19	1136	662	274	57	45
	(38%)	(37%)	(19%)	(4%)	(2%)	(52%)	(30%)	(13%)	(3%)	(2%)

Percentage of Excellent or Good Receptions of
WEFAX by Elevation Angle Increments
(901 charts and 2174 pictures evaluated)
(December)



WEFAX Participating Stations
(by antenna elevation angle)

Station	Antenna Elevation Angle	
GSFC, Maryland	4°	
Toronto, Canada	5°	0° to 15°
Fuchu, Japan	7°	
Tampa, Florida	11°	
Guam, Marianas	16°	
Aberdeen, S. Dakota	18°	
Anchorage, Alaska	21°	16° to 30°
Lake Jackson, Texas	22°	

Station	Antenna Elevation Angle	
Mojave, California	36°	
San Francisco, Calif.	37°	31° to 45°
Kunia, Hawaii	65°	
Papeete, Tahiti	68°	Over 45°

Figure 14-3. Percentage of Good or Excellent Receptions (December).

Average Grey Scale Steps of
Receiving Stations (December)

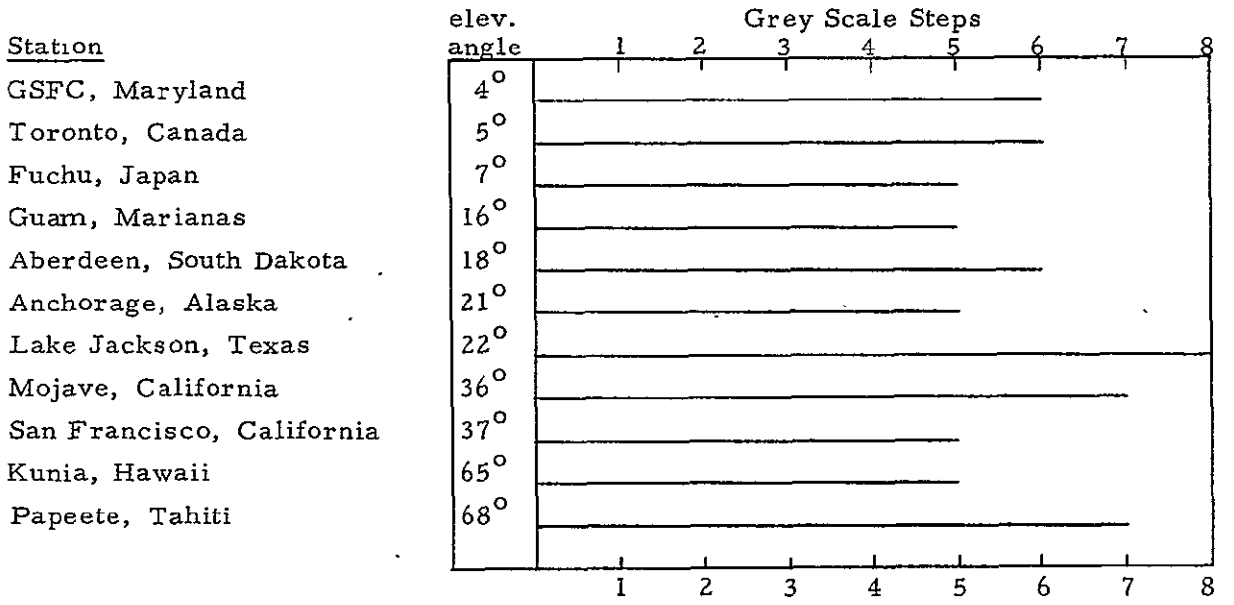
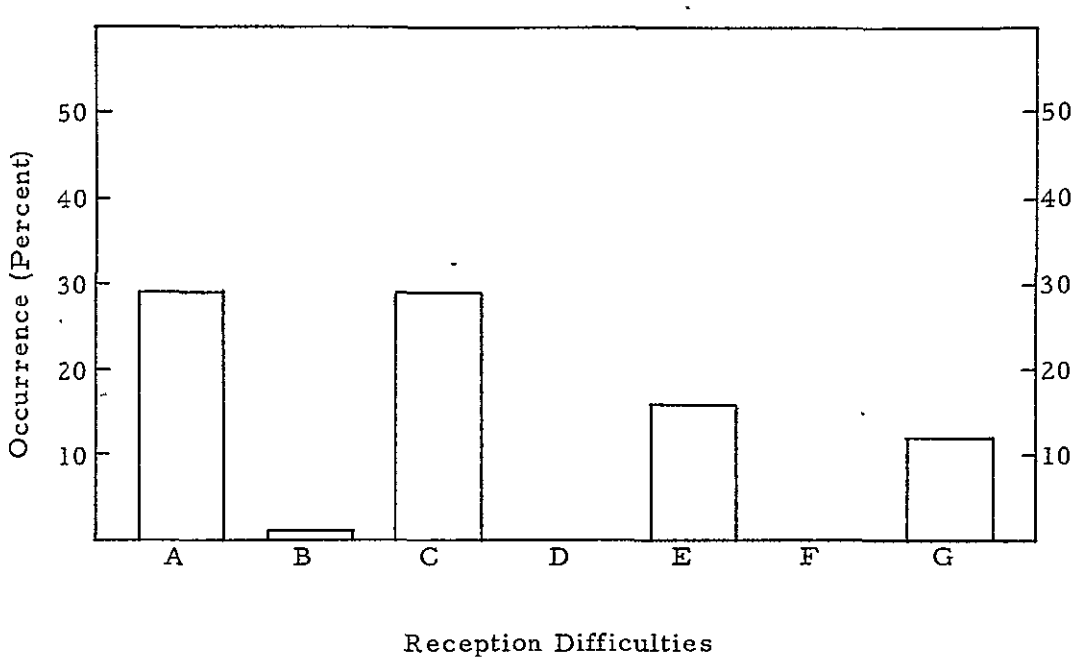


Figure 14-4. Received Grey Scale Steps (December).



A - Interference - Visible patterns appearing on chart format as a result of external signal sources or internally generated beat frequencies.
B - Bleeding - Smearing and presentation on white areas by black.
C - Signal plus noise-to-noise - White or black streaks on chart, uniformity of tonal shades, snow effect.
D - Distortion - Large scale geometric deviation from time pattern.
E - Skew - Deviation of a vertical line from a vertical normal. Test limit - 1/4" in 8".
F - Multi-Image - The multiple chart reproduction (ghosts) caused by multiple path transmission or reflection.
G - Jitter - Periodic irregularities on lines and patterns.

Figure 14-5. WEFAX Experiment facsimile reception difficulties occurring at 12 APT receiving stations during December 1967. 203 WEFAX Test Charts evaluated.

SECTION 15

PROBLEM AREAS

15.1 LANDLINE

The facsimile landline from Suitland, through GSFC, to Mojave was a leased line. In most instances, checks made on this line indicated a high noise level. During December 1966, the line capability was released to the telephone company for maintenance on numerous occasions. No definite repair resulted, although by the end of December 1966, sufficient improvement was noted to allow its continued use, with only a slightly adverse effect anticipated on the data.

Landline noise problems were not encountered during January, and the transmissions from Suitland were satisfactorily accomplished. Again during February and March, the high noise level of the line was frequently detrimental to transmissions from Suitland. The landline capability was occasionally released to the telephone company; however, good and even excellent receptions were consistently noted at many stations during times of the higher noise level.

Measurements of the noise level on the facsimile line were conducted at Mojave during June and July. The line was terminated with a matched level sensor. The level sensor was calibrated to deliver a pulse for each noise pulse that exceeded -40dbm. The number of pulses were counted as a function of time. A pulse counting technique was used because the video type data transmitted are most susceptible to noise pulse type interference. Measurements were made daily for the periods 0500 to 0600Z, 1400 to 1500Z, and 2100 to 2200Z. Measurements for June and July are presented in Tables 15-1 and 15-2. The results of the June and July data indicate that the facsimile line had extremely low noise characteristics.

15.2 INTERFERENCE

Local interference affecting WEFAX reception remained prevalent at the receiving APT ground stations. Most stations were able to operate effectively, even with the sporadic interference. "Spin modulation" type of noise interference which began in March (see Section 5) was investigated. It was not discernible on all WEFAX transmissions, nor was it reported by various stations at the same time. The interference was apparently emitted from the spacecraft, and appeared on the WEFAX receptions whenever the received signal strength was low. The "spin modulation" interference decreased slightly during May and became infrequent

TABLE 15-1

Facsimile Line Noise Measurements
(June)

	Number of Noise Pulses above –40dbm			
June	0500-0600Z	1400-1500Z	2100-2200Z	Total
1	13	17	2	32
2	14	15	10	39
3	11	16	9	36
4	12	40	13	65
5	8	15	6	29
6	13	12	10	35
7	14	24	40	78
8	11	19	22	52
9	30	23	10	63
10	18	36	20	74
11	10	22	30	62
12	41	54	26	121
13	16	48	22	86
14	25	62	43	130
15	14	16	10	40
16	20	32	19	71
17	10	27	19	56
18	8	32	24	64
19	15	44	36	95
20	0	12	25	37
21	31	92	84	207
22	65	78	83	226
23	62	21	14	97
24	*	32	91	123*
25	*	*	72	72*
26	*	*	243	243*
27	*	130	6	136*
28	34	146	40	220
29	21	96	111	228
30	32	208	149	389
Totals	548	1369	1289	3206

* Data missing due to line in use or equipment inoperative.

TABLE 15-2

Facsimile Line Noise Measurements
(July)

	Number of Noise Pulses above -40dbm			
July	0500-0600Z	1400-1500Z	2100-2200Z	Total
1	34	61	346	441
2	107	245	84	436
3	89	10	86	185
4	86	*	68	154*
5	86	68	48	202
6	101	36	24	161
7	131	107	84	322
8	24	60	64	148
9	22	3	1	26
10	10	143	44	197
11	10	37	64	111
12	45	45	30	120
13	267	140	186	593
14	56	140	648	844
15	56	10	8	74
16	*	25	13	38*
17	140	38	131	309
18	182	2	211	395
19	366	15	158	539
20	8	325	25	358
21	15	19	11	45
22	158	41	15	214
23	41	*	77	118*
24	77	161	35	273
25	82	261	45	388
26	294	1151	*	1445*
27	21	108	76	205
28	218	91	21	330
29	45	32	101	178
30	88	241	92	421
31	79	134	21	234
Totals	2938	3749	2817	9504

* Data missing due to line in use or equipment inoperative.

after mid-June. Results of the special tests conducted on the "spin modulation" interference problem have been inconclusive.

An investigation was conducted of the possible effects of solar phenomena upon WEFAX reception. Results indicate that a correlation exists between solar phenomena and interference reported by the participating stations. Results of the investigation are reported in Appendix A.

15.3 SKEWING

During the test transmissions which were completed in the engineering phase, certain receiving ground stations reported that a constant skew existed in all charts and pictures received. The skew was caused by a free running oscillator in the facsimile scanners used at both ESSA and Mojave. This free running oscillator permitted a constant drift in the cycle count. Since only a few of the participating stations use equipment that is unable to cope with this drift, it did not appear necessary to attempt a modification.

15.4 PICTURES

The rebroadcast of spin scan cloud camera pictures was one of the most difficult problems encountered in the WEFAX transmission procedures. Attempts to determine the best possible configuration for transmitting these pictures were made on a theoretical basis, prior to launch, and again during December, prior to the start of the regular WEFAX transmission schedule. During early efforts, it was noted that much of the detail in the original picture was lost during transmission over the WEFAX channel. This fact, plus other minor difficulties encountered in the photographic processes, caused the experimenters to discontinue the transmission of such pictures through the ATS-1 spacecraft on 27 December 1966. Efforts to improve the quality of picture transmissions continued at the Mojave ground station site. Allied Research and Fotorite personnel conducted many tests utilizing several types of photographic paper, various exposure times in preparing the enlargements, and by scanning several sizes. An improvement was noted as the tests progressed, but results were still below the standards of quality which were considered necessary if excellent pictures were to be satisfactorily transmitted. It was believed that the method of picture transmission must be changed before better, more detailed reproductions could be realized. Investigations leading toward a better transmission technique continued along two lines: first, a method of scanning the EIS negative directly and, secondly, placing the video information, as received from the camera,

in a digitized form which could then be returned to a transmittable signal and sent over the WEFAX frequency. Both methods would result in a greater dynamic range for picture transmissions. However, on 8 January 1967, it was decided to again transmit the spin scan cloud photographs over the WEFAX frequency using the same procedure of scanning an enlargement made from the EIS negative. Noticeable improvement in the retention of detail can be seen in Figures 3-2 and 3-3, as compared to the earlier receptions shown in Figure 2-2. While this improvement was quite substantial, the resulting receptions were still below the desired standards. ESSA 3 picture reception was not affected since the scanning technique was not employed in their transmission. A system similar to that used for ESSA 3 picture transmissions was tested through the spacecraft (see February, March and April Evaluations) and results appeared very promising. In these tests, taped video signals from reconstituted digitized data were used for the spin scan picture transmissions. Throughout March, the ATS-1 spin scan cloud camera pictures acquired at Mojave ATS ground station were distorted. Distortion was caused by a false sync pulse generated during the satellite eclipse period. Attempts to reduce or eliminate the distortion were made by modifying the ground station receiving equipment. Distortion was not eliminated and continued until the end of the satellite eclipse period.

Transmission of digitized ESSA 3 pictures became the prime type of WEFAX picture transmission in May. ESSA 5 pictures replaced ESSA 3 pictures beginning on 1 June. Transmission of SSCC pictures was limited to one small full disc per transmission period in June and July. ESSA 5 digitized picture transmissions were changed to mosaic format during the latter part of July. The area covered by the mosaic is from 40°N to 32°S and from 85°E to 110°W, and is transmitted in 8 APT frames (see Figure 11-6).

During August there were special test transmissions of digitized SSCC pictures. Digitized SSCC tapes, which had been recorded at the Mojave ATS ground station, were computer processed at NESC/ESSA. Figures 10-5 thru 10-8 are reception samples of these test transmissions. Although the results of the tests were very encouraging, additional refinements are needed to improve the grey scale range and the gridding. Figures 15-1 and 15-2 show the comparison between the digitized test transmissions and the standard facsimile scanner transmissions. Figure 15-1 is a copy of the original SSCC picture plus copies of the reception of some of the digitized test transmissions. Figure 15-2 displays copies of the original SSCC picture, the picture transmitted over WEFAX from the Mojave facsimile

From Archival Negative

Received Lake Jackson 17 Aug 67

Received Toronto 15 Aug 67

Received Lake Jackson 22 Aug 67

Figure 15-1 Comparative SSCC Picture of 2152Z 26 June 1967.

From Archival Negative

Received Mojave 27 June 67

Transmitted By Mojave 27 June 67

Received Lake Jackson 27 June 67

Figure 15-2 Comparative SSCC Picture of 2216Z 26 June 1967.

flatbed scanner, and the reception of the picture at Mojave and Lake Jackson. The 2152Z picture of 26 June 1967 was used in the digitized tests depicted in Figure 15-1. The succeeding SSCC picture (2216Z) was used for the regular WEFAX transmission shown in Figure 15-2. A comparison of the two figures reveal that there is significantly more cloud and land detail in the digitized pictures.

15.5 GRIDDING

Grid accuracy of the spin scan pictures did not present any great problem in the early stages of the WEFAX experiment. Grid overlays, containing certain prominent land masses were used. For gridding application these land masses (Baja California, Hawaiian Islands, New Zealand, etc.) were located on the photographic enlargement and fitted to the prepared grids. The accuracy of the grids near the outer extremities of the picture was known to be poor, because of picture distortion. Accuracy of the central portion of the grids was considered satisfactory. During February, it was noted and reported to the participating ground stations that grid accuracy, in some cases, had deteriorated, even towards the central portions of the picture. In cases where the prepared grids were noticeably in error, only partial grids were placed on the cloud pictures. In an investigation of grid misalignments, it was noted that, during January, when the satellite was east of the nominal 151° West Longitude for which the grid overlays were drawn, Baja California appeared to the west of the gridded location when horizons were mated. It was necessary to generate a grid larger than the actual earth image in order to make Hawaii and Baja fit. During the latter part of February, as the satellite drifted westward through the nominal subpoint, grid fitting improved. It appeared that most discrepancies could be eliminated by using grids generated for the actual picture subpoint, rather than for the nominal 151° West Longitude. New grids were prepared in April for subpoints at one degree intervals along the equator, and the gridding accuracy improved. The north-south excursions of the satellite subpoint were too small to justify generating grids for other latitudes.

15.6 SCHEDULING

The scheduling of the WEFAX transmission times became a problem during February. Frequent changes in the ATS-1 weekly scheduled transmission times began occurring during the latter part of the month. During the period of 18-28 February, thirteen changes were made which altered the WEFAX scheduled transmission times. The greater portion of these changes were caused by the introduction

into the announced schedule of higher priority experiments; such as the Aircraft VHF Communications and the Spin Scan Cloud Camera Experiments. Whenever possible, advance notice of these scheduled changes were transmitted via WEFAX and TBUS messages. In many cases, the changes occurred too late for the WEFAX participating stations to receive any notification. It was in such instances that much reception data were lost to the experiment, and the manpower drain on the already limited resources of many stations became extreme. During March, schedule changes continued to be a problem. There were 42 changes in WEFAX transmission times during the month. Some of the changes were due to the satellite's power limitations during and preceeding the satellite eclipse time. Other changes were caused by the need for periods of continuous SSCC pictures during the Line Island Experiment. During the first ten days of April there were 15 schedule changes; however, only 5 changes were made during the remainder of the month. It was necessary to make 20 schedule changes during May, but only 5 during June. Beginning in July, fewer changes were necessary in the published weekly schedules.

15.7 SIGNAL STRENGTH

The strength of the received WEFAX signal was variable at many of the participating stations. The minimum-maximum range of received signal strength at the Mojave APT station antenna during June and July is presented in Figures 15-3 and 15-4. Also shown in the figures are the transmitted power in kilowatts for the Mojave VHF transmitter and the sum of the spacecraft's 8 antenna element output power in watts. All of these readings were made during the main WEFAX transmissions.

Regardless of the variance of the transmitter power, the spacecraft output power was relatively insensitive to the input signal level. On June 3, the transmitted power was 1.4 kilowatts and the spacecraft output power was 20.8 watts; on June 27, however, the transmitted power was increased to 2.3 kilowatts and the spacecraft output power remained at 20.8 watts.

The average signal strength received at the Mojave APT antenna during the month of June was -146 dbw. This compared favorably with the computed theoretical value of -149 dbw, as shown on page 40 of the WEFAX Participants Guide. The range of variation during any one transmission period was from 1 to 9 db, with an average of 3.8 db. Since the transmitted power from the spacecraft is a constant and the parameters of the receiving station were held constant, the variation in received signal level can only be a result of the atmospheric conditions. Except for one day, the worst minimum signal level received at the antenna during the month of June

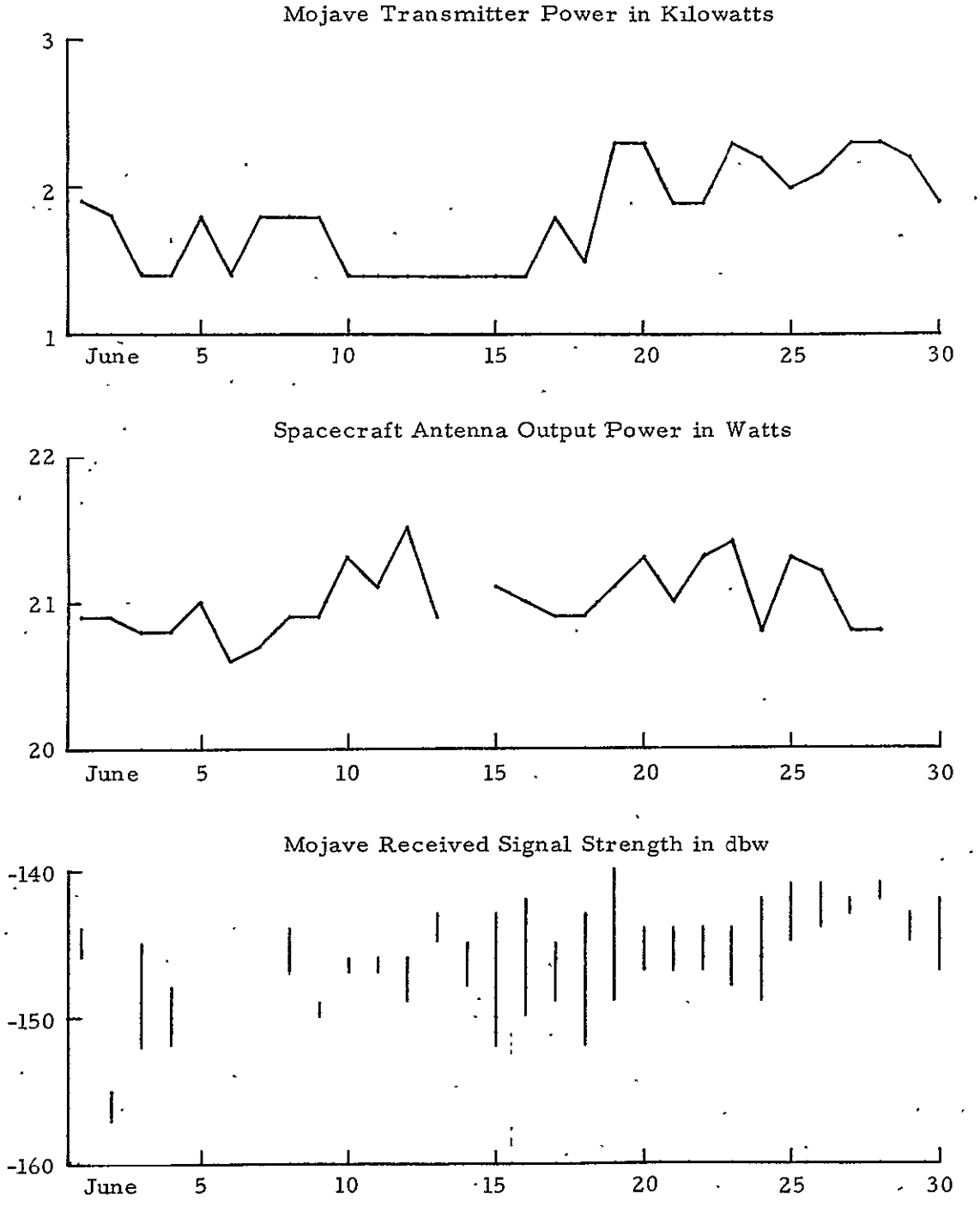


Figure 15-3 Power and Signal Strength Measurements (June)

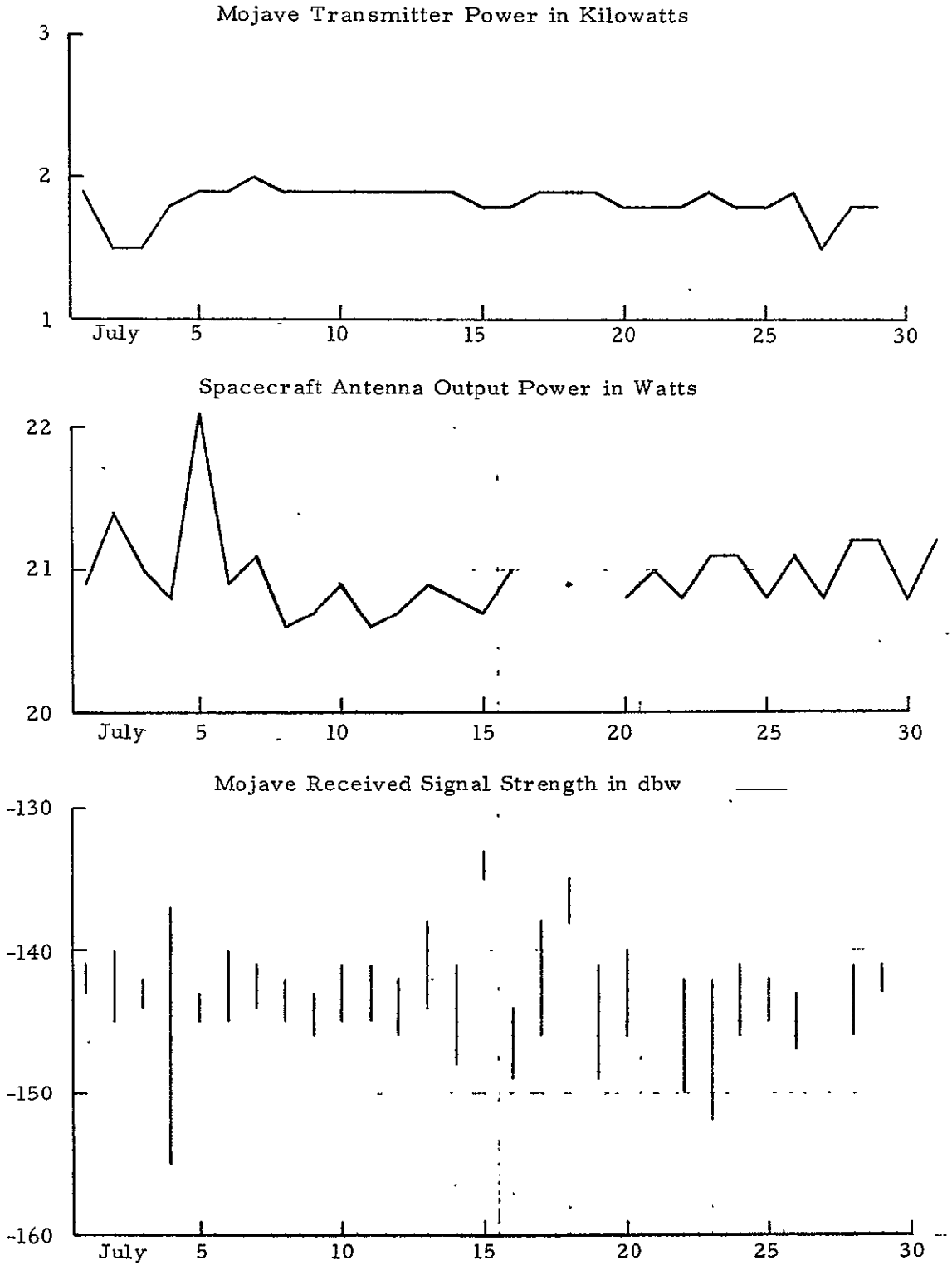


Figure 15-4 Power and Signal Strength Measurements (July)

was -152 dbw. This would result with a receiver having a 50 kHz bandwidth, and a noise figure of 4.5 db, in a carrier signal to noise level of 11 db. This is sufficient to receive good to excellent WEFAX charts and fair to good cloud cover pictures.

SECTION 16

EVALUATION SUMMARY

The WEFAX Evaluation Report furnishes statistical results attained by the WEFAX evaluators from data collected by the participating stations from January through December 1967. Also included are the preliminary results obtained during the period from satellite launch (6 December 1966) to the start of the regular WEFAX Experiment on 2 January 1967. This section summarizes the results for each month and also presents the cumulative results.

During December 1966, engineering checks were made of equipment, communication lines were placed in working order, and all operating procedures were activated and tested in both normal and emergency modes. Test transmissions of weather charts and spin scan camera pictures were made utilizing receiving stations at Mojave and GSFC to obtain the preliminary data required prior to the start of the overall experiment. A test of WEFAX transmissions (weather charts) originating at Suitland, Maryland was made commencing on 14 December 1966. Improvements were made in cloud picture transmissions, and work progressed satisfactorily toward obtaining digitized data, from the spacecraft signal, for retransmission.

During January, 27 different APT ground stations received and classified a total of 3810 weather charts and 1176 spin scan cloud camera pictures. A total of 317 WEFAX test chart receptions were evaluated and the results were very encouraging. Tabulations of WEFAX weather chart receptions showed that 65% of all charts received by the participants were of an "excellent" or "good" classification, and only 5% were categorized as "unusable". Reception of spin scan cloud camera pictures showed 69% of those received were considered either "excellent" or "good", and only 6% were classified "unusable". These first tabulations were gathered by participating stations, 70% of which had elevation acquisition angles less than 30°. Another encouraging indication was that these reception statistics were compiled from stations which reported local interference during at least 50% of the reception times, and "signal plus noise-to-noise" problems during at least 20% of the receptions. Favorable comments from the users indicated that the WEFAX Experiment progressed very satisfactorily during the first month of regular operation.

Reception of excellent and usable charts and pictures by the participating stations continued in February. Only 1837 charts were classified during the month, but the number of pictures processed was more than doubled from the previous month with 2407 received and classified. Tests were made transmitting cloud pictures through the spacecraft using a taped video signal derived from digitized data. Even in these early tests, this system gave every indication that it was vastly superior to the conventional facsimile scanner method. Further tests were planned during subsequent months. Support of the Line Island Experiment started 20 February 1967, and continued through March. The support furnished, though complicated by several problems, was considered satisfactory. On 16 February, ESSA 3 satellite cloud pictures were added to the WEFAX transmission program and the response indicated that such transmissions should continue.

During March, even though "spin modulation" noise interference started affecting the WEFAX receptions, good, usable weather charts and satellite pictures were received by the participating stations. Twenty-two participating stations submitted 1329 test and weather charts and 2087 satellite pictures for evaluation. Evaluation results showed that over 70% of the charts and pictures were classified as "excellent" or "good", and that less than 5% were classified as "unusable". Additional test transmissions of digital processed ATS-1 spin scan cloud camera pictures proved that this method was far superior to the photographic processed facsimile scanned pictures. Steps were taken to further refine the digital processing procedures. Many favorable comments on this transmission of the digitized ESSA 3 AVCS pictures of the Pacific area were received. Time restrictions on the WEFAX transmission limited the number of areas that could be covered by the ESSA 3 pictures.

Twenty-two participating stations submitted 3037 charts and pictures that were received in April. Of the 1345 test and weather charts, 72% were classified in the "excellent" or "good" categories. Also in the "excellent" or "good" categories were 73% of the 1692 satellite pictures. Less than 5% of the charts and pictures were classified as "unusable". The reception results continued to be impressive during April, even though the spin modulation noise interference increased.

The WEFAX transmission results in May were very similar to the previous months. A total of 4516 charts and pictures were submitted by 21 participating stations. There was a decrease in the spin modulation noise interference, and an increase in the signal to noise. Reception results continued to be very good, with less than 5% of the charts and pictures being classified as "unusable". Of the 1362

test and weather charts, 71% were classified as either "excellent" or "good". Also in the "excellent" or "good" categories were 70% of the 3154 satellite pictures.

June data were submitted by 21 participating stations, and included 3424 charts and pictures. Of the 2171 test and weather charts, 71% were classified in the "excellent" or "good" categories. Classified in the "excellent" or "good" categories were 66% of the 1253 satellite pictures. This was the first time that charts or pictures fell below 70% since January. Signal-to-noise continued to be a problem, especially to stations with a low antenna elevation angle. Interference was again a problem during June, but the spin modulation type of noise interference decreased appreciably.

There was little change in the quality of reception of WEFAX data transmitted in July. A total of 3887 charts and pictures were evaluated from 18 participating stations. There was a significant improvement in the quality of reception of satellite pictures. Of the 2181 pictures evaluated, 75% were classified in the "excellent" or "good" categories. The quality of reception of weather charts decreased slightly. Only 67% of the 1706 charts evaluated were classified in the "excellent" or "good" categories. There was a general improvement in the July reception difficulties, as four of the difficulties decreased appreciably and two increased slightly. Interference, which had been a major reception difficulty, decreased to the lowest percentage (25%) of occurrence since the beginning of the WEFAX experiment.

WEFAX data for August were submitted by 20 participating stations. A total of 2616 weather and test charts, and 2673 satellite pictures were evaluated. The quality of reception of the satellite pictures continued to be very good, as 76% of the received pictures were classified as "excellent" or "good". However, the quality of reception of the weather charts decreased, with only 58% of the charts classified as "excellent" or "good". This decrease was due mainly to the reduction in size of the received charts to about 35% of the size of the standard charts. There were only minor variations in the reception difficulties, although the occurrence of signal-to-noise improved to only 23% in August.

Twenty-one participating stations submitted September data for evaluation. Satellite picture reception during September was outstanding, with 83% of the 3052 pictures classified as "excellent" or "good". Reception quality of weather charts continued to be relatively poor due to the use of reduced size charts until the latter part of September. Of the 2249 weather and test charts evaluated, only 60% were classified "excellent" or "good", and 14% were rated as "unusable". Reception difficulties showed only minor variations from the previous month.

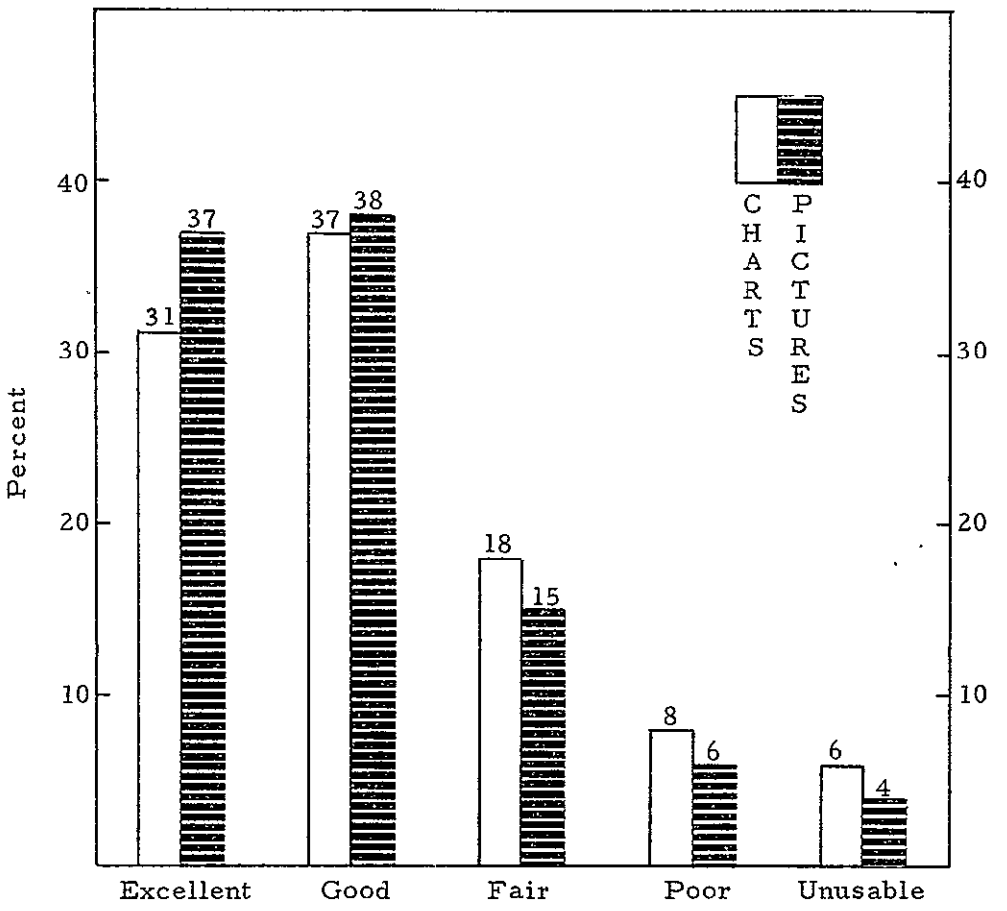
During October, the reception quality of weather charts improved; 72% of the 906 weather and test charts classified as "excellent" or "good". Charts classified in the unusable category decreased from 14% in September to 4% in October. Of the 3401 satellite picture receptions evaluated, 77% were classified as "excellent" or "good". There was a substantial increase of interference and noise noted during the WEFAX receptions; especially during the half power transmissions.

The reception quality of WEFAX data during November showed a substantial improvement. Satellite picture reception was outstanding, as 88% of the 1810 pictures evaluated were classified as "excellent" or "good". Eighty-two percent of the 493 weather and test charts were also classified as "excellent" or "good". Only 1% of the satellite pictures and 3% of the weather charts were classified as "unusable". All seven of the major reception difficulties showed a decrease in percentage of occurrence in November.

During December, the reception quality of WEFAX data remained relatively high. Twelve participating stations submitted 901 weather and test charts and 2174 satellite pictures for evaluation. Seventy-five percent of the charts and 82% of the pictures were classified as "excellent" or "good". Only 2% of the charts and pictures were rated as "unusable".

Some of the monthly statistics do not include all data received for that month. In many instances, data were received too late to be included in the monthly report. Final results reported below include all data received.

During the WEFAX experiment, nearly 50,000 charts and pictures were evaluated by the participating stations and the WEFAX evaluators. Figure 16-1 shows the classification of weather charts and satellite pictures for January through December 1967. Satellite picture receptions were rated slightly higher than the weather chart receptions. Eighty-six percent of the charts were classified as "excellent" to "fair" and 14% as "poor" to "unusable". For satellite pictures, 90% were classified as "excellent" to "fair" and only 10% as "poor" to "unusable". Figure 16-2 shows the monthly trend of charts and pictures classified as "excellent" or "good". The drop in the chart classifications during July through September was caused by transmitting reduced size charts. Satellite picture classifications of "excellent" or "good" were 75% or higher beginning in July when the ESSA 5/3 mosaics were added to the WEFAX program.



Classification Guidelines

	Legible Information Available	Quality
Excellent	100% of data	Less than 10% imperfections
Good	At least 90% of data	Less than 30% imperfections
Fair	At least 70% of data	Less than 40% imperfections
Poor	At least 50% of data	Less than 50% imperfections
Unusable	Less than 40% of data	More than 75% imperfections

Figure 16-1. Classification of WEFAX Receptions.
Weather chart and satellite picture classifications for January through December 1967. 22,458 charts and 27,334 pictures evaluated.

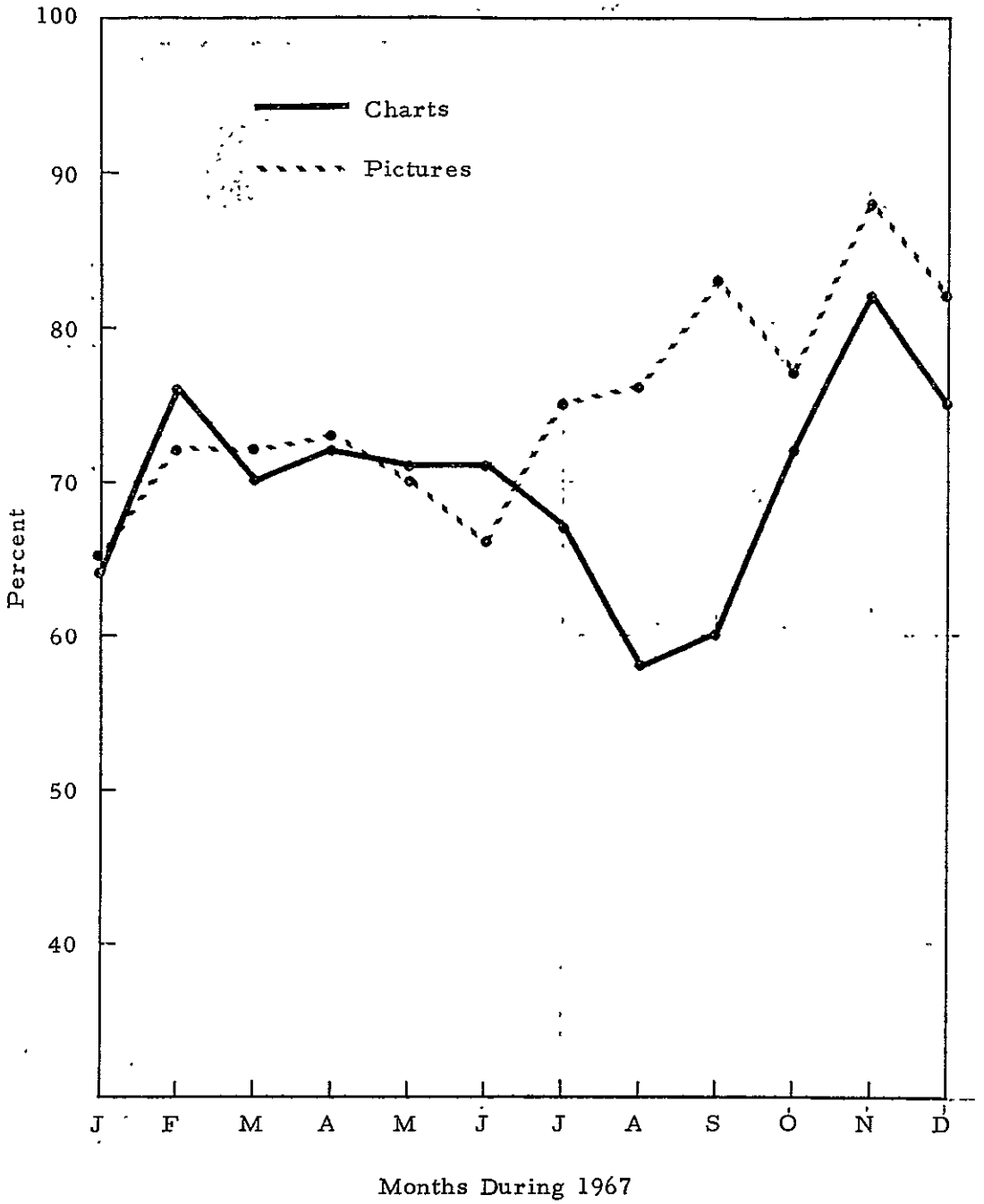


Figure 16-2. Percentage of excellent or good receptions by months.

The average number of grey scale steps discernible on the WEFAX test charts are depicted in Figure 16-3. Although the number of grey scale steps which are discernible is dependent upon the type of receiving equipment and the recording paper used, it is still a measurement of the capability of the WEFAX system. The average for all stations was 5.8 grey steps; however, two stations, Lake Jackson, Texas and Papeete, Tahiti, averaged 7.2 grey steps.

The major difficulties noted in WEFAX receptions are presented in Figure 16-4 as percentages of occurrence. Interference, which was the major reception difficulty, occurred 34% of the time. Noise was next at 30%, followed by jitter at 26%. The relatively high occurrence of jitter can be attributed to the use of tape recorders in recording the transmissions. The other reception difficulties were rather minor and did not materially affect the WEFAX receptions.

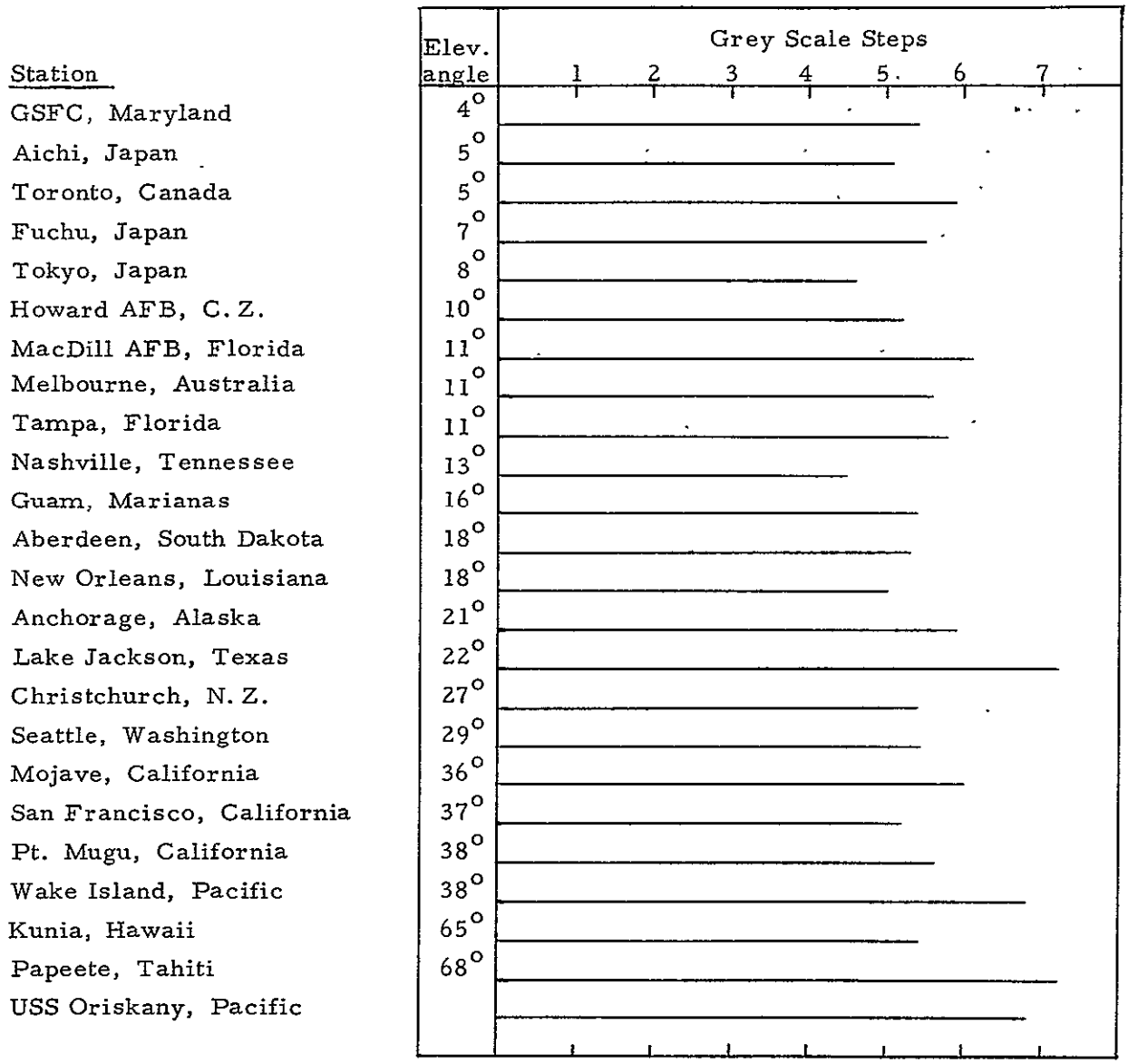
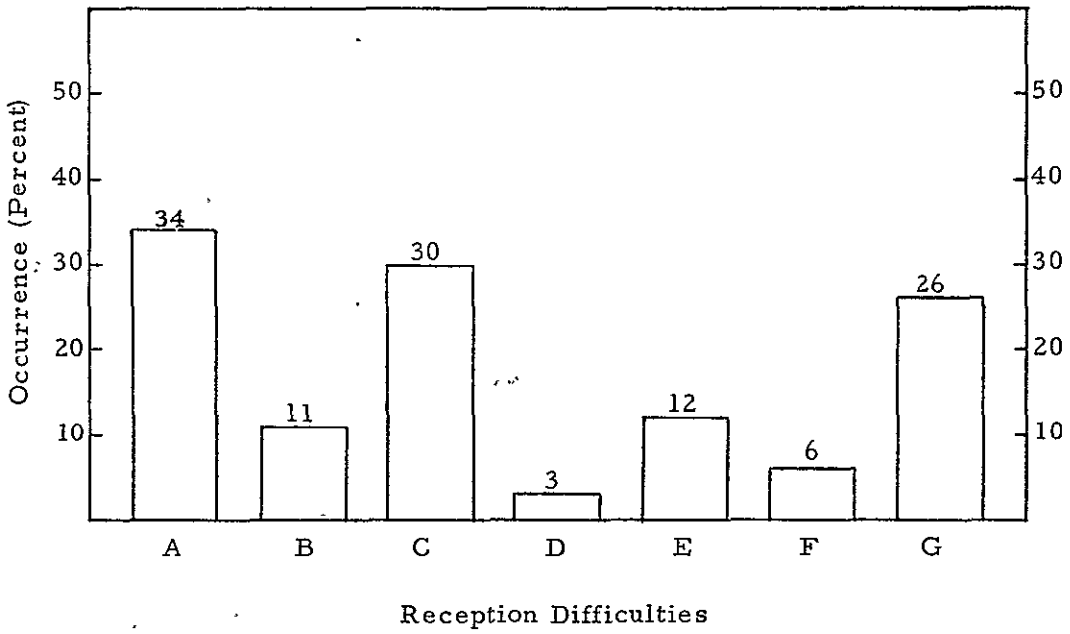


Figure 16-3. Average grey scale steps received.
The average grey scale steps discernible on the WEFAX test chart for the period of January through December 1967. A total of 2,745 WEFAX test charts were evaluated.



A - Interference - Visible patterns appearing on chart format as a result of external signal sources or internally generated beat frequencies.
B - Bleeding - Smearing and presentation on white areas by black.
C - Signal plus noise-to-noise - White or black streaks on chart, uniformity of tonal shades, snow effect.
D - Distortion - Large scale geometric deviation from time pattern.
E - Skew - Deviation of a vertical line from a vertical normal. Test limit - 1/4" in 8".
F - Multi-Image - The multiple chart reproduction (ghosts) caused by multiple path transmission or reflection.
G - Jitter - Periodic irregularities on lines and patterns.

Figure 16-4. Percentage of Occurrence of Reception Difficulties during WEFAX receptions January through December 1967.

SECTION 17

CONCLUSIONS AND RECOMMENDATIONS

17.1 CONCLUSIONS

The WEFAX Experiment has demonstrated that it is feasible to disseminate meteorological data from a central source through an earth synchronous satellite to widely scattered receiving units. Usable reception can be assured 95% of the time. Equipment presently in use for transmitting, relaying, and receiving WEFAX data is sufficiently capable and reliable. These conclusions are based upon the evaluation of the reception of nearly 50,000 WEFAX charts and pictures.

WEFAX has provided useful and needed meteorological data, which was previously not available, to many weather stations. Worldwide cloud cover pictures from ESSA meteorological satellites, available only at NESC, Suitland, Maryland, can be processed and transmitted over WEFAX. WEFAX has proven to be a system which could be used for a worldwide meteorological data link utilizing earth synchronous satellites.

17.2 RECOMMENDATIONS

Weather Charts

Weather charts, manual or computer produced, can be successfully transmitted through the use of a flatbed facsimile scanner. Optimum chart reception is attained with a chart scale of approximately 1 to 30 million and scanned in the 11 inch lens mode.

Recommendation: Weather chart transmissions should be from charts of an approximate scale of 1 to 30 million and scanned by a flatbed facsimile scanner in the 11 inch lens mode.

Satellite Pictures

Meteorological satellite cloud cover pictures, especially in mosaic format, provide more operational usability to weather stations than do weather charts. Satellite pictures can be successfully transmitted utilizing a flatbed facsimile scanner. However, optimum results are attained utilizing computer processed digital data transmitted as mosaics in APT format.

Recommendation: Satellite cloud cover picture transmissions should be made from computer processed digital data.

APPENDIX A

SOLAR EFFECTS ON WEFAX RECEPTION

A.1 INTRODUCTION

As indicated in Section 15 of the WEFAX Experiment Evaluation Report, an investigation has been performed to correlate reception interference as reported by the participating WEFAX stations with the occurrence of certain solar phenomena. This appendix presents the results of these studies. An eight month period is covered beginning with the initiation of operational WEFAX transmissions on 2 January 1967, and continuing through August of the same year.

A.2 BACKGROUND INFORMATION

While much is known concerning the effects of solar interference on ground-to-ground communications, virtually no work has yet been done in the area of trans-ionospheric communications. A review of solar effects on ground-to-ground communications can, however, provide some clues as to which solar phenomena might adversly affect satellite transmissions.

It would be beyond the scope of this appendix to present the various current theories as to what the sun spots actually are, or to discuss how solar flares might be formed. Rather, we shall simply accept their existence, and confine our attention to the ways in which these and solar phenomena affect terrestrail communications.

The Ionosphere consists of a series of at least four concentric layers of ionized air extending from a height of about 80 km to 350 km. The ionization in these layers is due primarily to ultraviolet radiation from the sun, and increases from layer to layer with height. It is the ability of these ionized layers to reflect (actually refract) radio waves which makes long range (beyond line-of-sight) radio communications possible. As the electron density in the higher layers increases, radio waves of higher and higher frequency will be reflected. The "critical penetration frequency" is proportional to the square root of the electron density. The lowest (D) layer with an electron density of about 10^3 electrons/cm^3 will reflect radio waves with frequencies of 50 Kc/sec or less while the highest (F_2) layer with an electron density of about 10^6 electrons/cm^3 will ordinarily reflect frequencies of 10 MHz or less.

The electron densities in the layers of the Ionosphere are strongly dependent upon solar activity. During the 11 year sunspot cycle for example, the electron density may vary by as much as a factor of two in the F_2 - layer from sunspot minimum to sunspot maximum. Solar flares, in turn are more likely to occur with a greater number of sunspots. The immediate effect of a solar flare is to produce a flash of ultra-violet light whose intensity may be 5 to 10 times greater than that ordinarily received at the earth. The number of free electrons in the D-layer increases rapidly bringing about Sudden Ionospheric Disturbances, the most significant of which for our purposes is the short-wave radio fadeout. The fade-outs are caused by the increased absorption of the short-waves as they pass through the D-layer. The fadeout begins suddenly during the flash of the flare, and lasts for about 25 minutes, after which radio signals slowly recover their original strength. Most of the remaining varieties of Sudden Ionospheric Disturbances affects only the very low frequencies.

In addition to the immediate effects of solar flares, there are also delayed effects. Charged particles emitted by the sun during the flare, bombard the earth's magnetism causing Magnetic Storms, auroral displays, and, in general, increase the level of Geomagnetic Activity. (It should be noted that not every flare produces magnetic storms, nor does every magnetic storm have its origin in the sun.)

Solar Radio Emission may be of several varieties. There is the background radiation of the "quiet" sun, the enhanced radiation associated with large sunspots, short bursts lasting a few seconds, and outbursts of great intensity usually associated with solar flares. These outbursts last about 10 minutes, and are believed to be generated as the charged particles emitted during a flare traverse to corona. An average frequency for these flare-related outbursts is about 60 MHz and will reach the earth about 10 minutes after the "flash" is sighted. (The amount of delay between the "flash" and arrival of the solar radio waves decreases with increasing frequency, so that solar radio waves at about 135.6 MHz, the transmitting frequency of the WEFAX experiment, will arrive after a slightly less than 3 minute delay.)

A.3 SELECTION OF SOLAR PHENOMENA

On the basis of the effects of the various solar disturbances upon ground-to-ground communications as discussed in the previous section, a total of four solar or solar-related physical phenomena have been selected for correlation with the occurrence of interference in the WEFAX transmissions. These are: Sun Spot Number, Solar Flares, Solar Radio Emission, and Geomagnetic Activity. Two other phenomena,

Sudden Ionospherics Disturbances and Magnetic Storms were initially considered for separate analysis, but were found to be so intimately associated with Solar Flares and Geomagnetic Activity respectively that it would have been impossible to distinguish between them. As was seen in the previous section, the short-wave radio fadeouts begin within minutes of the sighting of a flare, while Magnetic Storms may be most easily noted through a sharp increase in the general level of Geomagnetic Activity.

Two of the remaining phenomena are short-term, lasting from about a minute to a very few hours. Thus, interference caused by Solar Flares and Solar Radio Emissions had to be sought through their effect on specific transmissions. Sun Spot Number and Geomagnetic Activity are more indices of the level of solar activity over prolonged periods, and thus lend themselves more readily to a statistical approach.

A.4 DATA SOURCES AND THEIR VALIDITY

A.4.1 Interference Data

Data on the occurrence of interference was compiled directly from the WEFAX Daily Evaluation Reports sent to Goddard by the participating stations. For dealing with the short-term solar phenomena, the results of individual transmissions were recorded separately on those days when multiple transmissions occurred. One problem, particularly in February and March when numerous multiple transmissions occurred, was that the time of interference was often not given, or words such as "sporadic" or "occasional" were used. Where feasible, it was generally assumed that the main WEFAX transmission of the day was meant, or that the time slot usually monitored by a particular station was intended. To facilitate a statistical approach to the correlation with more long-range solar phenomena, the data were converted to a form indicating the percentage of stations reporting interference on a given day. First, however, those stations reporting interference due to local sources on a given day were eliminated from the calculations. This was necessary because of the impossibility of determining whether any real non-local interference could have been observed over and above that caused by local troubles.

The reporting of interference is at least a partially subjective matter. This is evidenced by the fact that some stations almost never reported interference regardless of the difficulties being encountered by all others, while a few stations always noted interference. It was also found that dramatic changes in the amount of interference could occur with shift changes at a given station as different personnel manned the read-outs. In working with the data, considerable effort was made to at

least partially compensate for this class of discrepancy. This, of course, amounts to a subjective interpretation of already subjective reports, but was felt to be justified.

With the exception of the special data collection periods held each month, the number of stations, free of local interference, reporting on a single day was generally between five and ten. In such cases a change in one or two stations can drastically affect the interference percentages. In compilations for the long range solar phenomena, an interference percentage was weighted by the number of reports in its makeup, and all cases with fewer than five reports were dropped.

A.4.2 Solar Data

The solar data were obtained from the monthly publication "Solar Geophysical Data", issued by the Institute for Telecommunication Sciences and Aeronomy of the Environmental Sciences Services Administration (ESSA). The input for this publication is derived from many observatories, laboratories, and agencies throughout the world. With the exception of the months of January, February, and March, the Solar Flare data used in this study are based on the "preliminary" listings in Solar-Geophysical Data. The six month definitive up-dates of the Solar Flare data for the remaining months were not yet available at the time of publication of this report.

A.5 CORRELATION OF SOLAR PHENOMENA WITH OBSERVED INTERFERENCE

A.5.1 Sun Spot Number

A.5.1.1 Definition

The relative sunspot number, R, is expressed by:

$$R = k(10g + s)$$

where "g" is the number of disturbed regions (groups and isolated spots), "s" is the total number of spots grouped or not. The constant "k" has a value depending upon the instrument used at a particular observatory. At Zurich, where results from other observatories are collected and examined, and a final sunspot number is compiled daily, the value of "k" is 1.

A.5.1.2 Findings

As has been seen, the sun spot number is more or less an index of the general activity of the sun, and as such would not directly affect space-earth communications. Inasmuch as solar flares and radio emission are related to the sunspot number however, one would expect to see some increase in communication difficulties with increasing sunspot number.

Figure A-1 shows the occurrence of interference expressed in percentages and plotted against the relative sunspot number. As can be seen, the interference is relatively insensitive to sunspot number in the lower ranges, oscillating about an average of approximately 40%. For sunspot numbers above 160, when solar flares and radio emissions are much more likely to occur, the occurrence of interference does begin to increase, reaching an average of 60% for sunspot numbers of the order of 200.

A.5.2 Solar Flares and Sudden Ionospheric Disturbances

A.5.2.1 Definition

Solar Flare data as listed in "Solar-Geophysical Data" includes the start and stop times as observed by particular observatories as well as some indication of the flare's importance. A dual importance scheme is used, indicating both the flare's size and its brightness. Thus, a flare may be ranked from 0f (small, faint) to 4b (large, brilliant). The Sudden Ionospheric Disturbance listings generally include an indication of the specific known flare with which that particular disturbance is associated.

A.5.2.2 Findings

The immediate effects of solar flares are line-of-sight phenomena, and thus may be detected only during daylight hours. Unfortunately the main WEFAX transmissions generally occurred between 0900 and 1200 UT, or between 2300 and 0200 local time at the satellite. Thus, transmissions generally began as late as 1800 local time at the western-most stations, and ended as early as 0700 local time at the eastern-most stations, or occurred largely during the hours of darkness. While this drastically reduced the opportunities for noting direct solar interference, the combination of occasional multiple transmission days, as well as the delayed effects of solar flares made it possible to isolate certain specific transmissions where solar interference was definitely a factor.

A total of 5 cases were found where it was felt that interference problems could be traced directly to solar flare activity. Table A-1 summarizes these cases giving the date, time, and importance of the flare as well as the percentage of stations reporting interference. These cases will be discussed individually below.

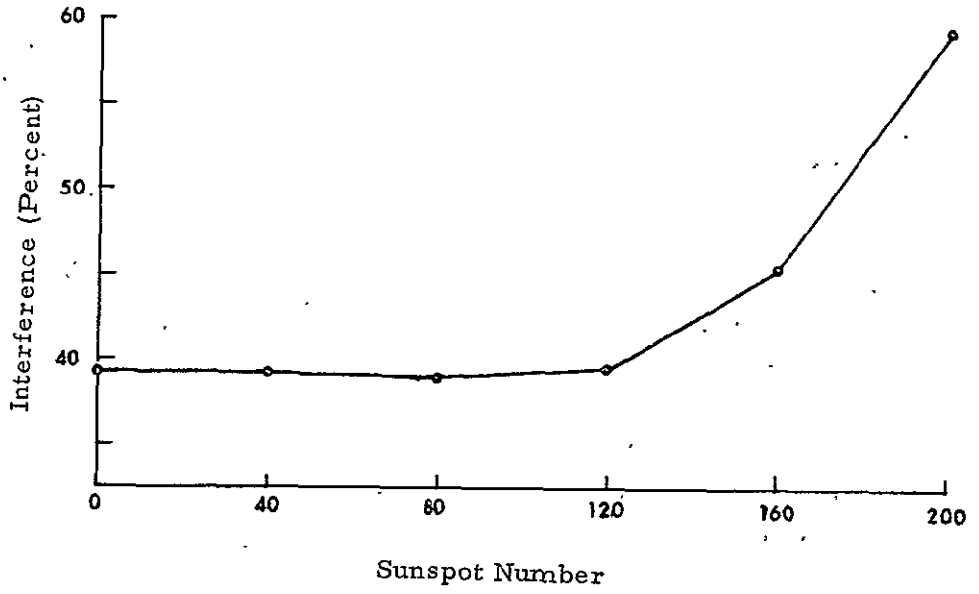


Figure A-1. Interference vs. Sunspot Number.

13 February On this date several observatories reported a flare of importance 1 N (normal brightness) beginning at 2213 just before (4 minutes) the beginning of the WEFAX transmission, and lasting until 2250. Only three stations reported monitoring this transmission, Guam, Christchurch (New Zealand), and Lake Jackson (Texas). Guam, which was in twilight, reported no interference while Christchurch and Lake Jackson both noted static and atmospherics. Lake Jackson in particular noted a termination in interference at 2250.

23 February On this date a large bright flare of importance 3B began at 0831 and ended at 0848. A WEFAX transmission began at 0830 and ended at 0930. All stations which were still within daylight at the times of the flare reported reception difficulties during the early part of the transmission.

1 April On this date, a solar flare of importance 1 B was in progress at the beginning of the WEFAX transmission at 0202, and lasted until 0213. Of the only five stations reporting, those two which reported no interference were both in darkness at the time.

26 May During the latter part of May of 1967, there was considerable solar activity with numerous flares occurring during the day, so that while a flare of importance 1 B did occur during the 0900-1000 WEFAX transmission on the 26th, it was impossible to distinguish its effects from those of earlier flares. Geomagnetic Activity levels at some stations on this date were among the highest ever recorded. Toronto reported static bursts possibly due to direct Solar Radio Emission and radio fade-out. A few days later Aberdeen (South Dakota) reported auroral activity and continuing interference. Since this was during one of the special data collection periods, reports from 23 stations were received with 68% of them reporting interference.

4 July Again during late June and early July, there was more than average solar flare activity, although the Geomagnetic Activity index remained low throughout the period. A solar flare of importance 1 B did occur during the 1030-1130 transmission period, and six of the eight reporting stations noted interference, even though most were in darkness. Because of the darkness, this case ordinarily would have been dropped were it not for the fact that some of the stations which almost never reported interference suddenly did so on this date, indicating some sort of wide-spread interference source.

TABLE A-1

SOLAR FLARE INTERFERENCE

Date	Start	Stop	Imp.	% Int.
13 Feb	2213	2250	1 N	67
23 Feb	0831	0848	3 B	67
1 Apr	0151	0213	1 B	60
26 May	0900	0945	1 B	68
4 July	0940	1105	1 B	75

A.5.3 Solar Radio Emission

A.5.3.1 Definition

As was seen in Section A.2, there were several types of Solar Radio Emission. We shall be concerned here with those relatively short bursts not associated with any known solar flare. Presumably the more spectacular solar flare related noise bursts were automatically included in the previous sections. "Solar-Geophysical Data" lists Outstanding Occurrences of Solar Radio Emission, giving date, time, duration, type, strength, and frequency of observing stations. These data are compiled from seven stations operating at 14 different frequencies from 107 MHz at Haleakala, Hawaii to 10,750 MHz at Pennsylvania State University.

A.5.3.2 Findings

During the eight month period of this study, Solar Radio Emission was noted on 37 occassions during WEFAX transmissions. Many of these occurred during local darkness at the receiving stations, or were associated with particular flares. In only seven of the remaining cases did it appear that the solar radio noise may have been the source of some of the interference problems reported by the stations. The failure of the stations in general to note the exact time of the noise bursts precluded our making any final conclusions regarding the significance of the static reported in these cases. It should be noted though, that reports of static bursts were much more prevalent during these periods than at other times.

A.5.4 Geomagnetic Activity and Magnetic Storms

A.5.4.1 Definition

Geomagnetic Activity is measured by means of the "K-indices". These effectively measure for each observatory the range of the most disturbed element for each 3-hour period of the day, after removing the effects of the diurnal variation. The indices range from 0 (no departure from the quiet day variation) to 9 (recorded only during the greatest magnetic storms) in steps of one third of a unit. These data are gathered from 12 observatories between geomagnetic latitudes 47 and 63 degrees. Magnetic Storms will not be examined separately, but it should be noted that they are ranked as moderate if the K index reaches five, moderately severe if six or seven is reached, and severe if the K index reaches eight or nine.

A.5.4.2 Findings

As was mentioned in Section A.4.1, the interference data were converted into a form indicating the percentage of stations reporting interference, to facilitate correlation with the Geomagnetic Activity indices. With the exception of the special data collection periods, the day to day correlations were difficult to evaluate owing largely to the small number of individual reports making up a given percentage figure. Within the special data collection periods, however, there was in general an excellent correlation between the occurrence of interference and Geomagnetic Activity. Figure A-2 shows one such period from 3 through 12 January 1967. All transmissions during this period occurred between 0900 and 1100. The Geomagnetic Activity indices used were for the fourth daily three-hour range, or from 0900 to 1200. As can be seen, the correlation is remarkably good.

In Figure A-3 is plotted the interference percentages vs. Geomagnetic Activity for all cases, including those based on only a few interference reports. It can be seen that despite the efforts to compensate for these cases by weighting as a function of the number of individual reports making up a given percentage figure, there is still considerable noise present, although the trend is obviously an increasing one with increasing Geomagnetic Activity.

A.6 SUMMARY

There is no question but that solar phenomena did in one way or the other affect the quality of the WEFAX transmissions. The actual Sun Spot Number played a part only insofar as a higher sun spot number implies a more active sun, with increased chances of solar flares or radio emission. Solar radio emission apart from that associated with specific flares was relatively ineffective, although there is some evidence that a few of these short intense bursts were felt at some stations. The immediate and delayed effects of solar flares were the most directly correlated with interference problems. Periods of high solar flare activity were directly reflected in increased reception problems, particularly during the very active period in late May. Correlation of Geomagnetic Activity with interference could be best seen during the special data collection periods when enough data were available to yield statistically significant percentages.

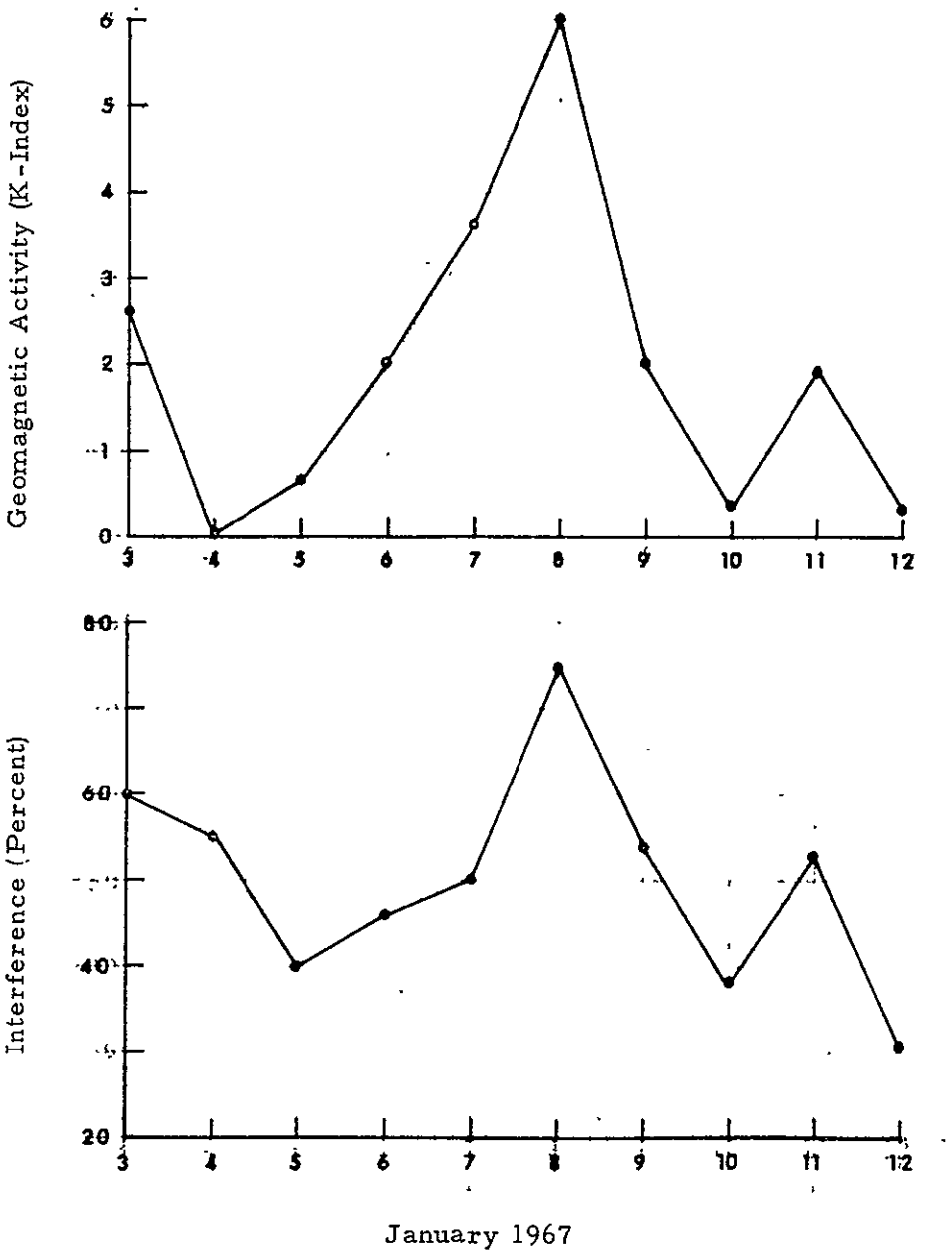


Figure A-2. Correlation of Interference with Geomagnetic Activity.

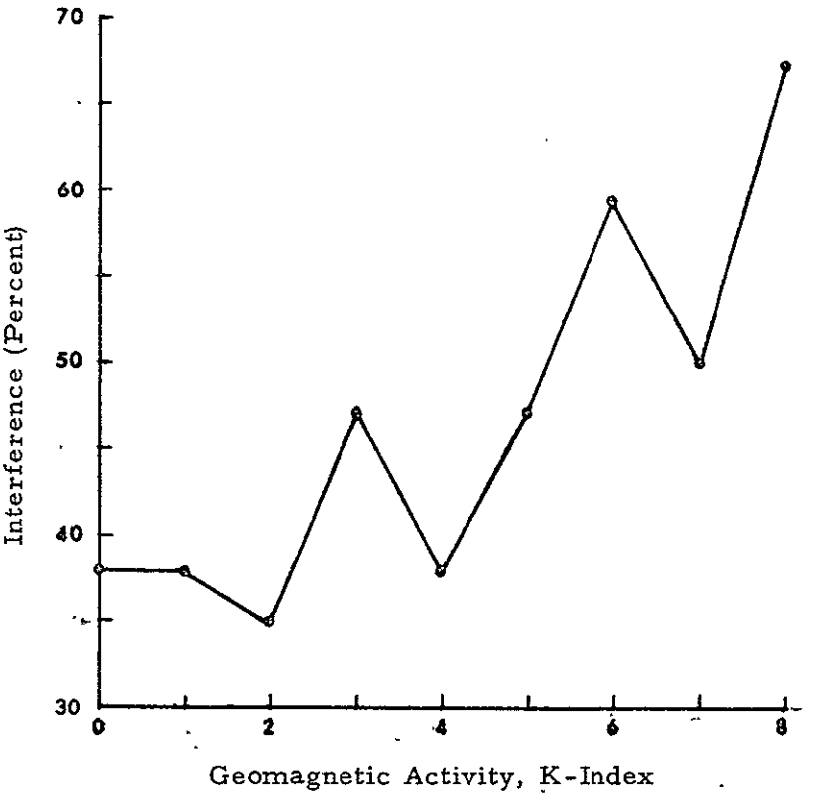


Figure A-3. Interference vs. Geomagnetic Activity.

APPENDIX B

PHOTO/GRIDDING VAN OPERATION

B. 1 INTRODUCTION

Personnel at the Mojave photo/gridding van processed ATS-1 spin scan cloud camera (SSCC) pictures into suitable format for WEFAX transmissions. Enlarged pictures were produced from selected SSCC negatives. The enlarged pictures were gridded, annotated, and then delivered to the APT van for transmission. Meteorological technicians assigned to the photo/gridding van also provided real-time evaluation of transmitted WEFAX data.

B. 2 FACILITIES

The photo/gridding van is a 10' x 36' trailer (see Figure B-1) divided into two basic work areas (see Figure B-2). One area is a dark room (Figure B-3) used for printing the enlarged SSCC pictures. The other area is used for gridding the pictures.

B. 3 PROCEDURES

a. SSCC negatives are received at the ground station and brought to the photo van for processing.

b. Negatives are inspected visually for imperfections such as sync, tears, etc.

c. Selection is made of one or more negatives to be used for printing enlargements in the proper format. Negatives are chosen according to daily requirements.

d. The negative is trimmed, placed in the enlarger negative carrier, cleared of dust specks and inserted in the enlarger.

e. An appropriate grid, selected on the basis of the longitude of the satellite subpoint, is placed on the enlarging easel and the projected SSCC image adjusted until the image and grid horizons match. This insures that the grid is properly scaled to the picture. The grid is rotated relative to the picture until the landmarks on the grid match (superpose) those on the picture.

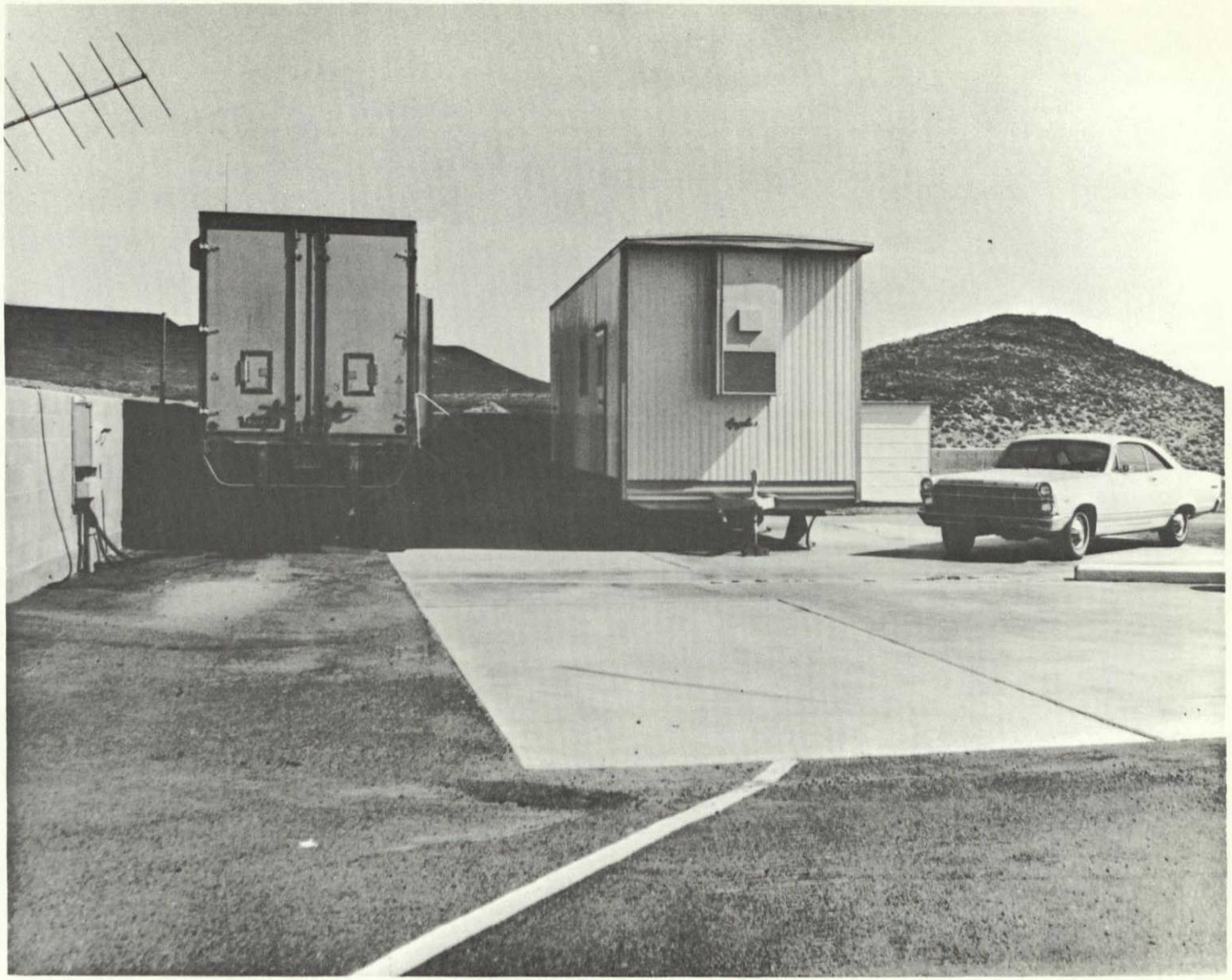
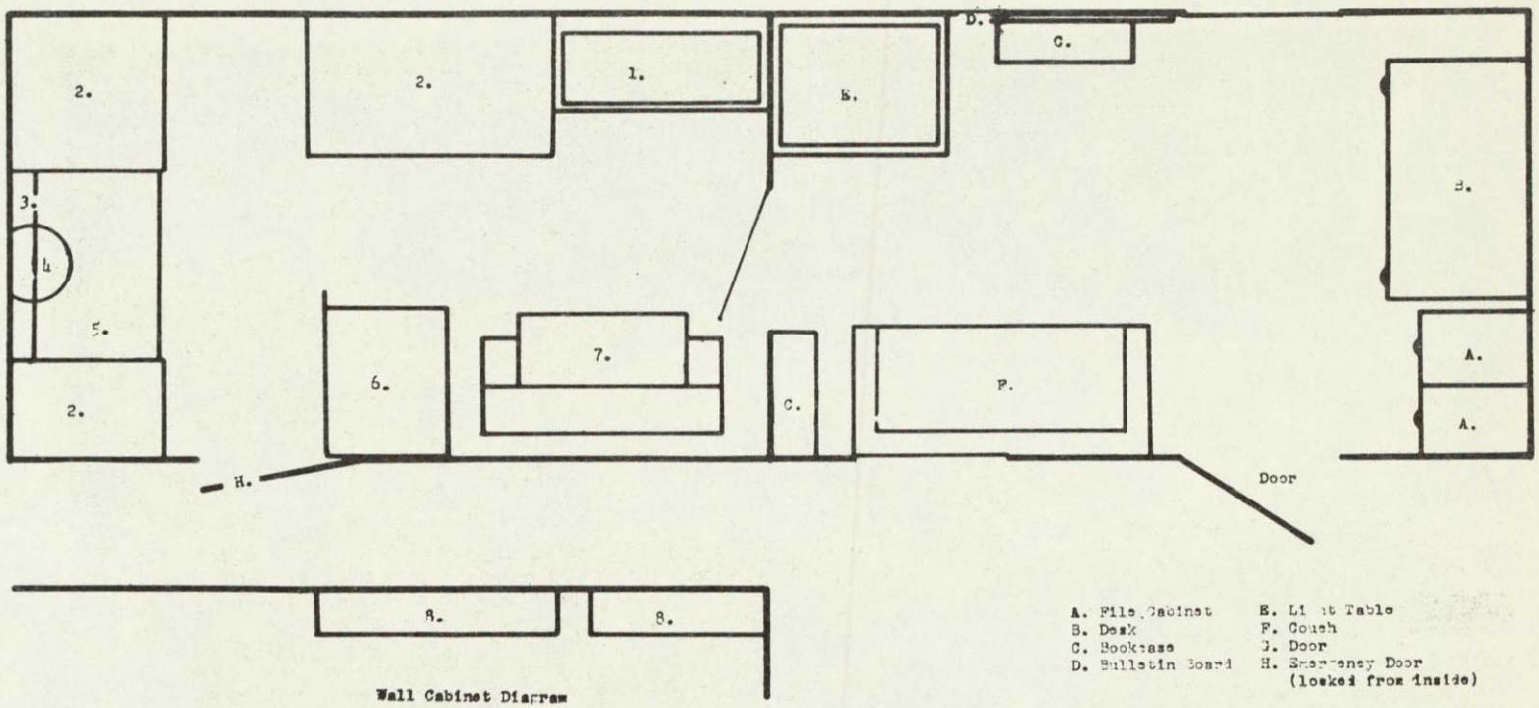


Figure B-1. Mojave APT and Photo/Gridding Vans.
Trailer on left is APT van. Trailer on right is Photo/Gridding van.



Wall Cabinet Diagram

A. File Cabinet
B. Desk
C. Bookcase
D. Bulletin Board
E. Light Table
F. Couch
G. Door
H. Emergency Door (locked from inside)

1. Sink
2. Floor Cabinet
3. Enlarger Base
4. Enlarger
5. Adjustable Easel
6. Paper Cutter
7. Fotorite Processor
8. Wall Cabinet

Figure B-2. Floor Plan of Photo/Gridding Van.

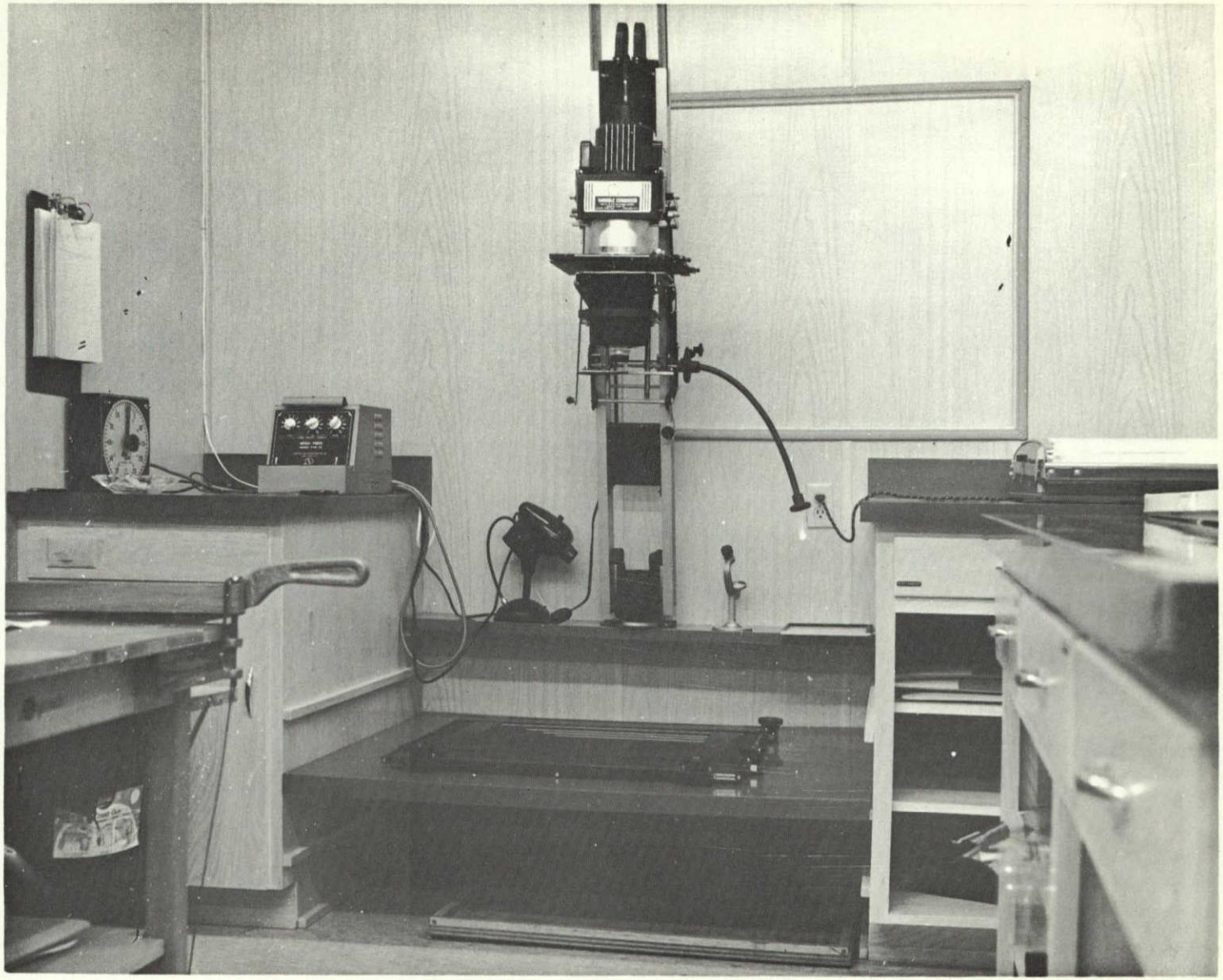


Figure B-3. Photo/Gridding Van Darkroom.

f. After the enlarger light is turned off, printing paper of proper size is inserted in the easel. A red filter is moved over the enlarging lens and the SSCC image is again projected onto the easel and paper to verify a correct grid fit.

g. Proper exposure of the paper is accomplished by using a densi-timer to assure prints of matching density range.

h. After exposure, the paper is removed and fed into the Fotorite Processor which develops, stabilizes and partially dries the print. Feed rate of paper through the processor is one inch per second. Completed prints are air dried in approximately 5 minutes.

i. Date/Time labels are properly placed and the finished print is delivered to the APT van for transmission.

B.4 SPECIAL SERVICES

The WEFAX photo/gridding van provided excellent support to the WEFAX experiment. Many special programs were supported by information extracted from the pictures produced at the photo/gridding van. Some of the events were:

Feb-Apr	Line Island Experiment
Mar-Apr	WMO Congress V, Geneva
Aug	Boy Scout World Jamboree
Sept	BIOSATELLITE II Flight
Sept-Oct	JTF-8 Exercise
Oct	Solar Observation Research Flights
Dec	DOD Western Test Range Operation
Dec	Presidential Flight to Australia

Photo/gridding van personnel also processed all SSCC negatives received at the Mojave ATS ground station and forwarded them to the ATS Project at GSFC. Table B-1 is a listing by months of the number of SSCC negatives processed and the number of frames of SSCC pictures transmitted over WEFAX.

TABLE B-1

SSCC Negatives Processed and Frames Transmitted

Month (1967)	Negatives Processed	Frames Transmitted
January	315	141
February	120	78
March	266	123
April	90	30
May	178	299
June	267	46
July	231	21
August	216	13
September	242	123
October	233	65
November	147	1
December	61	55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