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BRIEFING
on
METEOROLOGICAL SUPPORT FOR THE SAMOS SATELLITE SYSTEM

presented
to

AIR FORCE BALLISTIC MISSILE DIVISION
15 November 1960
by
DR. ROBERT D. FLETCHER

HEADQUARTERS
AIR WEATHER SERVICE(MATS)
SCOTT AIR FORCE BASE

BRIG. GEN. N. L. PETERSON
Commanding

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METROLOGICAL SUPPORT FOR THE SAMOS SATELLITE SYSTEM
HQ AIR WEATHER SERVICE
SCOTT AFB, ILL.

presented by Dr. Fletcher, 15 November 1960

1. Introduction.

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For the post several months Air Weather Service has devoted considerable effort to the analysis of meteorological problems associated with the development and operation of a SAMOS System. The reasons are obvious. From the standpoint of national security its value could hardly be over-estimated.

Since the major objective of the system is the collection of intelligence information, primarily by photographic means, the importance of atmospheric effects is quite clear: the most obvious effect is the degree to which intervening clouds degrade the usefulness of the photographs.

The purpose of this briefing is: (1) to define the meteorological requirements as we now see them, (2) to describe the current Air Weather Service capability to support these requirements, (3) to discuss the problem areas, and (4) to discuss these programs in brief or propose to improve this capability and solve the technical problems.

2. Meteorological-Support Requirements for SAMOS.

slide 2 middle

In examining the meteorological requirements associated with SAMOS, we realize that there may be certain engineering or operational constraints which would "over-ride" the meteorological considerations, particularly during the early phases of the program. We feel, however, that only through proper consideration of the meteorological factors can logical "trade-offs" be made to achieve balance between cost and performance. In developing a support program the Air Weather Service finds itself

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faced with relatively long lead-times in much the same manner as do the hardware developers. Consequently, it is necessary that our plans and programs provide for growth potential within the SAMOS System, increased reliability, increased operational effectiveness, and changing customer requirements. It is not expected that all aspects of the program which we shall outline will be applicable in their entirety during the initial stages of development and operation. Based upon this concept, we have chosen to divide the support requirements into four phases.

S-2 1st overlay

a. R&D AND LONG-Range Plans.

In this phase we are concerned with those meteorological effects which may influence design considerations and trade-offs, concepts of employment, number of launches required, capability of data-processing & handling facilities, etc. Consideration of all of these areas requires information concerning the amount, distribution and frequency of cloud cover, snow cover, and other phenomena affecting visual acuity over the geographical areas of interest. For example, this type of information may effect decisions concerning the relation between the size of the payload package and the satellite life. It is apparent then that we shall need a detailed climatological cloud analysis over the Soviet Union, China, and other areas of interest. Next we feel that consideration should be given to our ability to predict cloud conditions on a real-time basis if we are to achieve a proper balance between design and performance. Finally we feel we can provide you consultant service to ensure that the meterological data and other information are properly interpreted-for unfortunately they are of such a nature that only qualified meterologist can properly translate them. They cannot be treated in the same fashion as a Table of logarithms.

b. Launch.

lide
2 Again it is realized that the degree of selectivity which can be
overlay
2 exercised in chossing launch periods and conditions is not controlled by the meteorological factors alone. However, we feel that if the conditions, based upon other factors which you stipulate, are not too restrictive we can significantly improve the amount of "useful:take: by selecting an orbit period wherein cloud cover and distribution are expected to be a minimum relative to satellite position. This can be done most effectively by integrating cloud climatology and long-range forcasts (defined as 72-hour forecast with an outlook for 5 days). In considering the recoverable package these conditions must then be weighed against expected meterological conditions in the recovery area. Lastly, we must concern ourselves with the meterological conditions at the launch site which may affect range safety and, under extreme conditions, even the success of the launch itself.

lide2 c. Photographic Control.
overlay
3 Neglecting the reliability factor, which of course will improve with time, the amount of "Useful Take" can be improved most significantly by basing the control decisions upon the non-existence when the amount of cloud cover is less than certain critical values. This requires that we process the meteorological data received from the geographical area of interest and prepare prediction charts for the required orbital time periods. These data would then be used in arriving at decisions as to whether we should or should not photograph.

d. Recovery.

The last phase of the meteorological-support program is concerned with recovery of the E-6 satellite package. This simply involves analysis and

prediction of these meterological conditions in the recovery area which could adversely affect our capability to retrieve the payload package.

3. Air Weather Service Capability to Support the SAMOS Program.

slide 3 I should like now to discuss briefly the Air Weather Service capability to support the SAMOS project.

a. Organization.

First let me describe that portion of the Air Weather Service organization which is directly involved in our support programs for SAMOS. The Air Weather Service, commanded by Brig. General N. Peterson, has its headquarters located at Scott AFB, Illinois. We are one of several service organizations assigned to the Military Air Transport Service. The Air Weather Service is charged with the responsibility of providing meterorological service to the Air Force and Army, and on technical matters we work directly with the Air Staff and Army Headquarters, as well as with ARDC and the Divisions within ARDC. Ths Scientific Services Directorate within our headquarters is concerned with the overall technical competency of the support progarm. The Climatic Center at Washinton D.C. as well as the meteorological-data repository at Asheville, N.C. are directly under the Deputy Chief of Staff/Operations, Headquarters Air Weather Service. The 4th Weather Gp, located at Andrews AFB, provides meterological support to ARDC. The Staff Meterorological Division at AFRMD is under this group, as is the Meteorological Detachment serving the Satellite Test Wing at Sunnyvale. The detachment at Sunnyvale is responsible for the launch support. Under the 3rd Weather Wing located at Offutt AFB we have a Technical Services Divison working on computer programs and other technical problems for SAMOS, and a Global Weather Central which is responsible for planning forecasts for

launch and recovery as well as forecasts for the Soviet Union, China, and other areas of interest. We have a Weather Forecast Center under the 1st Weather Wing at Kunia which provides support for recovery. The 55th Weather Reconnaissance Squadron, under the 9th Weather Group, located at McClellan AFB, provides reconnaissance support in the recovery area. We have recently organized a special meterological reconnaissance flight and instrument laboratory within the 55th Squadron to handle specific test and support problems. The 55th Squadron is equipped with WB-50's,one B-47, and one B-57.

b. SAMOS Satellite Task Team.

In view of the overall importance of the SAMOS program, and, in our opinion, the necessity of developing an adequate meteorological-support program at the earliest possible date, the Commander, Air Weather Service, directed the formation of a Satellite Task Team. The Task Team was organized under Dr. Robert Fletcher, Director Scientific Services, Headquarters Air Weather Service, and is composed of representatives from the Deputy Chief of Staff/Operations,Hq AWS;Hq 4th Weather Group: Staff Meteorological Division (4th Weather Group) AFBMD; Meteorological Detachment(4th Weather Group) serving the Satellite Test Wing; the Climatic Center; and the Global Weather Central, 3rd Weather Wing. It may interest you to note that we have eight Doctorate-level meteorologists engaged in this program, either on the team or providing support to it. The functions of the Satellite Team:

(1) To define the meteorological requirement for support to the SAMOS program.

(2) To assess the current Air Weather Service capability to provide the necessary support.

(3) To conduct climatic analyses and technical studies necessary to ensure proper consideration of the meteorological factor and to improve Air Weather Service support capability.

(4) To develop the overall meteorological-support program for SAMOS.

c. Meteorological Data Collection Program.

slide 5

(1) Data Flow.

Now let us look at our data-collection program. Meteorological observations (including surface and upper-air) are taken on a routine basis throughout most of the countries of the world. Through a network of land-line and radio communications these data are collected at central points, edited organized into collection Bulletins, and distributed to our weather units serving the USAF and Army according to their needs.

This chart shows the meteorological-data-collection program, as it affects the SAMOS system support. Data from the entire northern hemisphere flow through the Collection and Editing Center to the Global Weather Central. Portions of these data are provided the Weather Center at Kania, and the Meteorological Detachment at the Satellite Test Wing as required. It should be noted that the Global Weather Central receives more data than any other meteorological organization in the United States through special Air Force weather communications facilities. These data are recieved by the Global Weather Central on the order of 2 to 4 hours after observation time. Analyses covering the northern hemisphere are completed at 6-hourly intervals. Support in the form of processed products-analyses and forecasts is forwarded from the Global Weather Central to the Kunia Weather Center, and the Meteorological Detachment at the Satellite Test Wing. The Kunia Weather Center prepares the forecast for the recovery area and the sunnyvale meteorological Detachment provides meteorological service for the Satellite Test Wing.

(2) Surface observing Network-USSR.

slide 6

Shown here is the surface observing network over the western area of the Soviet Union. The dots represent individual observing stations. Data from this network are received at three hourly intervals; However, individual reports are often missing. The data are sufficient to permit toutine analyses and forecasts although not in as much detail as desired for support to the SAMOS system. The density of observations over other portions of the Communist Bloc is variable and in many areas unsatisfactory. As a result, the climatology for many stations is incomplete.

(3) Surface and Cloud Analyses.

slide 7

This slide shows the surface weather analysis as it existed at 0000z on 31 January 1960, over a portion of Western Russia. (Slide 8) This is the cloud situation as it appeared at that time. The clear area indicates that less than 2/8 of the total sky was covered by cloud. The shadings of increased darkness show when cloud categouies of increasing cloudiness exists-2/8 to 3/8,4/8 to 5/8, and 6/8 or more of the total sky cloud-coverd. These four categories were tentatively accepted at a recent meeting of AWS and AFBMD personnel concerning SAMOS support. This analysis shows that the transition zone between "clear and overcast" areas is very small. In connection with this chart, I should like to emphasize that the analysis is based upon reports of clouds as seen by ground observers. I am sure that the first SAMOS flight will indicate a need for correcting the cloud patterns as viewed by the satellite with those derived from surface observations.

d. Electronic Data Processing Facilities.

As you may have surmised already, the provision of meteorological support to our strategic weapons systems [illegible]

about 100,000 individual observations are received at the Global Weather Central each day. Each of these reports is used in the preparation of analysis and forecast for various using agencies. This can be accomplished on a timely basis only through the use of electronic data-processing equipment. The Air Weather Service now has a substantial capability here. As shown on this chart, we have anIBM 7090 general-purpose computer at the Global Weather Central at Offutt. We also have an IBM 705 computer and associated card-punch machines at the National Weather Records Center at Asheville, N.C. to process our climatological data. We have a smaller card-punch and sorting capability at the Climatic Analysis Center at Washington, D.C. The Joint Numerical Weather Prediction Unit, under the direction of the U.S. Weather Bureau, Washington, D.C., has a 7090 compter. Basic meteorological analysis prepared by this unit are transmitted to the Global Weather Central at Offutt, as well as to other Air Weather Service units, via teletype and facsimile. This avoids duplication and permits the full use of the 7090 computer at Offutt for military problems. These facilities will be utilized as reqired to provide meteorological support to the SAMOS system.

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e. <u>Air Weather Service Analysis and Forcast Capability.</u>

The Air Weather Service has the capability to prepare analyse and forcasts of weather conditions on a global basis. Analyses are made continuously for the nothern hemisphere-including, of Course, the Soviet Union.

Upper-air analyses of the pressure, temperature,wind and moisture fields are constructed at 12-hour intervals. Forcasts are prepared for periods of zero to 72 hours, outlooks are prepared for a5-day period, and beyond this we normally depend upon climatological estimates. Upper-air dat

in limited amounts are received at 6-hourly intervals and permited special analyses if required.

Surface analyses of presure, temperature, wind, cloud, weather, and moisture fields are constructed at 6-hourly intervals-again with emphasis on the nothern hemisphere, These analyses are used to prepare 5-day outlooks and forecasts for periods ranging from zero to 72 hours. Again, we depend upon climatology for outlooks beyond 5 days. Three-hourly surface data are received which permit special analyses when required.

The Air Weather Service has the capability to provide forecasts for the SAMOS System. However, the nature of the problems is such that special techniques will be required. As would be expected, the accuracy of a forecast deteriorates with the passage of time. From about 3 to 5 days it may be much better than climatological expectations-i.e. a statement of the mean monthly conditions. In other words, the degree of sucess in forecasting clouds depends on the quality of the initial cloud observations and on the speed with which we can collect and process these observations.

Certain cloud patterns tend to be uniform over large areas for days at a time. Other patterns are extremely changeable. Cloud variability is quite promounced in some areas of the Communist Block. Even during the season of most cloudiness conditions, there is still enough variability to require frequent analyses and forecasts.

The construction of accourate cloud analyses from the visual surface observations, often made at widely separated points, will obviously lack great detail. Consider these facts:

(1) SAMOS viewing swaths are of the order of 10 to 60 miles in width (with provision for wider swaths in later models).

(2) The reporting surface-weather stations in the Communist Block have a mean separation of about 50 miles in the densest part, which is in European Russia. This separation increases to 200-300 miles in some parts of Arctic Siberia.

(3) Cloud cover is abrupt in its varartion. Two simultaneous (synoptic) cloud observations at points 50 miles apart might both have 8/8 coverage (or overcast), but it does not necessarily follow that there is 8/8 coverage throughout the region between the stations. The 3rd Weather Wing has developed a technique which provides 24- and 36-hour cloud forecasts which are superior to both persistence and climatology. In a limited test of the method, a categorical YES or NO forecast of cloud cover of -2/8 or 2/8 verified approximately 85% of the time. This result is not too meaningful, however, since there are many areas and times when the forecaster can be practically certain of either very clear or very cloudy conditions. We feel that we can improve upon this capability and have initiated study programs which will be discussed later.

In order to determine our forecast capabilities more precisely, simulated forecasts will be issued routinely during the first SAMOS tests. These will be verified, and the potential effect of the accuracy of the forecasts on the SAMOS mission will be determined.

f. Use of Meteorological Satellites in SAMOS Support.

slide 11 It is clearly apparent, however, that the conventional system of cloud observation made from the ground at discrete points may not permit the detailed analysis and forcast necessary for optimum support of SAMOS. Another observational tool is needed.

This slide shows a TIROS I picture of clouds (with the white area being clouds) in the North Atlantic Ocean near 30°N. We have only a very

limited number of meteorological observations in this area. They are limited to a few weather ships and commercial vessels. A scale length of 200 miles might be taken as typical of the distance between surface station in most of Asiatic Russia. It is seen that the detail revealed by the picture cannot possibly be reproduced by an analysis based on conventional surface cloud observations.

The spectacular sucess of TIROS I, even though it was the first esperminent in a new field of endeavor, indicates that a new cloud-observation technique with the necessary area of coverage and the required degree of cloud detail can be obtained by meteorological satellites. Recognizing this potenial, the Air Weather Service has been very active in the meterological satellite feild, even though the program in its research phase is now under the National Aeronautics and Space Administration. On the third day after the launch of TIROS I, the Air Weather Service started the routine facsimile transmission of cloud analyses made from the satellite pictures. This activity will be increased and speeded up in the future NASA TESTS.

Realizing that NASA's charter calls for the development of an optimum operational meteorological-satellite vehicle, it is conceivable that such a system will not be realized for a number of years. Therefore, the Air Weather Service has proposed to Air Force that a simple reliable-cloud-cover satellite system should be developed for support of aero-space activity of the immediate future. DOD and NASA are presently in the process of resolving several questions concerning the supervision and control of an operational meterological-satellite system.

In summary, the scale of cloud observations required for accurate cloud analyses and forecasts can be obtained by a meteorological satellite system. Not only would the use of meteorological staellites enable accurate

detailed, original analyses upon which to base the cloud forecasts, but the nearly continuous cloud pictures received would permit more frequent shorter-range forecasts and would furnish immediate indications of any divergence of the forecast form the observed conditions. If the Communists for some reason should deny us their weather data, as certainly would happen in case of war, a staellite might be the only means of gathering cloud data over a large portion ofthe globe.

4. Problem Areas.

slide 12

I should now like to describe some of the problem areas which I feel require attention.

a. Climatic support.

The nature of the SAMOS System and its objectives requires that we specifically tailor our meteorological-support program. It would be desirable for the Air Weather Service to work closely with your systems analysis Group to define clearly the climatological requirements for the R&D and Long-Range-Planning phases. The definition of requirements will govern the type and format of the climatological program. The present data are not recorded on a form most suitable for the type of analysis required.

b. Photographic Degradation.

We are certain that the degree of photographic degradation will depend upon the types of intervening clouds. We need to know more precisely the types of cloudswhich will not seriously derade the usefulness of the photographs-this would probably depend upon user requirements. We feel that this knowledge would substantially improve our forecast accuracy.

c. [redacted]

[redacted]

METEOROLOGICAL SUPPORT FOR THE SAMOS SATELLITE SYSTEM

AIR WEATHER SERVICE
SCOTT AIR FORCE BASE, ILLINOIS

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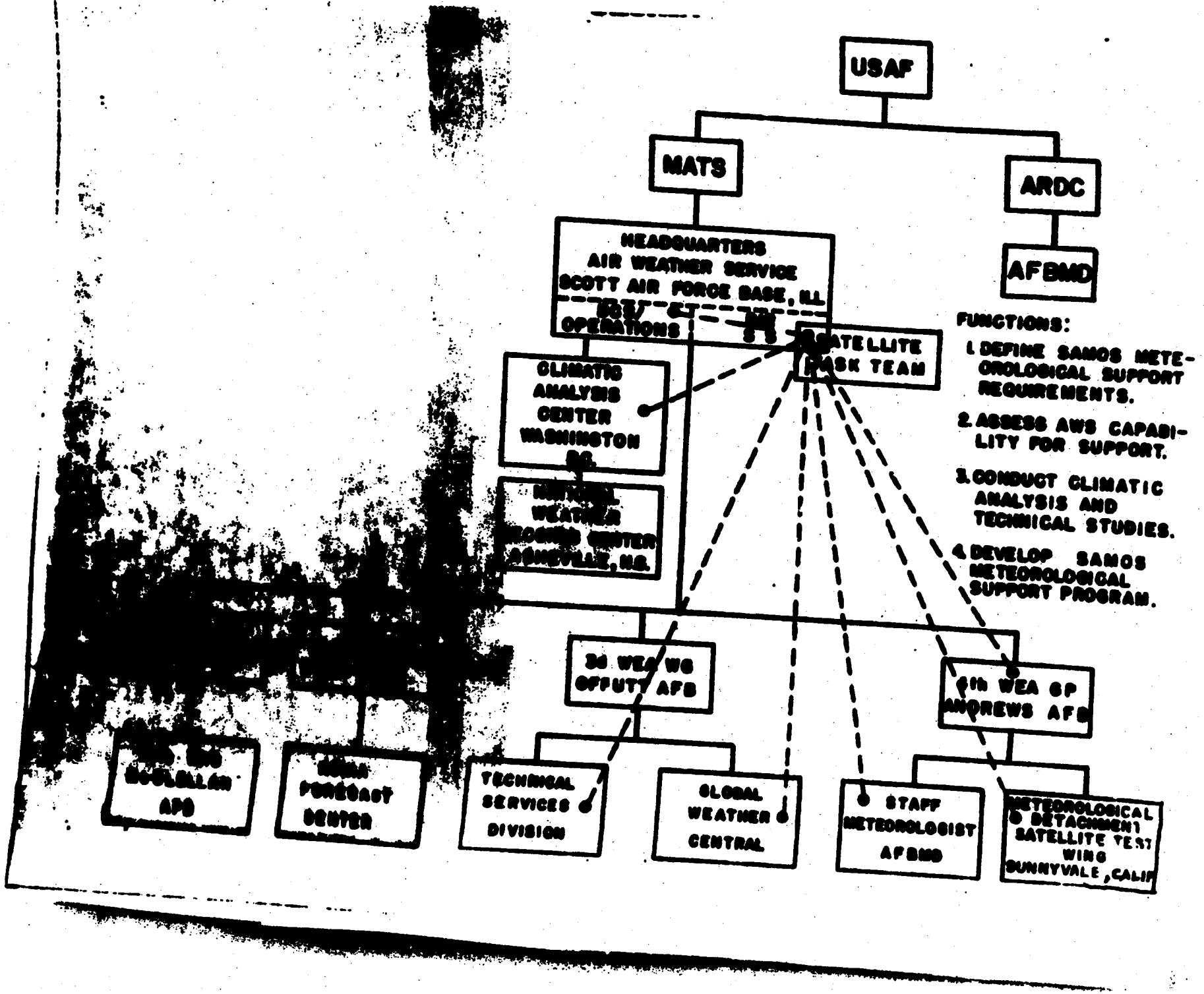
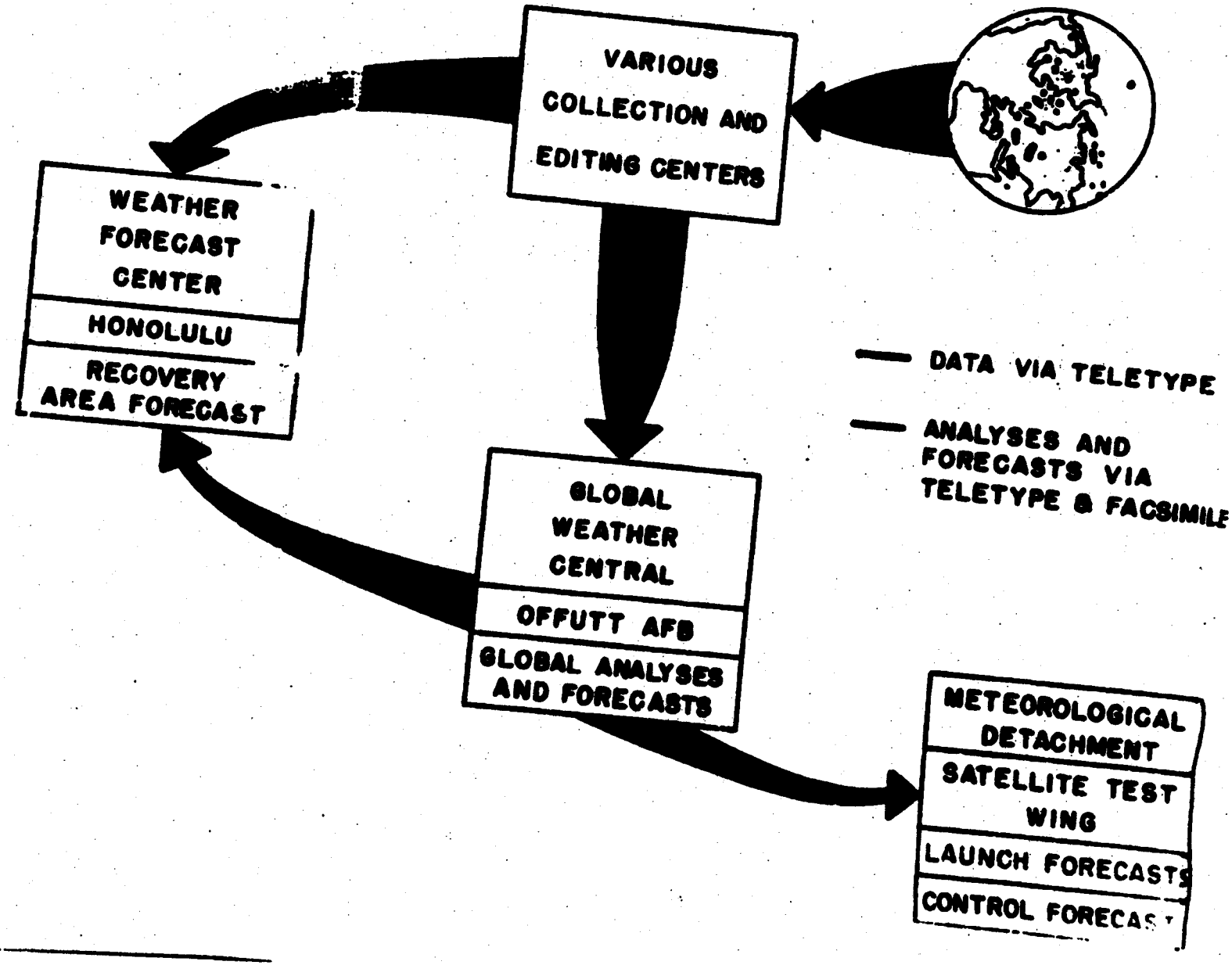
METEOROLOGICAL SUPPORT REQUIREMENT FOR SAMOS

- R&D AND LONG-RANGE PLANS
  - DETAILED CLIMATOLOGICAL CLOUD ANALYSES.
  - PREDICTABILITY OF CLOUD CONDITIONS ON A REAL-TIME BASIS.
  - METEOROLOGICAL CONSULTANT SERVICE.
- LAUNCH
  - PLANNING FORECAST TO OPTIMIZE LAUNCH PERIOD.
  - OPERATIONAL FORECAST FOR LAUNCH AND RANGE SAFETY.
- PHOTOGRAPHIC CONTROL
  - FORECAST OF CLOUD CONDITIONS ALONG ORBITAL PATHS.
  - PRIORITY TARGET FORECAST.
  - CLIMATOLOGICAL EXPECTANCY.
  - COMBINED PROBABILITY MODEL.
- RECOVERY
  - OPERATIONAL FORECASTS FOR RECOVERY AREA


USAF
MATS
ARDC
AFBMD
HEADQUARTERS
AIR WEATHER SERVICE
SCOTT AIR FORCE BASE, ILL.
OPERATIONS
SATELLITE
TASK TEAM
CLIMATIC
ANALYSIS
CENTER
WASHINGTON
D.C.
NATIONAL
WEATHER
RECORDS CENTER
ASHEVILLE, N.C.
FUNCTIONS:
1. DEFINE SAMOS METEOROLOGICAL SUPPORT REQUIREMENTS.
2. ASSESS AWS CAPABILITY FOR SUPPORT.
3. CONDUCT CLIMATIC ANALYSIS AND TECHNICAL STUDIES.
4. DEVELOP SAMOS METEOROLOGICAL SUPPORT PROGRAM.
2d WEA WG
OFFUTT AFB
6th WEA GP
ANDREWS AFB
TECHNICAL
SERVICES
DIVISION
GLOBAL
WEATHER
CENTRAL
STAFF
METEOROLOGIST
AFBMD
METEOROLOGICAL
DETACHMENT
SATELLITE TEST
WING
SUNNYVALE, CALIF

METEOROLOGICAL DATA COLLECTION PROGRAM

slide 5



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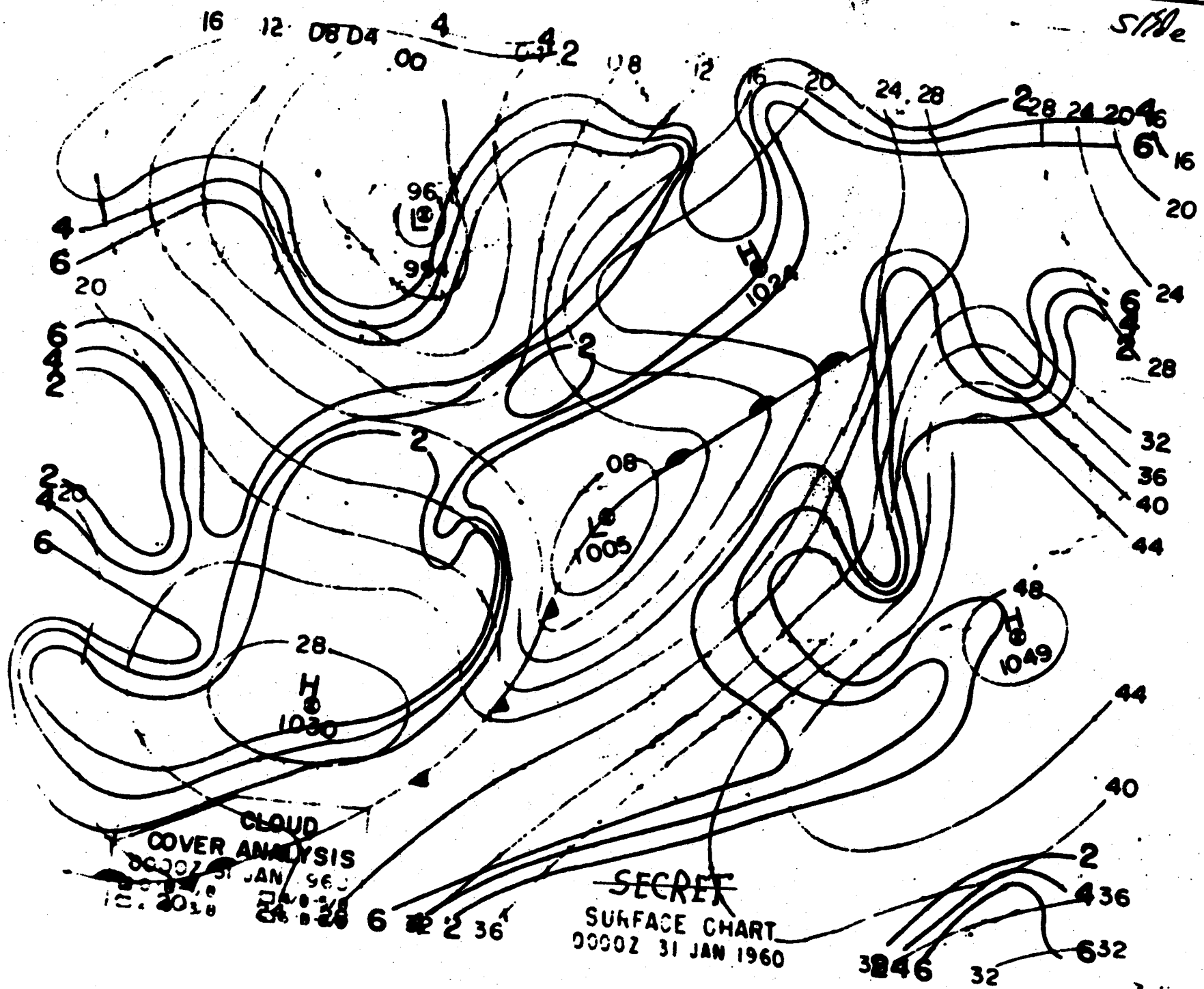
SECRET
SURFACE CHART
0000Z 31 JAN 1960
CLOUD
COVER ANALYSIS
1005
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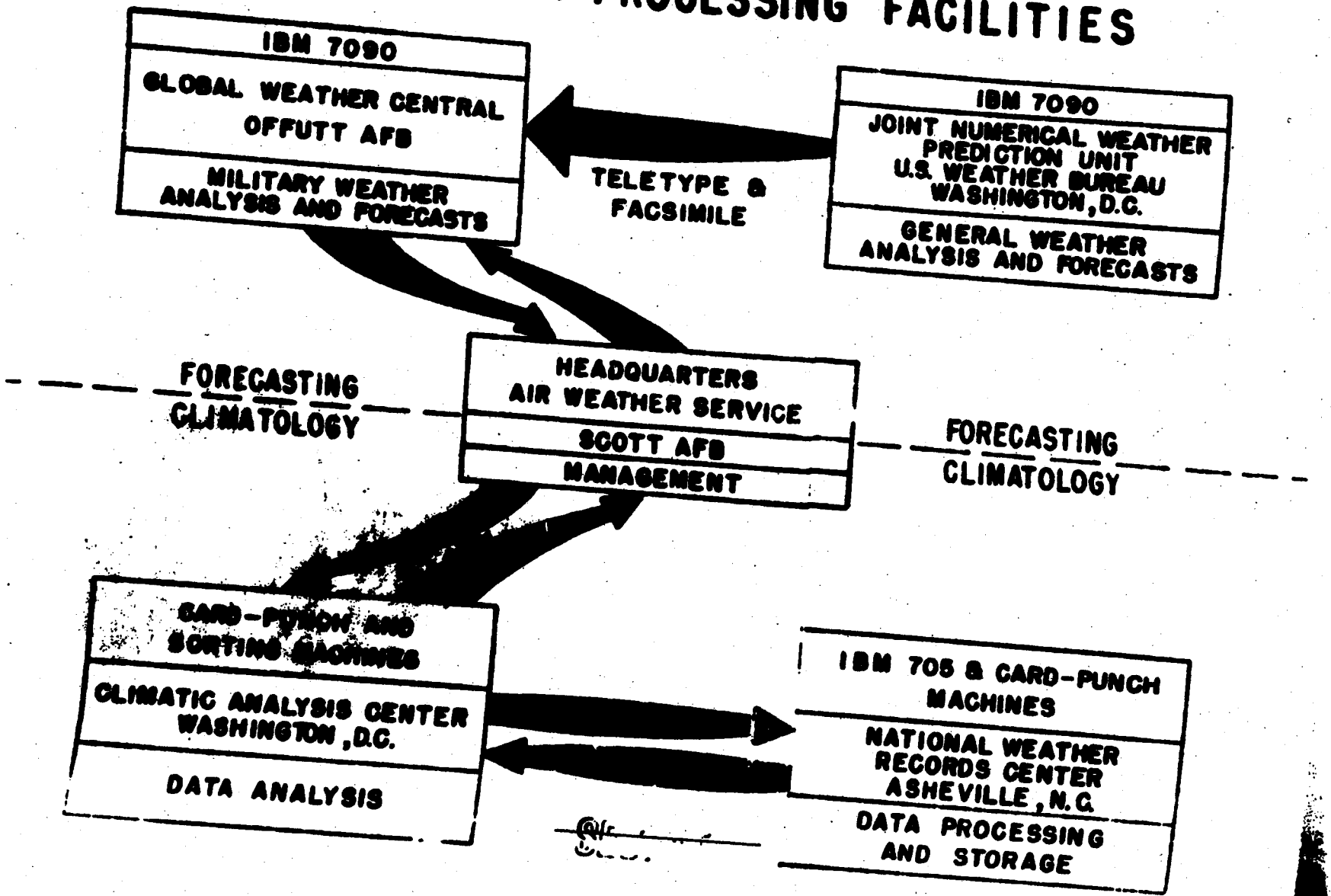
Slide #9

AIR WEATHER SERVICE
ELECTRONIC DATA PROCESSING FACILITIES



AIR WEATHER SERVICE
ANALYSIS AND FORECAST CAPABILITY

- GLOBAL (Major Emphasis on Northern Hemisphere)
  - REGIONAL
  - TERMINAL
- UPPER AIR (Pressure, Temperature, Winds and Moisture)
  - ROUTINE ANALYSIS — 12-Hourly Intervals
  - FORECASTS
    - 0 TO 72 Hours
    - 5 Day Outlook
    - Climatology
  - REGIONAL ANALYSES AND FORECASTS — 6-Hourly Intervals
- SURFACE (Pressure, Temperature, Winds, Moisture, Clouds and Weather)
  - ROUTINE ANALYSIS — 6-Hourly Intervals
  - SPECIAL ANALYSIS — 3-Hourly Intervals
  - FORECASTS
    - 0 TO 72 Hours
    - 5 Day Outlook
    - Climatology
- [redacted] ANALYSES AND FORECASTS (As Required)

Slide #11

slide #12

METEOROLOGICAL SUPPORT TO SAMOS

PROBLEM AREAS

- CLIMATOLOGICAL SUPPORT FOR SAMOS SYSTEM ANALYSIS GROUP.
- DEGREE OF PHOTOGRAPHIC DEGRADATION DUE TO CLOUD TYPES
- CORRELATION BETWEEN SURFACE OBSERVATIONS AND CLOUDS VIEWED FROM SAMOS.
- SPARSITY OF DATA OVER SOVIET BLOC.
- IMPROVEMENT OF FORECAST TECHNIQUES.
- NEW APPLICATION TECHNIQUES.

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Slide #13

METEOROLOGICAL SUPPORT FOR SAMOS IMPROVEMENT PROGRAM

- CLIMATOLOGICAL ANALYSIS PROGRAM
- CLOUD FORECAST TECHNIQUES
  - TRAJECTORY
  - CONTINUITY EXTRAPOLATION
  - DYNAMIC MODEL
  - SYNOPTIC
- SATELLITE vs SURFACE OBSERVATION CORRELATION STUDY
- DECISION-MAKING MODEL