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NATIONAL SEVERE STORMS PROJECT

REPORT No. 20

Field Operations of the National Severe Storms Project In Spring 1963

by

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EDITOR'S NOTE

Since the date of preparation of this Report, the National Severe Storms Project and the Weather Radar Laboratory have been reorganized and consolidated at Norman, Oklahoma under the name "National Severe Storms Laboratory." Inquiries regarding the availability of any NSSP data for 1963, or for prior years, should be sent to the following address:

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FIELD OPERATIONS OF THE NATIONAL SEVERE STORMS PROJECT IN SPRING 1963

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1. INTRODUCTION

The 1963 field operations of the National Severe Storms Project (NSSP) were carried out in Oklahoma mainly during the period between April 15 and June 15. The surface research network, however, was in full operation from March 24 to June 30. NSSP, through a field office at Westheimer Field, Norman, Oklahoma, coordinated these operations involving the active collaboration of several governmental agencies and private and University contractors. The agencies which participated in the 1963 program - again called by the code name "Project Rough Rider" - were U. S. Air Force's Aeronautical Systems Division (ASD); Air Force Cambridge Research Laboratory (AFCRL); Air Defense Command (ADC) and Air Weather Service (AWS); Federal Aviation Agency (FAA); 3rd Target Acquisition Battalion, 26th Artillery, Fort Sill, Oklahoma; Soil and Water Conservation Research Division of the Department of Agriculture (USDA); and the U. S. Weather Bureau's NSSP and various field stations. Important technical and financial support to the project was provided by the National Aeronautics and Space Administration (NASA). Non-government organizations participating either under contract or on a cooperative basis were: The University of Chicago; the Electronics Division of General Mills, Inc. (GM); the Raytheon Corporation; the Burroughs Corporation; the Geophysical Corporation of America; Johns Hopkins University; and the University of Oklahoma (OU) which also provided space for the Weather Bureau's radar complex, operations office, and phototheodolites.

Previous reports in this preprint series [1, 2, 3, 4, 5] have described the origin, objectives, and previous operational seasons of what is now NSSP. The present cooperative effort by governmental agencies, private organizations, and universities is bound together by common interests in various aspects of severe local storm problems. The complementary objectives and facilities made possible a project of this scope.

This report is prepared to indicate the scope of the field operations in 1963 and to indicate what data are available for research use as a result of the program carried out. No attempt will be made at this time to present actual data or findings based thereon. Research results will be given distribution in the NSSP report (preprint) series, publications of the participating agencies, or as formal articles in the regular scientific journals. As stated in previous reports, the volume of

data collected is such that the existing Weather Bureau staff of NSSP cannot adequately research all phases on a current basis, and consequently, present effort is confined to cases which appear to hold most promise for advancing our knowledge of severe convective storms. It is sincerely hoped that other interested research groups will continue to avail themselves of the data for research use.

2. PLANNING AND OBJECTIVES

Basic objectives of NSSP are outlined in NSSP Report No. 1 [1]. The basic plan of field operations is contained in an Operational Guide [3] which was prepared for the 1961 operations and updated as necessary each succeeding year. An Operational Planning Conference was held January 31 - February 1, 1963, in Kansas City, Missouri, to review the previous year's operation and plan the operations and specific objectives for 1963. It was decided that the investigation of individual cloud systems would be stressed. Thus the objectives were to examine and explore (1) vertical and horizontal gusts; (2) electric field; (3) electrical discharges; (4) "free" water content; (5) cloud drop temperature; (6) cloud drop size distribution; (7) hail frequency and size; (8) wind flow patterns; and (9) growth characteristics of the thunderstorm cloud complex. Use was to be made of chaff, radar, sferics, cloud photography, surface and rawinsonde networks and aircraft observations to obtain the necessary data. A list of participants at this meeting is given in Appendix VI.

3. FACILITIES

Major milestones were passed in 1963. One of the most significant was the establishment of a radar research facility on the grounds of the University of Oklahoma Research Park at Norman, Oklahoma. For the first time it was not required that research programs be tailored to fit into a public service system attendant to joint use of an operational radar as was required in previous years. The acquisition of an MPS-4 RHI radar for research further increased the potentialities for discovering the secrets of thunderstorm formation. Also installed was an alternate level blanking contour circuitry on the WSR-57 logarithmic receiver for simultaneous display of four contour levels of echo intensity. Other milestones were the increase in the Beta network to cover the U. S. Department of Agriculture rain gage network, the decided improvement in accuracy of observations and operation of the Beta network, the improvement in the F-100 aircraft instrumentation such that measurement of the vertical component of the wind could be made, and the successful employment of "chaff" to determine wind flow patterns near the tops of thunderstorms. A description of the operational facilities follows:

A. Staging Area

The staging area, as in previous years, was in the environs of Oklahoma City. Operational headquarters was located in Building 604 on the grounds of

the University of Oklahoma's Research Park at Norman, Oklahoma. This building also housed the radar, communications, and aircraft control facilities. The military aircraft, with the exception of the U-2, were based at Tinker Air Force Base. The U-2 was based at Edwards Air Force Base, California, and was available upon request. At the operational headquarters "hot line" communications were available to the Severe Local Storms Forecast Center (SELS) in Kansas City and to various field operation sites. Weather teletypewriter on Service A (aviation weather), Service C (synoptic weather), and the Radar Warning Circuits (RAWARC) were available along with facsimile equipment. The data gathered from the aforementioned transmissions and the information received from SELS were integrated with the local radar intelligence in the planning and conducting of each day's operation.

B. Radar

The integration of the research facilities and control facilities at the National Severe Storms Project's Weather Radar Laboratory offices in Norman, Oklahoma, was accomplished in sufficient time for full operation in the 1963 season. The radar complex consisted of a WSR-57 radar, an MPS-4 RHI radar, and an AN/MPX-7 IFF interrogator which was synchronized with the WSR-57. The AN/MPX-7 was used in conjunction with the WSR-57 in the control of aircraft during cloud penetrations and during other flights in range of the radar, particularly the chaff drops. On the WSR-57 radar scopes, precipitation echoes, IFF and "skin paint" returns from aircraft were displayed. The FAA controller, in addition, had on his repeater scope a video map of the high altitude airways. For photographic purposes, the information on the basic WSR-57 scope was photographed. Several new features were added to the research photography, one being the photographing of the scope of the MPS-4 RHI radar defining the vertical structure of the cloud being penetrated, another, the photographing of an alternate level blanking contour circuit on the logarithmic receiver of the WSR-57. This contour circuit, in effect, produced, starting at approximately 5 db., a bright band for the range between 5 db. and the next selected db. level, a blanking out of the next step, or an inversion appearing as a dark area on the scope, and for the third range, a bright area on the scope. This permitted viewing several levels of intensity simultaneously, and greatly facilitated the vectoring of the aircraft. The vectoring of the aircraft has previously been described by C. F. Van Thullenar [6, 7].

A coordinated program with AFCRL was designed for quantitative studies of echo intensities. This program made use of the Air Weather Service CPS-9 radar and the ADC FPS-6 RHI and FPS-20 search radar. Automatic video attenuation on the Weather Bureau's WSR-57 used in conjunction with the contour circuitry on the logarithmic receiver could be correlated with the double iso-echo circuitry installed on the FPS-6 by AFCRL. These facilities made reflectivity studies possible before and after each aircraft penetration of a thunderstorm and throughout prearranged radar programs.

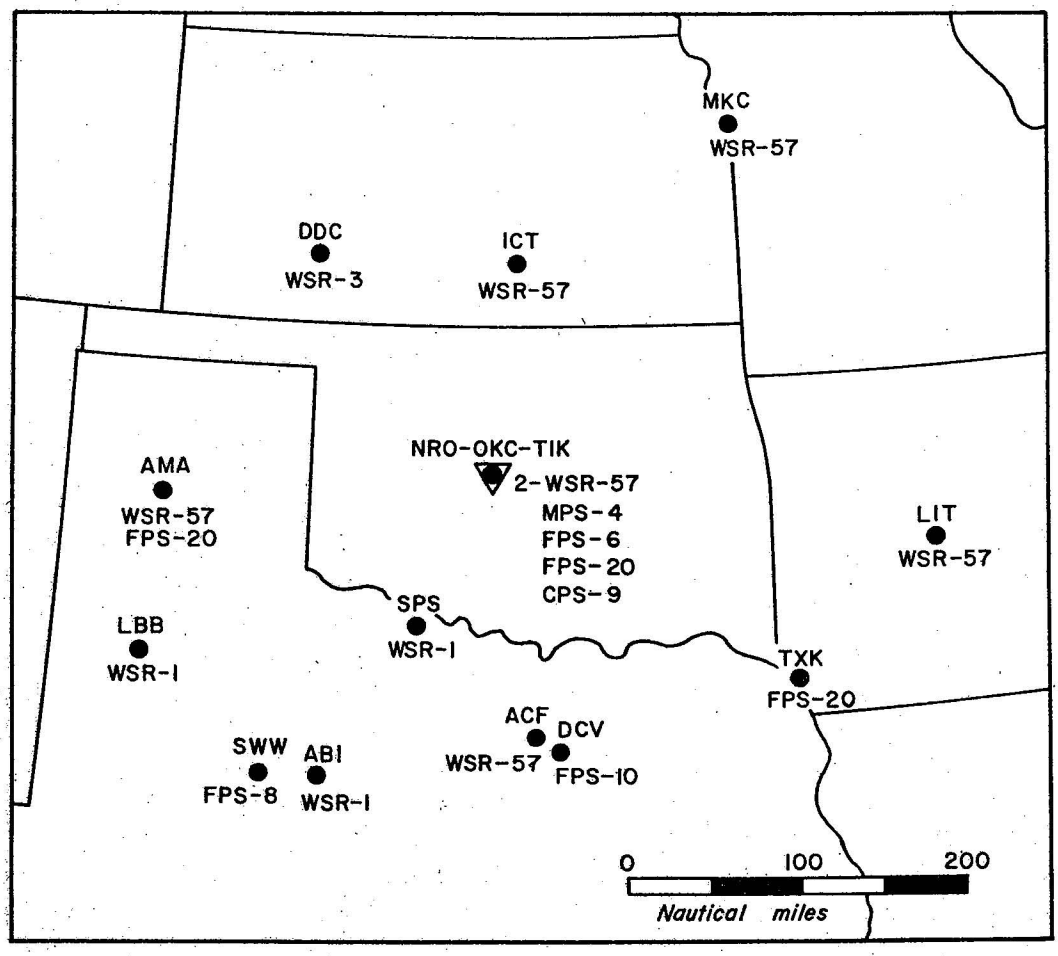

Figure 1.— Types of radars and locations where scope photography was available during 1963 operations of NSSP. Operational, and research radars in the Oklahoma City area were sited at Tinker Air Force Base (TIK), Will Rogers Field (OKC WBAS), and at Norman (NRO), all lying within the indicated triangle.

An M-33 radar was used under contract to the Weather Bureau by the University of Oklahoma to track balloons released in series in several situations in order to determine the low-level wind flow patterns in the vicinity of convective activity. One good example occurred on May 26th. The results of the M-33 operation are presented in a contract report to the Weather Bureau by the University of Oklahoma Research Institute [8]. Further studies of this information will be published.

Radar scope photography was also available from a number of Weather Bureau radars in the operating area and from other ADC sites. Research radar scope photography and the ADC radar photographs are all on 35 mm. film. The additional coverage around the Oklahoma City area and the area of operational interest was provided by other radar sites as shown in figure 1. Scope photography was requested from the stations on the basis of expected areas of convective activity and expected areas of aircraft operations. Coordination of the radar program was handled by the Operations Center at NSSP headquarters.

C. Upper-air Network

The upper-air network remains substantially the same as in 1962 and is shown in figure 2. One new station at Abilene was added over the 1962 program. This supplemented the regular Weather Bureau stations. In addition, numerous special observations were provided on request by the meteorological section of the U. S. Army's 26th Artillery Unit at Fort Sill, Oklahoma.

Regularly scheduled rawinsonde observations at the Weather Bureau stations (0000 and 1200 GMT) were supplemented by (a) nearly 56 special or serial ascents made at 90-min. or 3-hr. intervals by selected stations upon request from NSSP, (b) special observations made at 1800 GMT (noon CST) upon request from the Severe Local Storms Forecast Center, (c) observations made at noon for Project Springfield, and (d) approximately 300 special or serial observations provided by

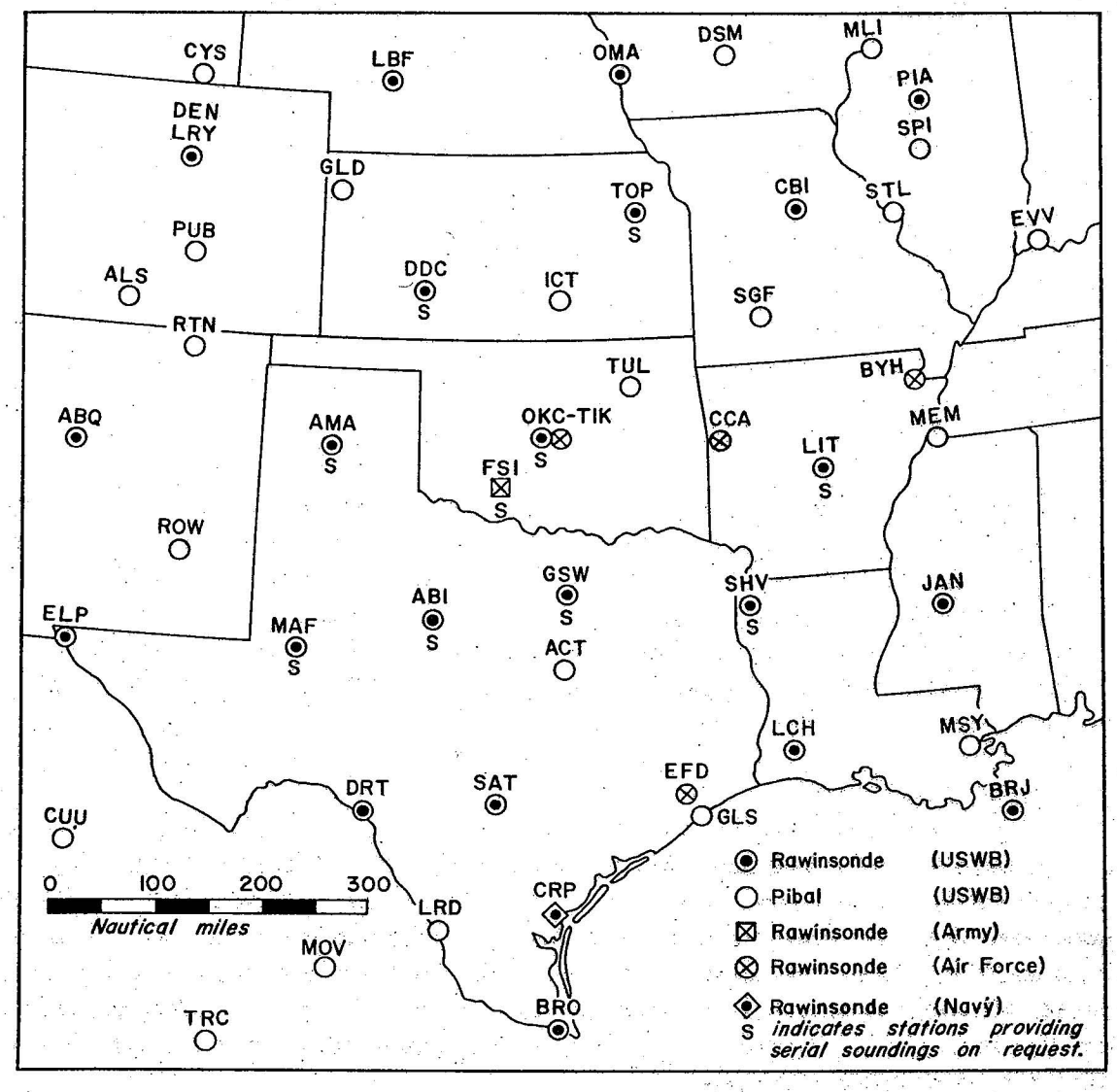

Figure 2.— Upper-air network during 1963 NSSP Operations. Stations which provided serial rawinsondes on request are designated by the letter "S" beneath the station circle.

Fort Sill either in response to requests by NSSP or in fulfillment of their own requirements. The program at Fort Sill, to satisfy their own requirements did provide, however, a large number of serial low-level rawinsondes, some covering periods of up to 36 hours. Stations which provided serial soundings on request during the 1963 season are shown in figure 2 with the letter "S" directly underneath the station circle.

D. Sferics Network

1. 500 kc. per sec. sferics. The Electronics Division of General Mills, Inc., under contract to the Weather Bureau provided one SPARSA sferics station and one omni-directional sferics station which were located on the grounds of the Research Park at the University of Oklahoma, Norman, Oklahoma. This equipment was supplemented by a SPARSA-K system operated by General Mills under an AFCRL contract. All General Mills' equipment monitored sferics at 500 kc. per sec. and provided an output of sferics count within a range of 200 n. mi. In the SPARSA system, 5.6-degree sectors of the azimuth circle are automatically sequentially sampled. The SPARSA-K system, however, is a manually controlled directional sferics system with a variable angle of acceptance.

A description of the operation of the SPARSA unit is given in the NSSP Report No. 13 [9]. A preliminary study of the 1963 data is given in a report to the Weather Bureau by the General Mills Electronics Group [10] and substantially follows the indications given in the 1962 analysis. The SPARSA-K system, with its directional and variable angle of acceptance, was used in conjunction with a number of the C-130 aircraft flights to obtain sferics count from the particular storm around which the C-130 was flying and making electric field measurements.

2. Multi-frequency sferics. Raytheon, Inc. operated a multi-channel omni-directional sferics unit. This unit was located on the roof of the Physics Building on the south campus of the University of Oklahoma. The sampling range was from 10 kc. per sec. to 150 kc. per sec. Continuous operation was maintained from the last week of April to June 30th. In addition, a "full-sky" camera was in operation during most of the daylight hours. A report on the equipment, data, and preliminary findings is now being prepared by Raytheon.

E. Phototheodolite System

In 1963, an experimental phototheodolite system was installed on the grounds of the Research Park. The equipment used was made by Eastman Kodak Company and had a recording accuracy specified and tested to be approximately 1/10 mil. A base line of over 6,000 ft. was oriented in a north-south direction. The two phototheodolites were connected by a leased line service and were simultaneously triggered at selected intervals to take pictures of cloud growth. Unfortunately, during the season of operation, very few clouds presented themselves which were suitable for photographic purposes.

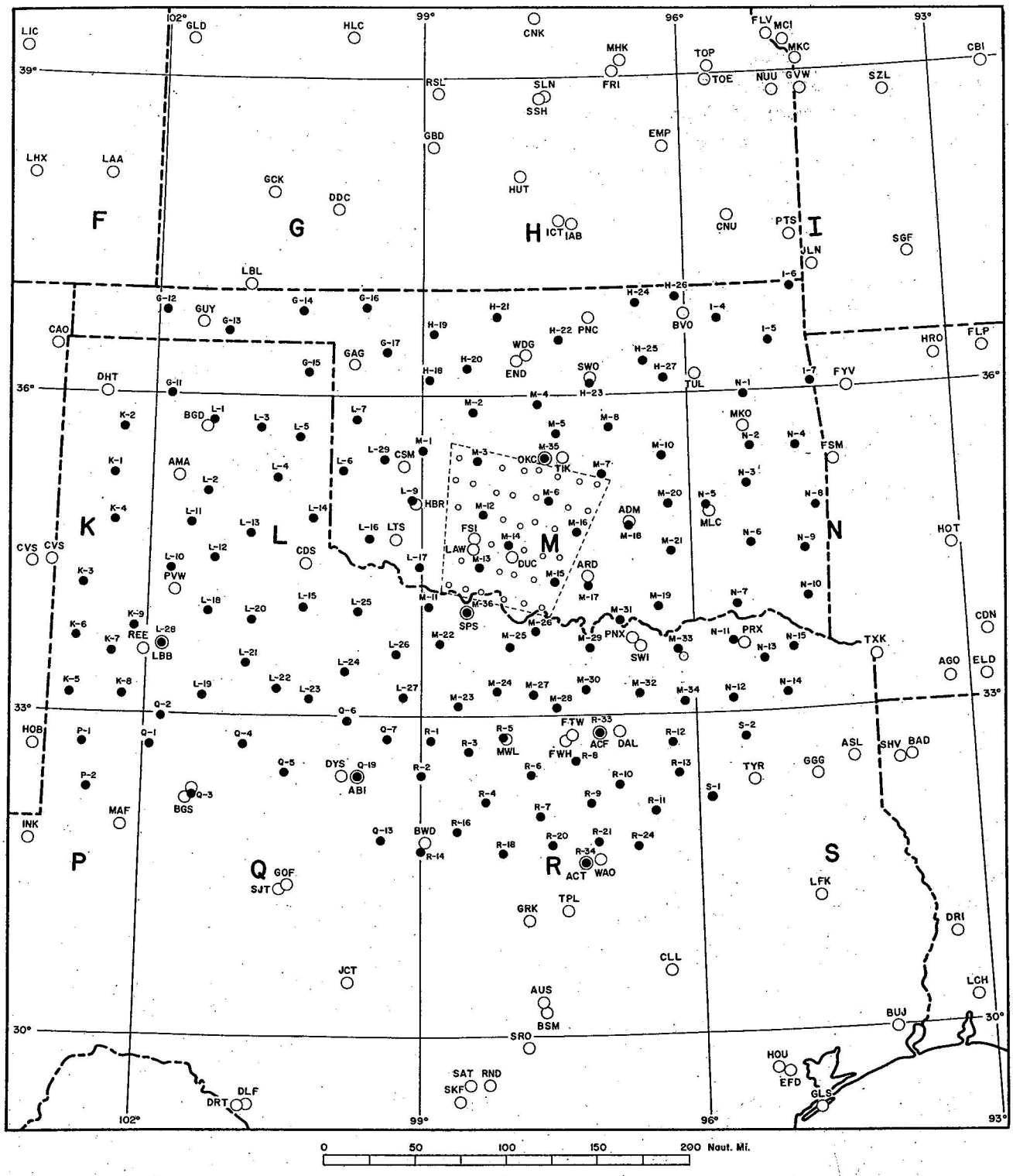

Figure 3.– NSSP Alpha surface network, 1963. Beta network is also shown by outlined area in southwestern Oklahoma.

F. Surface Networks

1. Alpha network. The surface network, which was in full operation from March 24 through June 30, 1963, remained basically unchanged from that of 1962. However, a number of Alpha stations in Texas and all Alpha stations in Kansas were removed and some of the equipment was used to extend the Beta network to cover the U. S. Department of Agriculture rain gage system in the Washita River watershed near Chickasha, Oklahoma. A detailed index of the 1961 network, which is still valid in general, has been prepared by Fujita [11].

Stations in the Alpha network, figure 3, are spaced at intervals of 30-50 n. mi., and the network covered Oklahoma and a portion of the northern part of Texas. The 130 Alpha stations were all instrumented with 12-hr. microbarographs and most with 12-hr. hygrothermographs and 24-hr. recording rain gages.

2. Beta network. Stations in the Beta network (fig. 4) are spaced in oblique checkerboard fashion in a 6 x 6 array at intervals of 10 to 15 n. mi. There is one exception - this is the extension in the northwest section to cover the U. S.

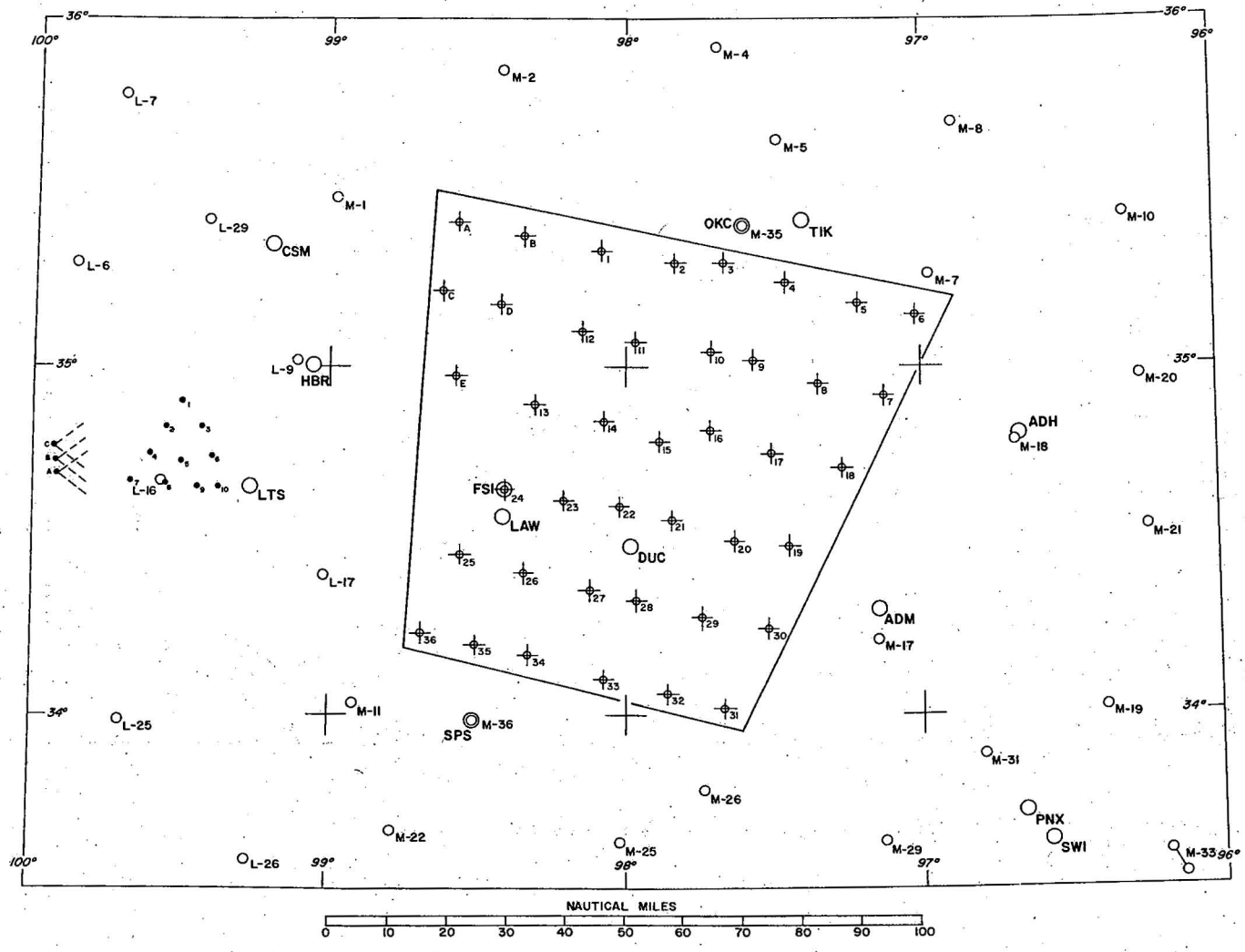

Figure 4.– NSSP Beta surface network, 1963.

Department of Agriculture rain gage network. The network covered, in general, that portion of southwest and central Oklahoma that lies between Oklahoma City, Oklahoma, and Wichita Falls, Texas. The 41 stations were instrumented with 12-hr. microbarographs and hygrothermographs, 24-hr. recording rain gages and wind recorders. Wind speed was continuously recorded and wind direction was recorded at 1-minute intervals to 16 points of the compass. A timing device at each station, twice daily, automatically sent an impulse which was recorded simultaneously on all charts at that station. This permitted a more accurate determination of the sequence of events at a particular station. A chronometer was used by field personnel to time the wind recorder records so that time compatibility between stations (dependent upon cumulative clock errors between successive chronometer comparisons) was very good. Time discrepancies between stations did not exceed 5 min., and in most cases were less than 2 min.

Appendix V contains further discussion of the Beta network data along with the condensed tabulations and significant features revealed by a preliminary examination of the 1963 data. Examples of analysis of some of these interesting features are also presented.

3. USDA rain-gage network. During the 1963 season, the Soil and Water Conservation Research Division of the Department of Agriculture at Chickasha, Oklahoma, again operated a network of 170 recording rain gages. These gages were spaced at 3-mi. intervals and were located in the northwest portion of the NSSP Beta network. This portion covers a part of the Washita watershed. These data are very accurate and very complete. Through informal arrangements, these data are made available to NSSP.

4. Altus network. In addition to the Alpha and Beta networks, there was established in the spring of 1963, under the auspices of the University of Chicago, AFCRL, and NSSP, a small network in the vicinity of Altus, Oklahoma. This network consisted of 10 surface stations as indicated in figure 5. The southern edge of the triangular pattern thus formed extended roughly along the Missouri-Kansas-Texas Railroad from the city of Altus on the east to the Harmon County line on the west. The vertex of the triangle was just northeast of Mangum, Oklahoma. Stations were spaced approximately 5 mi. apart and the center of the network was located at 34°45' latitude, 99°30' longitude. To the west of this surface network, which contained recording wind, pressure, temperature, and rainfall equipment, was set up a camera network consisting of three 35 mm. cameras located approximately along a north-south line; the southernmost camera being located on the outskirts of Hollis at latitude 34°41'24", longitude 99°54'23". The positions and orientation of the camera and surface observation stations are shown in figure 5.

Wind data collected at the surface stations of the Altus network were recorded on a type-C Belfort instrument. The output, recorded on a 20-pen Easterline-Angus recorder, gave a direction pulse every minute to 16 points of the compass; and speed by pulses indicating passage of each .1 and 1 n. mi. of air. One-

minute timing pulses were also recorded. The wind set is a completely transistorized unit requiring three 6-volt batteries for operation. Electronic circuitry, batteries and recorder are enclosed in a case mounted on the mast. The hygrothermograph, the microbarograph, and recording rain gages are similar to those used in the Beta network.

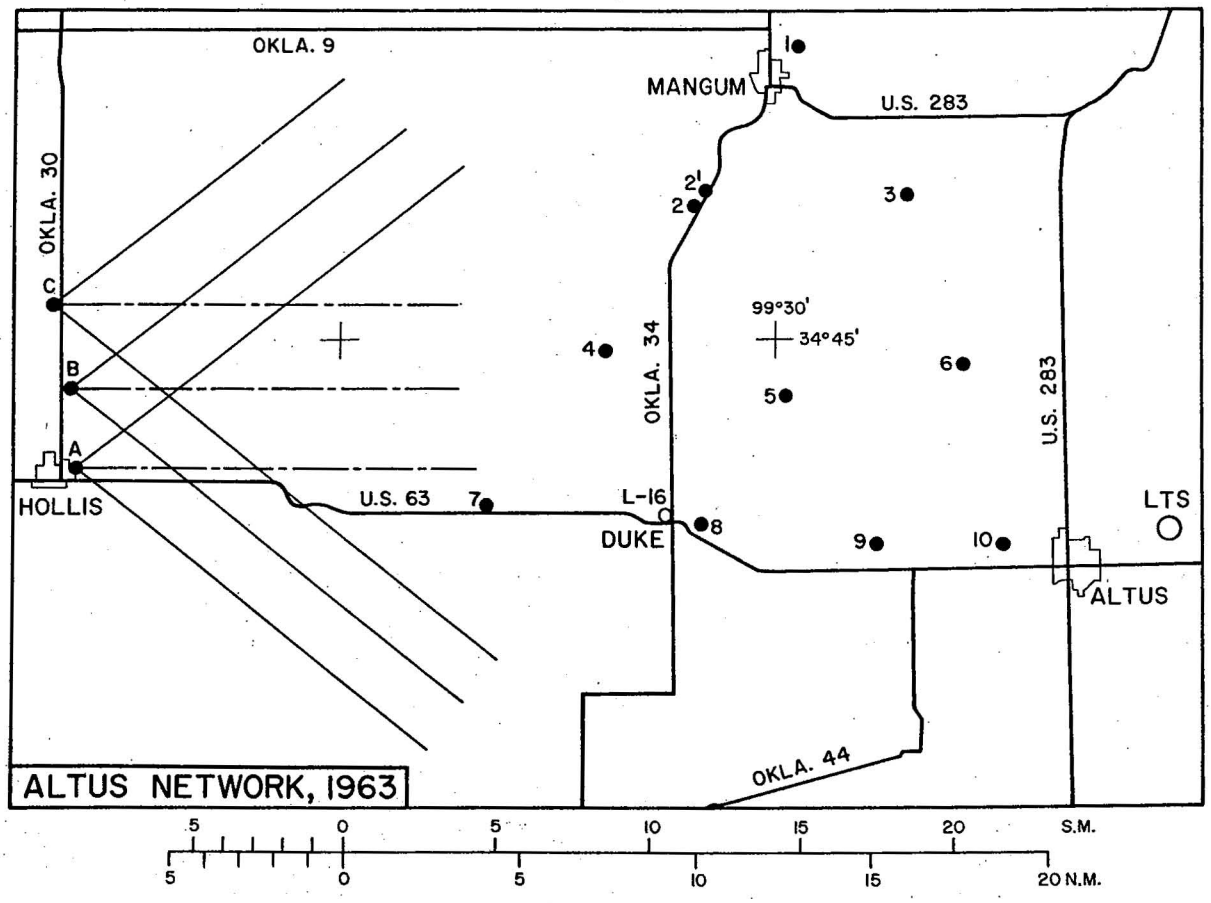

Figure 5.— Altus surface network, 1963. Cameras were sited at points A, B, and C, with the indicated angular fields of view.

Photographs were taken at the rate of 1 frame per min. at each of the 3 camera sites and were synchronized by intervalometers. A type T-232 MK-7, 35 mm. camera, which was manufactured by the Canadian Applied Research, Ltd. of Toronto, Canada, was used. The cameras were modified to give a double frame (25 x 36 mm.) format. Angular view of the lens in the vertical and horizontal was approximately 50° and 70° respectively. The cameras were so placed as to permit photographic measurements of cumulus development over the 10-station surface network. A 70 mm. panoramic camera of the type used in the U-2 aircraft was placed in a horizontal position and was located at the southernmost 35-mm. camera site, and oriented the same as the camera in that position. The 70-mm. camera included an angular view in azimuth of 180° (from north through east to south) and a vertical view above the horizon of 21°. Exposures were at the rate of approximately 1 frame per 90 sec.

All instruments were visited as early as possible each day, generally before 1200 CST. Charts were changed daily and time hacks were put on the charts according to times received from WWV. Cameras were operated 7 days a week from early morning until late afternoon.

The network was set up in order to photograph developments along the "dry line" which normally can be found in this region. It was also hoped to photograph the western side of storms which developed to the east of the station and to continue photographing as these storms moved eastward over the Beta network. At the same time it was hoped that the stereophoto network in the Norman region would photograph the advancing edge of the storm line. Such a situation never developed during the 1963 observation period. However, some interesting storm developments were observed, particularly on May 26 and on June 5. On June 5 a tornado was reported just east of the surface network. This tornado was coming from the cloud system being photographed by the surface network. Data on this storm were also collected by the C-130.

G. Special Severe Weather Reporting Network

In 1963 a special hail reporting network was established in four counties of Oklahoma. All residents, especially in the rural areas, were asked to cooperate and fill out on preprinted forms the time of occurrence of hail, tornadoes, and high winds. These counties - Caddo, Grady, Jefferson, and Stephens - were used as "control" counties to try to establish a statistical relationship between severe storm and hail occurrences as reported by the dense network and reports received through normal channels [12]. The network was also used in correlating radar echo presentations and hail size and intensity reports so that more accurate radar warning procedures can be developed.

In addition, during the period of May 11 to June 5 a group under the direction of AFCRL was in readiness to make detailed studies and ground surveys of severe storms occurring in the Oklahoma City area.

H. Aircraft

The 1963 operations saw the use of 5 aircraft in the sampling and in the operations in and around thunderstorms. The Weather Bureau RFF aircraft were unable to participate in 1963 operations due to international commitments in another area. The specially-instrumented ASD F-100F made a total of 53 thunderstorm penetrations. A T-33 aircraft was used as a chase aircraft. Penetrations this year were made at altitudes from 15,000 through 35,000 ft., and equipment operation was considered one of the most satisfactory in recent years, particularly in the recording of vertical gust measurements. The B-47 furnished by ASD participated by performing chaff drops in and around thunderstorms and thunderstorm complexes as well as taking aerial photographs of the storm systems. The experimental chaff drops were very successful and differential movement between the outer edges of the cloud system and the storm center was easily discernible. The experimental program also demonstrated that

with pinpoint chaff sources, the WSR-57 radar was able to detect the chaff even on the rear (or the side away from) the radar. The AFCRL C-130 aircraft investigated a number of storms, particularly with electric field measurement equipment, and worked closely in cooperation with the SPARSA-K sferics system of General Mills Electronics Division. On some storms the C-130, the F-100F and an AFCRL U-2 made simultaneous electric field measurements of various portions of the cloud. The U-2 flew at high levels over the top of the cloud while at the same time the F-100F penetrated the cloud and the C-130 made a box pattern around the cloud at approximately the level of the F-100F penetration. In at least 2 cases, the U-2 flew over storms which were producing tornadoes on the surface.

Table 1 gives the period during which each aircraft was available, and Table 2 is a listing of the meteorological and navigational data recorded by each aircraft.

Table 1. Availability of Observing Facilities

F-100F (ASD)	April 23 – June 6
B-47 (ASD)	April 23 – June 6
C-130 (AFCRL)	May 10 – June 7
U-2 (AFCRL)	May 10 – June 7
Radar Program:	
WRL WSR-57	April 15 – June 30
WRL MPS-4	April 15 – June 30
TIK CPS-9	May 11 – June 5
OKC FPS-6	May 11 – June 5
OKC FPS-20	May 11 – June 5
Other Stations	April 15 – June 15
M-33 radar (WB – Univ. of Oklahoma)	May 15 – June 30
Sferics, omni-directional and SPARSA (GM)	May 10 – June 30
Sferics – SPARSA-K (GM)	May 10 – June 7
Sferics – (Raytheon)	April 28 – June 30
Rawinsonde Serials (WB & U.S. Army)	April 15 – June 30
Alpha Surface Network	April 1 – June 30
Beta Surface Network	April 1 – June 30
Altus Surface Network	May 16 – June 7
Altus Camera Network	May 22 – June 7
Special Hail Reporting Network	April 15 – June 10
Phototheodolites	April 15 – June 15
Damage Survey Teams	May 11 – June 5
TIROS Cloud Photography	April 1 – June 30

Table 2. NSSP Aircraft Observational Capabilities

PARAMETERS	F–100F	C–130	U–2
Free air temperature	A	A	A
Humidity	–	A	–
Liquid water content	A	A	–
Wind speed and direction	–	–	A
Pressure altitude	A	A	A
Gusts (lateral and vertical)	A	–	–
Differential pressure	A	–	–
Refractive index	–	A	U
Electric field strength	A	A	A
Aircraft charge	–	A	–
Atmospheric electricity conductivity	–	–	U
Static discharges	A	A	–
Drop–size camera	F (70mm)	–	–
Droplet sampler	–	A	–
Luminous intensity in cloud	–	A	–
Hail mass (strain gage)	A	–	–
Cloud drop temperature (Infrared radiometer)	A	–	U
Ozone concentration	–	–	U
Weather search radar	–	F	–
Cloud photography:			
Time lapse	F (16mm)	F (T–11)	F (70mm)
Still	–	F (T–11)	F (35mm)
Icing detector	A	–	–
Ice crystal detector	U	–	–
Position	–	F	A
Airspeed (indicated)	A	A	A
Heading (magnetic)	A	A	A
Drift angle	–	–	A
Pitch	A	A	–
Roll	A	A	–
Time	A	A	A
IFF transponder	X	X	X
Doppler radar navigation	–	–	X

A = Analog recorder F = Film U = Unknown X = Instrument on aircraft

4. OPERATIONS

The operational season for 1963 was scheduled as April 15 through June 15 with the surface network (figs. 3 and 4) operating from March 24 through June 30. During the period of operation, various collaborating groups arrived and remained for varying periods of time. In table 1 are listed the dates when the aircraft were available and, in the discussion of the surface network, the time of operation of the special network in the Altus vicinity is given. The operational period was planned to encompass the normal two distinct peaks in the frequency of tornadoes and severe storms in Oklahoma, centered near the end of April and near May 20. This year was extremely unusual in that very few storms were recorded during the operational season and the fact that a preliminary analysis of the data indicates that during the whole operational period not one large squall line passed through the area. Appendix III is a daily log of observations made and which are available for research. This daily log indicates the observational activity on each day, the times the aircraft were flying and the times at which other observational facilities were in use. Also included is a record of the serial and special rawinsonde observations requested. The material in this appendix covers all facilities except the NSSP surface networks which were in continuous operation and more of which is detailed in Appendix V.

On a typical day, the objectives for the day were determined after an analysis had been performed of the pertinent surface and upper air synoptic charts and soundings. Utilization was made of severe storm forecasting procedures to determine the extent, degree of development, and the area of development of possible organized convective activity. The objectives were such that in case one form of activity did not develop, a secondary or backup objective program was at hand. Requests were made for the desired supplemental observations such as radar-scope photography from other than the research radar, serial rawinsondes, etc.

A briefing of the commanders of the flight organizations and meteorologists was held to discuss the meteorological situation and the day's objectives. General flight patterns were prepared for the participating aircraft and the coordination of the various aircraft was accomplished so that the objectives could best be met. In some cases the actual flight pattern could not be finalized until the time the penetration aircraft were airborne, inasmuch as single-storm systems were the major target of observation during the 1963 season. In this case, the decision on the flight pattern was withheld until the nature of the convective growth and development was observed on radar.

A tape transcription was made of all air-to-ground and ground-to-air contacts between the controller and the research aircraft. These tapes were then transcribed and the time of the beginning of each comment was inserted. This procedure, it is hoped, will make possible a better correlation between the pilot reports, the aircraft recorded data and the ground observations during thunderstorm penetrations. Following the termination of each mission, debriefings were conducted.

Appendix I, 1963 NSSP Aircraft Operations, is a list of the dates on which the aircraft were flown and a brief summary of the flight objectives.

Appendix II is a list showing the individual aircraft and the days on which flights were made. No differentiation is made between the T-33 and the F-100 inasmuch as the T-33 was used basically as a chase aircraft.

5. DATA PROCESSING AND ARCHIVING

As in previous years, the plan is to process the 1963 data as rapidly as possible and archive it either at the National Weather Records Center (NWRC) at Asheville, North Carolina, or at the Weather Radar Laboratory (WRL) Norman, Oklahoma. At the time of this report some of the aircraft data are still being processed. Data from the Alpha and Beta networks are archived at NWRC, Asheville.

The following is a listing of the data gathered, their form and availability:

A. Radar

Film from Weather Bureau radar stations is archived at NWRC, Asheville, North Carolina. Film taken by the radars located at the Weather Radar Laboratory and by cooperating agencies are archived at WRL, Norman, Oklahoma. Observational data from the M-33 radar, which was operated at Norman, Oklahoma, by the Atmospheric Research Laboratory of the University of Oklahoma Research Institute, are presented in a contract report to the Weather Bureau [8].

B. Special and Serial Rawinsonde Observations

Original forms, WBAN-31A, -31B, and -31C (Weather Bureau Forms 610-14A, -14B, and -14C) and WBAN-20 (Weather Bureau Form 610-12) for the Weather Bureau stations are archived at NWRC. The original records for the observations made at Fort Sill are also filed at NWRC.

C. Sferics Data

Original observational records from the SPARSA, SPARSA-K and omni-directional sferics station operated at Norman, Oklahoma, by the General Mills Electronics Group have been retained by that organization. These data have been processed and a general summary of the SPARSA and omni-directional information has been presented in a final contract report to NSSP [10]. A similar summary of the results obtained from the SPARSA-K system has been made to AFCRL.

Original sferics observational records and "full-sky" camera photographs taken by Raytheon, Inc. are being processed and summarized by Raytheon. Original data will be retained by that organization.

D. Surface Network Data

1. Alpha and Beta. Original barograms, hygrothermograms, wind recorder charts and rain gage charts of the Alpha and Beta networks have been edited, annotated, microfilmed and bound by days. These charts and the microfilm will be archived at NWRC, Asheville, N. C.

2. USDA. Charts from the recording rain gage network operated by the Soil and Water Conservation Research Division, Agricultural Research Service, U. S. Department of Agriculture, Chickasha, Oklahoma, are retained by that group. Copies of these charts for selected cases have been obtained by NSSP and will be archived at Kansas City. Arrangements to obtain data for other dates can be made through the U. S. Weather Bureau, Kansas City.

3. Altus meso-network. The University of Chicago will retain all original records of the surface network and the original 35 mm. photographs. Copies of the 35 mm. photographs and photocopies of all of the surface network data are on file at NWRC. The original film taken by the U-2-type panoramic camera will be retained by AFCRL. Copies will be available at the University of Chicago and at NWRC.

The reports received from the special severe weather reporting network are archived at the Weather Bureau in Kansas City.

E. Aircraft Data

A substantial portion of the aircraft data have now been processed. The majority of the data will be archived at NWRC, Asheville.

Flight logs maintained by the aircraft crews, recorded inflight comments, recorded air-ground control comments and records of debriefing sessions have been transcribed and are on file at Kansas City. Specific additional data from the various aircraft are handled as follows:

1. ASD F-100F. Data from this aircraft are being processed by ASD. The data will be studied by ASD first and then the reduced data will be supplied to the Weather Bureau as soon as they become available. Because of the complexity of the data reduction from these aircraft, the complete data may not be available until the latter part of 1963.

2. ASD B-47. The original cloud photographs made by the B-47 will be retained by ASD in Dayton, Ohio. Radar-scope photographs of chaff drops made by the B-47 are available at WRL, Norman, Oklahoma.

3. AFCRL C-130. Airborne radar film, oscillograph recorder traces and calibration charts and cloud photographs from the T-11 cameras have been retained by AFCRL. Selected portions of the data will be reduced and analyzed by AFCRL and may be published in reports prepared by that organization.

4. AFCRL U-2. Flight logs and prints or film copies of the 70 mm. film from the 180° sweep, downward-looking, tracking camera have been provided to the Weather Bureau, Kansas City. Printouts of the meteorological and navigational data are also available at Kansas City. Original records, however, will be retained by AFCRL. Inquiries regarding these data can be made to AFCRL.

F. TIROS Photography

Information regarding TIROS satellite photography presented in Appendix IV has been extracted from the series of catalog preprints issued by the National Weather Satellite Center, U. S. Weather Bureau, Washington 25, D. C. Preliminary nephanalyses and additional information are given in the catalogs. The procedure for obtaining copies of the TIROS master films either in the form of positive transparencies or duplication negatives is indicated in the catalogs.

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9. Kohl, D. A., and J. E. Miller, "500-Kc./Sec. Sferics Studies in Severe Storms," National Severe Storms Project Report No. 13, (preprinted report) U. S. Weather Bureau, Washington, D. C., April 1963, 36 pp.

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12. Staff, Radar Analysis and Development Unit, "Preliminary Results of a Hail Reporting Project," Monthly Weather Review, vol. 92, No. 2, February 1964, pp. 77-78.

APPENDIX I

1963 NSSP AIRCRAFT OPERATIONS

April 25 F-100F and T-33 flew radar tracking and control test. F-100F made two test penetrations at 21,000 ft. in which hail and light to moderate turbulence were encountered (no data evaluated).

April 27 B-47 made successful chaff drop tests. Single chaff bundles were detectable on WSR-57 at a range of 75 n. mi.

May 5 T-33 and F-100F flew a penetration mission about 100 n. mi. NE of Norman. F-100F made 6 penetrations. B-47 made 6 chaff drops at 25,000 ft. on N and W sides of a cell 65 n. mi. ENE of Norman.

May 6 T-33 and F-100F flew penetration mission in weak thunderstorm cells 25-50 n. mi. SW of Norman (over Beta network). F-100F made 7 penetrations at altitudes of 15,000 and 19,000 ft.

May 11 T-33, F-100F and C-130 flew a coordinated mission to investigate severe thunderstorm activity 100 n. mi. NW of Norman. A funnel cloud was reported from the cells investigated. F-100F made 5 penetrations at 20,000 ft., encountering light hail, heavy turbulence and lightning strikes. C-130 photographed SE side of storm complex and made electric field measurements.

May 14 C-130 gathered data on the mT inversion layer in central Oklahoma.

May 15 T-33, F-100F and C-130 flew a coordinated investigation of a small thunderstorm echo complex 125 n. mi. WNW of Norman. F-100F made 3 penetrations at 25,000 ft. G.M. sferics equipment monitored penetration cells. B-47 made 5 chaff drops at 40,000 ft. around a strong thunderstorm complex 150 n. mi. W of Norman.

May 16 C-130 and U-2 flew a joint investigation of a thunderstorm complex 120 n. mi. SW of Norman, having cloud tops to 56,000 ft. CAT was encountered on the W side of the storms. T-33 and F-100F investigated a dissipating thunderstorm 95 n. mi. SW of Norman, with F-100F making 3 penetrations at 20,000 ft. Penetration aircraft diverted to a developing squall line where F-100F made 4 penetrations of a mature cell 60 n. mi. N of Norman. B-47 made 15 chaff drops at 40,000 ft. on NW and SE sides of squall line 50-100 n. mi. NNE of Norman. Aircraft investigations were supported by ground-based stereophotography, time-lapse photography and sferics observations.

May 19 C-130, T-33 and F-100F investigated thunderstorm cells 60-85 n. mi. SSE to SSW of Norman. C-130 made electric field measurements in vicinity of cells penetrated. F-100F made a total of 6 penetrations at 25,000 ft. in three cells.

May 24 C-130 and U-2 flew a photographic and electric field investigation of convective activity in vicinity of Tucumcari, New Mexico.

May 25 T-33 and F-100F flew a penetration mission at 25,000 ft. in severe convective activity W and NW of Norman. The F-100F made 2 penetrations of a cell 80 n. mi. W of Norman and 6 penetrations in 2 cells 60-95 n. mi. NW, encountering heavy turbulence and large hail. Mission was terminated due to a cracked windscreen. B-47 made 3 chaff drops at 45,000 ft. around the last penetration cell, then terminated mission due to turbulence. SPARSA-K sferics observations were made of storms penetrated.

May 26 B-47 attempted a chaff drop mission around severe thunderstorm activity S of Norman. Mission was aborted due to turbulence and inability to get close to storms. An attempt was then made to photograph the west side of the storms extending to the north of Norman, using hand-held cameras. Large hail and several tornadoes were reported from these storms.

May 29 B-47 made 11 chaff drops at 43,000 ft. to study wind field around tops of thunderstorms 100 n. mi. NNE of Norman.

May 31 C-130 and U-2 flew an electric field-photographic investigation of large thunderstorm cells north of Lubbock, Texas. (Two tornadoes were reported from these storms).

June 2 T-33, F-100F, C-130 and U-2 flew a coordinated penetration-electric field-photographic mission in thunderstorm cells 100 n. mi. west of Norman. F-100F made 6 penetrations at 20,000 and 30,000 ft.

June 3 C-130 investigated the development of severe thunderstorm activity in the Texas Panhandle. Mission was terminated due to generator trouble.

June 5 T-33, F-100F, and C-130 made a coordinated investigation of a N-S line of thunderstorms 100 n. mi. W of Norman. F-100F made 5 penetrations at 25,000, 30,000, and 35,000 ft. C-130 made electric field measurements of penetration cells, photographed the N end of the line of thunderstorms, then made 4 chaff drops to study the wind field around the southern end of the line.

June 6 B-47 made 10 chaff drops at 25,000 to 30,000 ft. around an area of strong convective activity 120 to 150 n. mi. NW of Norman to study the wind field.

APPENDIX II

INDIVIDUAL AIRCRAFT FLIGHT DAYS

F-100F	April 25*, May 5, 6, 11, 15, 16, 19, 25, June 2, 5
C-130	May 11, 14, 15, 16, 19, 24, 31, June 2, 3, 5
B-47	April 27, May 5, 15, 16, 25, 26, 29, June 6
U-2	May 16, 24, 31, June 2

*Test flight

APPENDIX III

NSSP OPERATIONAL LOG, 1963

The following pages contain a listing of data collected by NSSP during the spring of 1963. The time interval (1100 to 2400 CST) covers the bulk of irregularly collected data although some radar observations were made during other hours.

The Alpha and Beta surface networks, which have been omitted from this tabulation, were in continuous operation from April 1 to June 30. The Altus surface network was in operation from May 16 to June 7. Times shown for the aircraft are the total flight times and do not necessarily indicate the period of data collection. Each aircraft did not necessarily record on every flight all meteorological parameters for which it was instrumented, this depending on the flight objectives and the operational status of the instrumentation.

The following comments pertain to specific types of data:

1. Aircraft. Participating aircraft were provided by the following agencies:

F-100F, B-47, U. S. Air Force, Aeronautical Systems Division

C-130, U. S. Air Force, Air Force Cambridge Research Laboratories

U-2, U. S. Air Force, Air Force Cambridge Research Laboratories

A T-33 of the Aeronautical Systems Division served as a chase aircraft whenever the F-100F was airborne. The T-33, however, carried no recording equipment.

2. Radar. Times shown are periods during which radar-scope photography was accomplished. In cases where photography began or continued at other than the time interval in the table, suitable remarks are included. The Weather Bureau M-33 radar was operated by the University of Oklahoma, and was used mainly for serial low-level wind soundings. The periods of M-33 operation are shown by the horizontal bars, the starting time of each wind sounding is indicated by a vertical mark.

3. Serial and special rawinsondes. With the exception of Fort Sill (FSI), all stations listed are Weather Bureau stations from which NSSP serial ascents were made. The time indicated is the actual time of release for all serial rawinsonde observations requested by NSSP, for all special ascents requested by SELS, for selected "Project Springfield" ascents, and for all regularly scheduled observations (1800 CST) which constitute part of a series. The regular 1800 CST (1730 CST release time) observations are also shown whenever special observations were made at either noon or midnight, CST. SELS specials that were made by additional stations not included in this listing were not included because they were considered to be too remote from the area of concentration.

4. Sferics. All sferics data were collected by the General Mills Electronics Group and Raytheon. Observation times were as indicated.

5. TIROS. Photographic coverage of part or all of the NSSP operational area by TIROS satellite is shown in Appendix III-B. Dates, times and pass numbers were tabulated from catalogs of TIROS cloud photography.

6. Station identification list.

ABI - Abilene, Texas

ACF (GSW) - Fort Worth, Texas

AMA - Amarillo, Texas

DCV - Duncanville, Texas

DDC - Dodge City, Kansas

FSI - Fort Sill, Oklahoma

ICT - Wichita, Kansas

LBB - Lubbock, Texas

LIT - Little Rock, Arkansas

OKC - Oklahoma City, Oklahoma

SPS - Wichita Falls, Texas

SWW - Sweetwater, Texas

TXK - Texarkana, Arkansas

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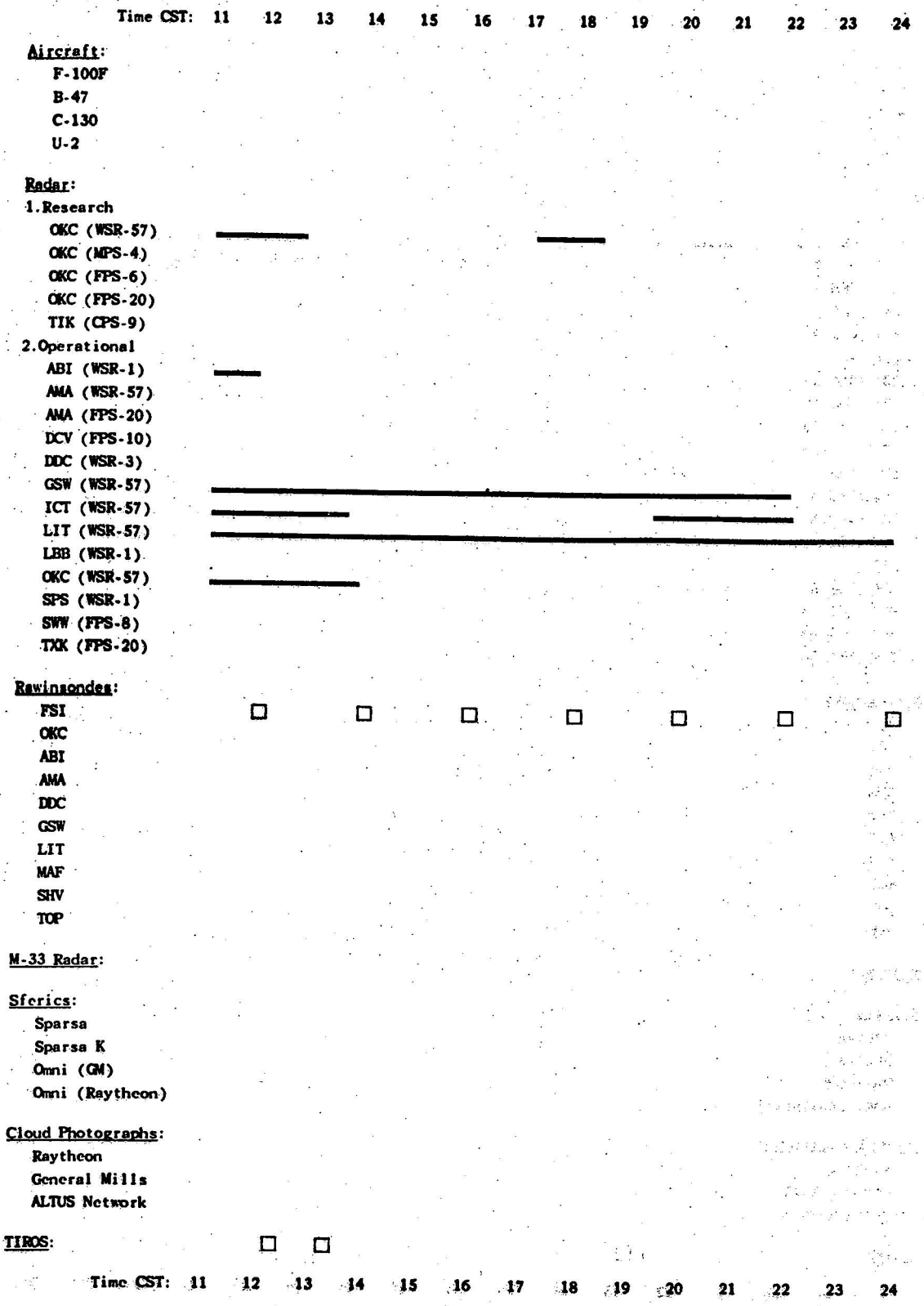

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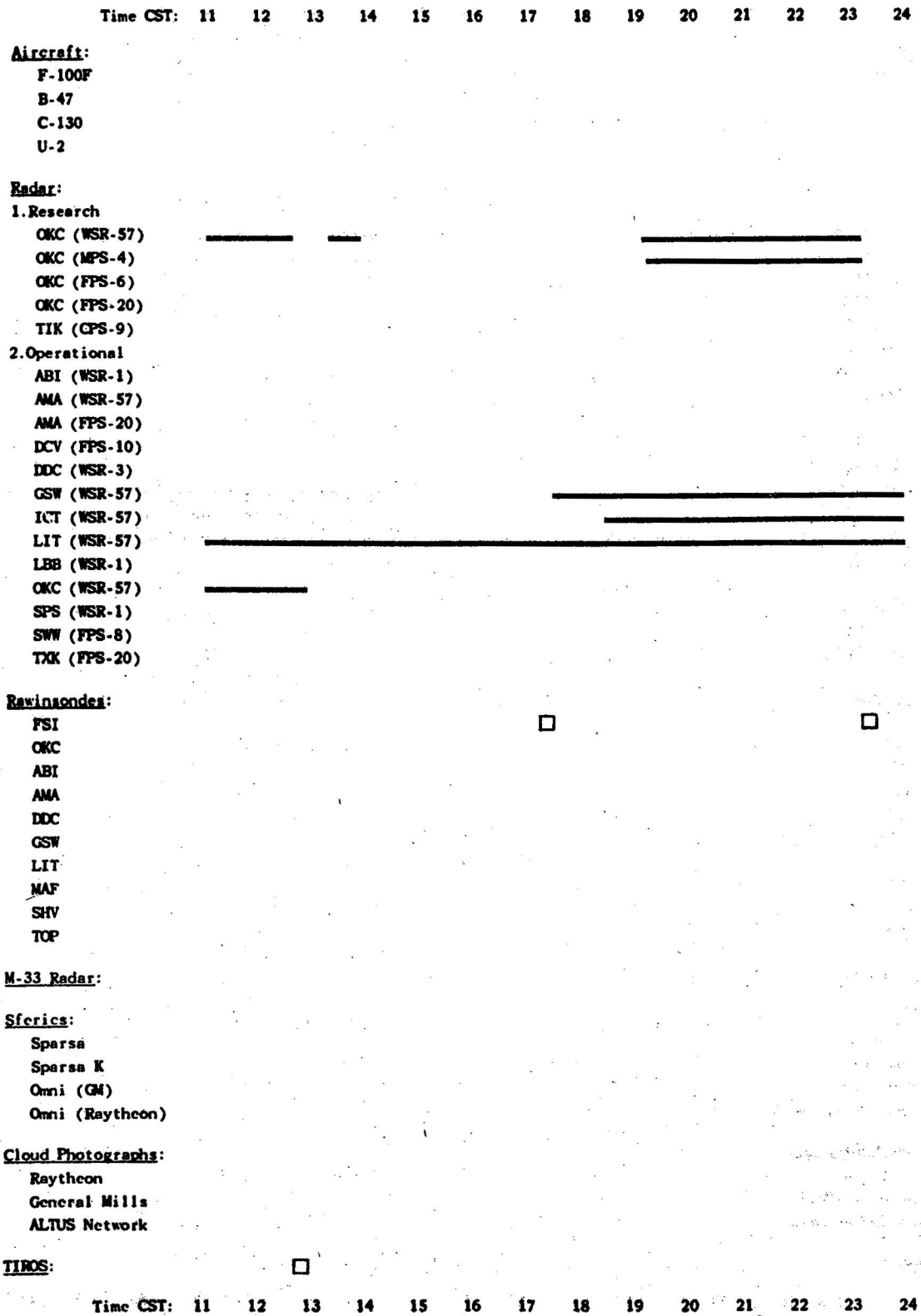

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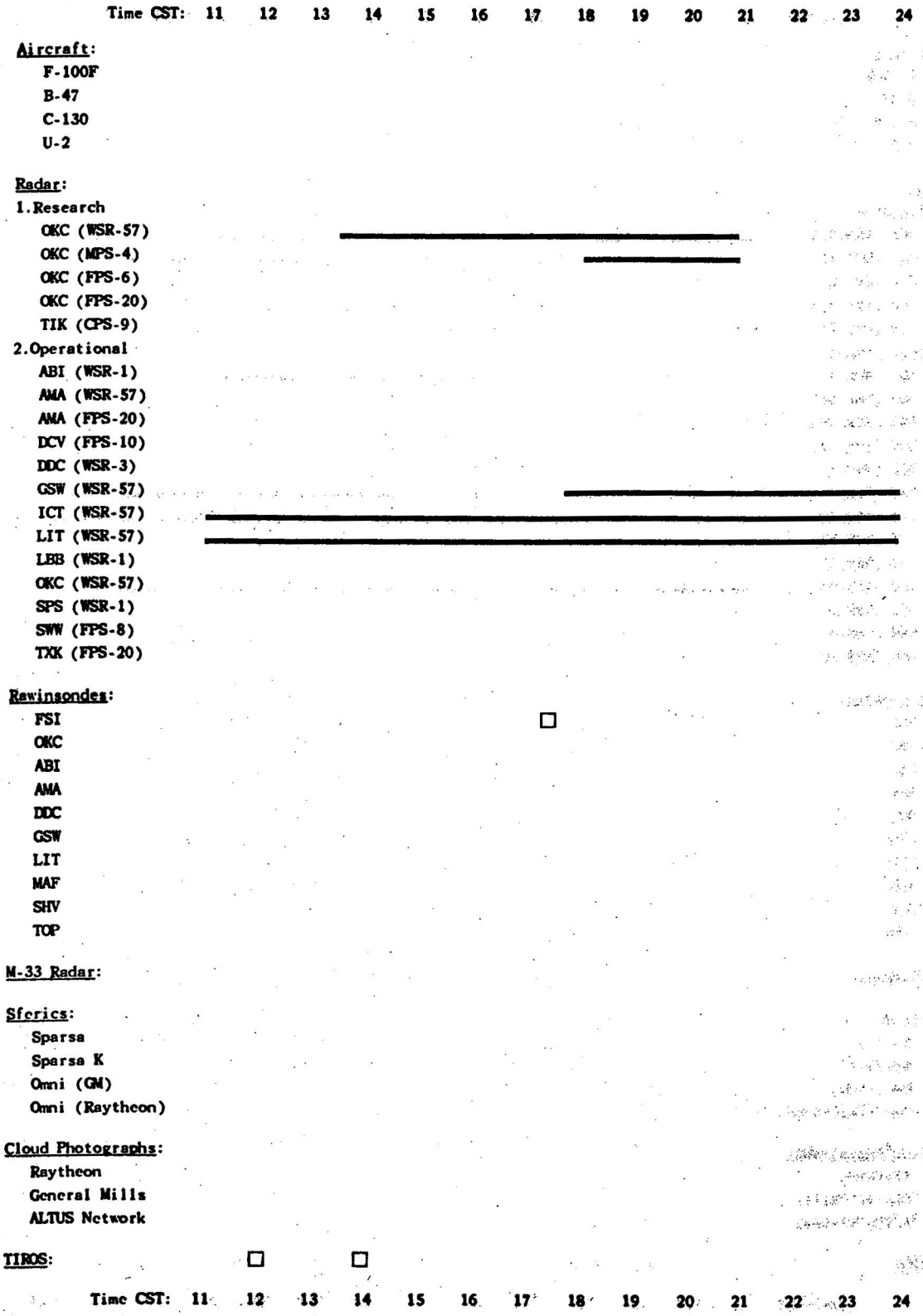

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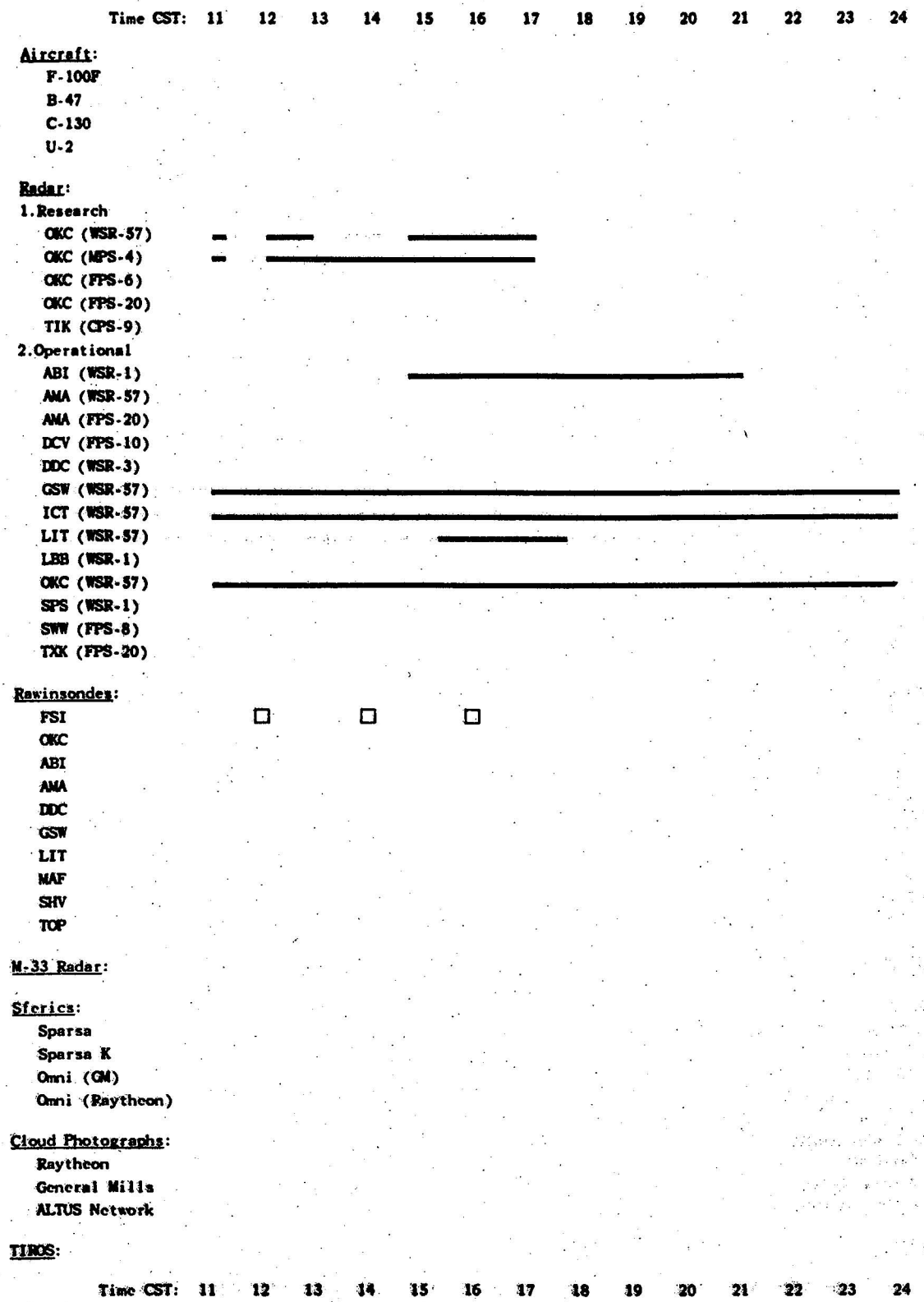

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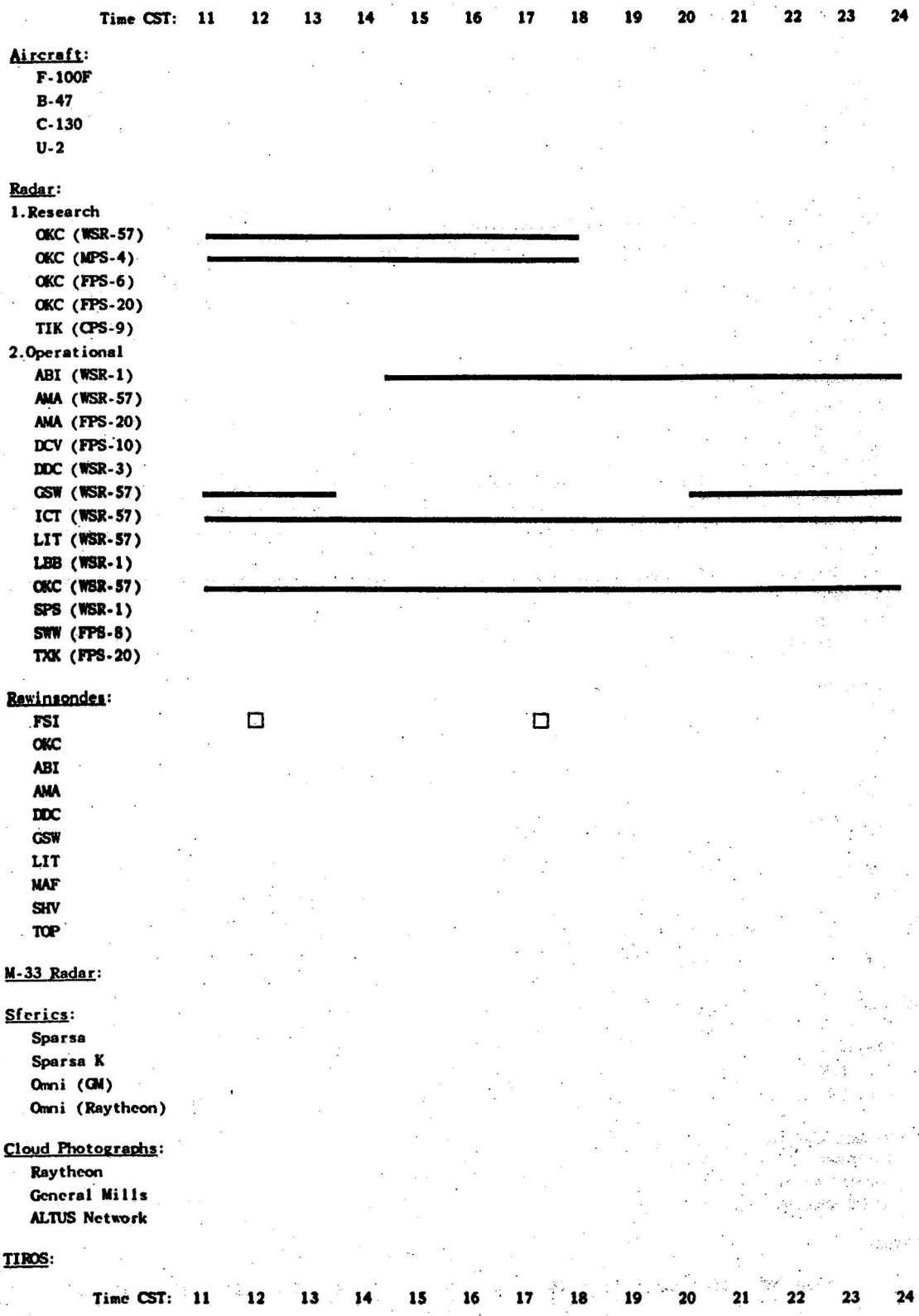

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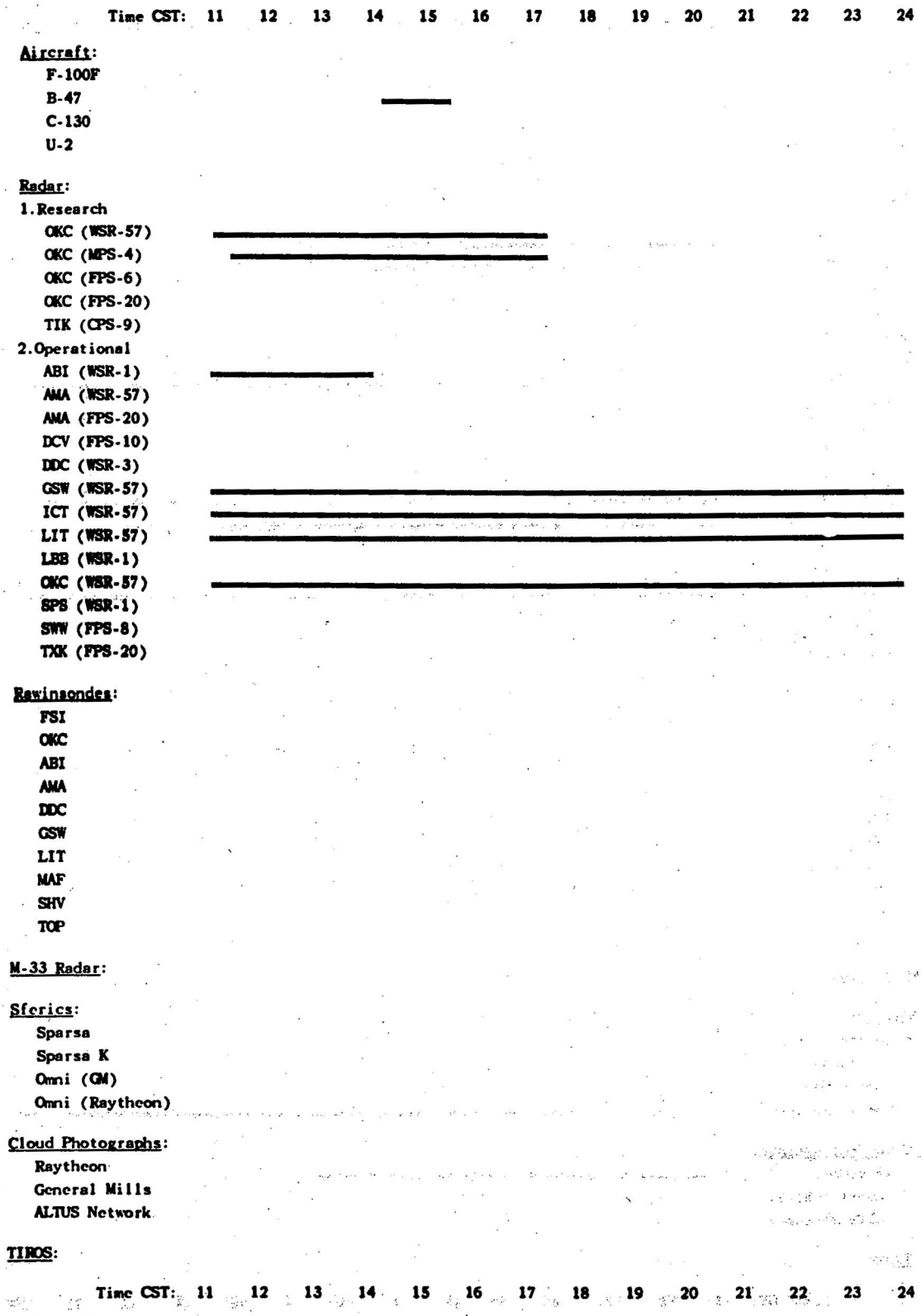

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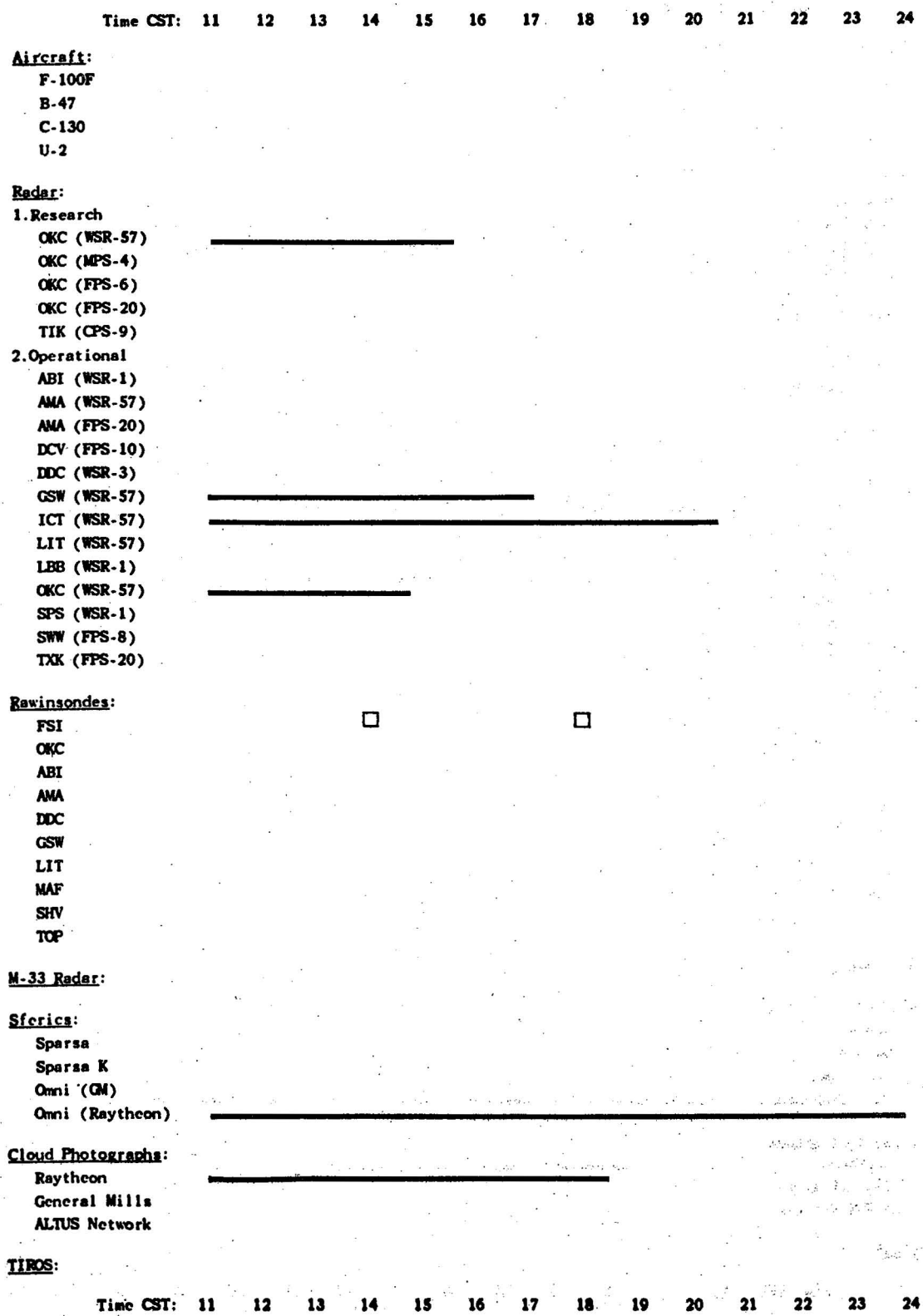
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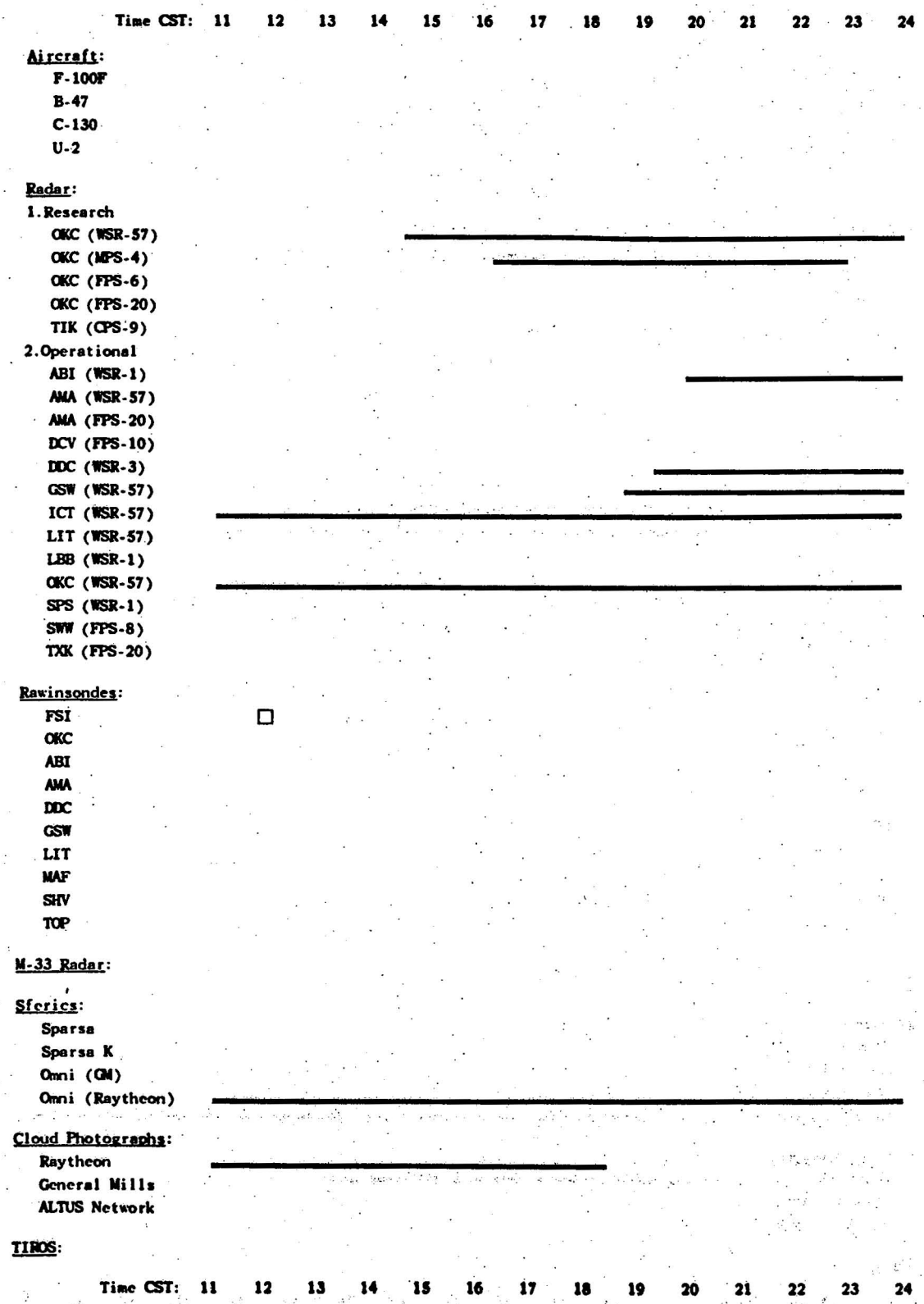
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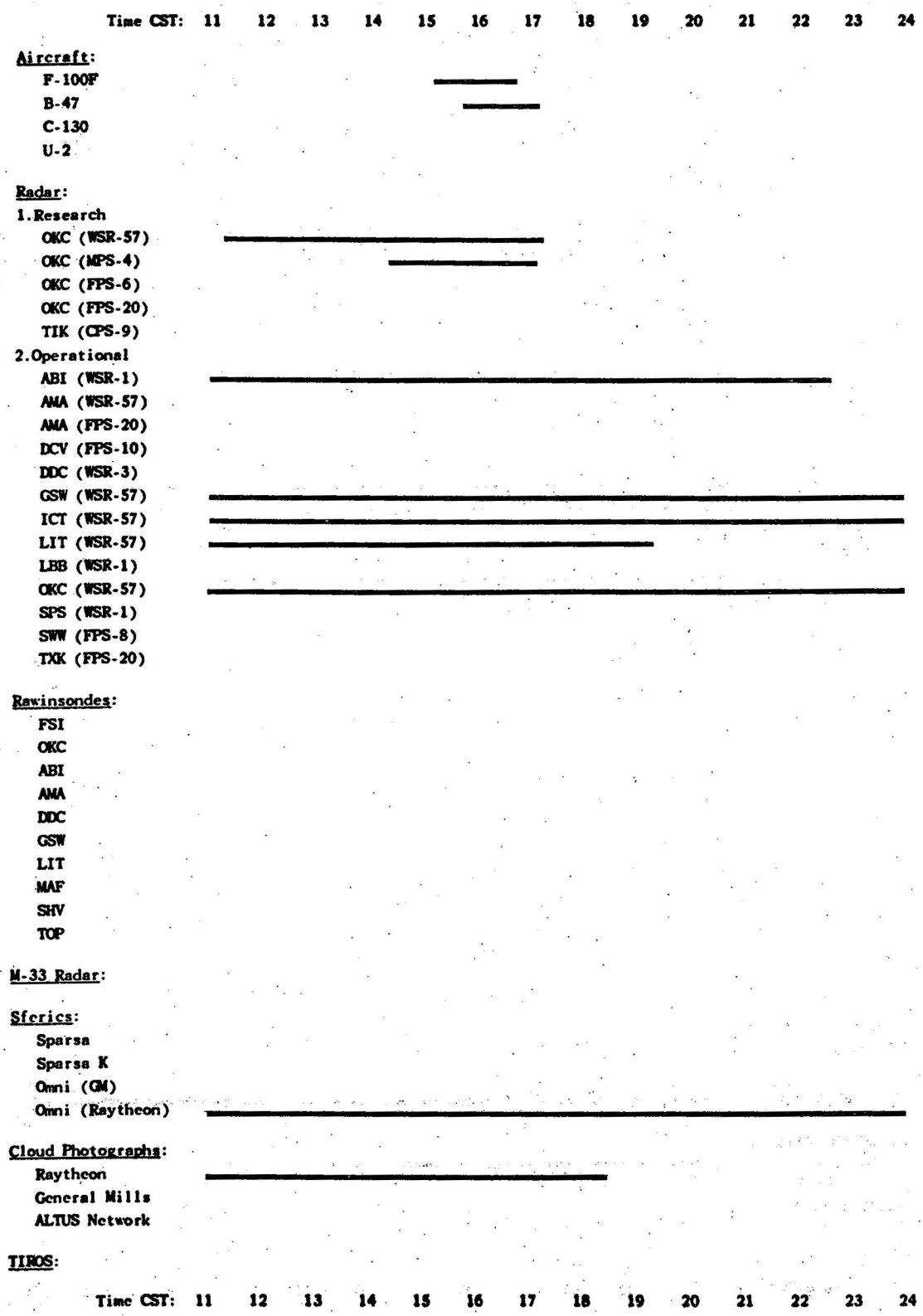
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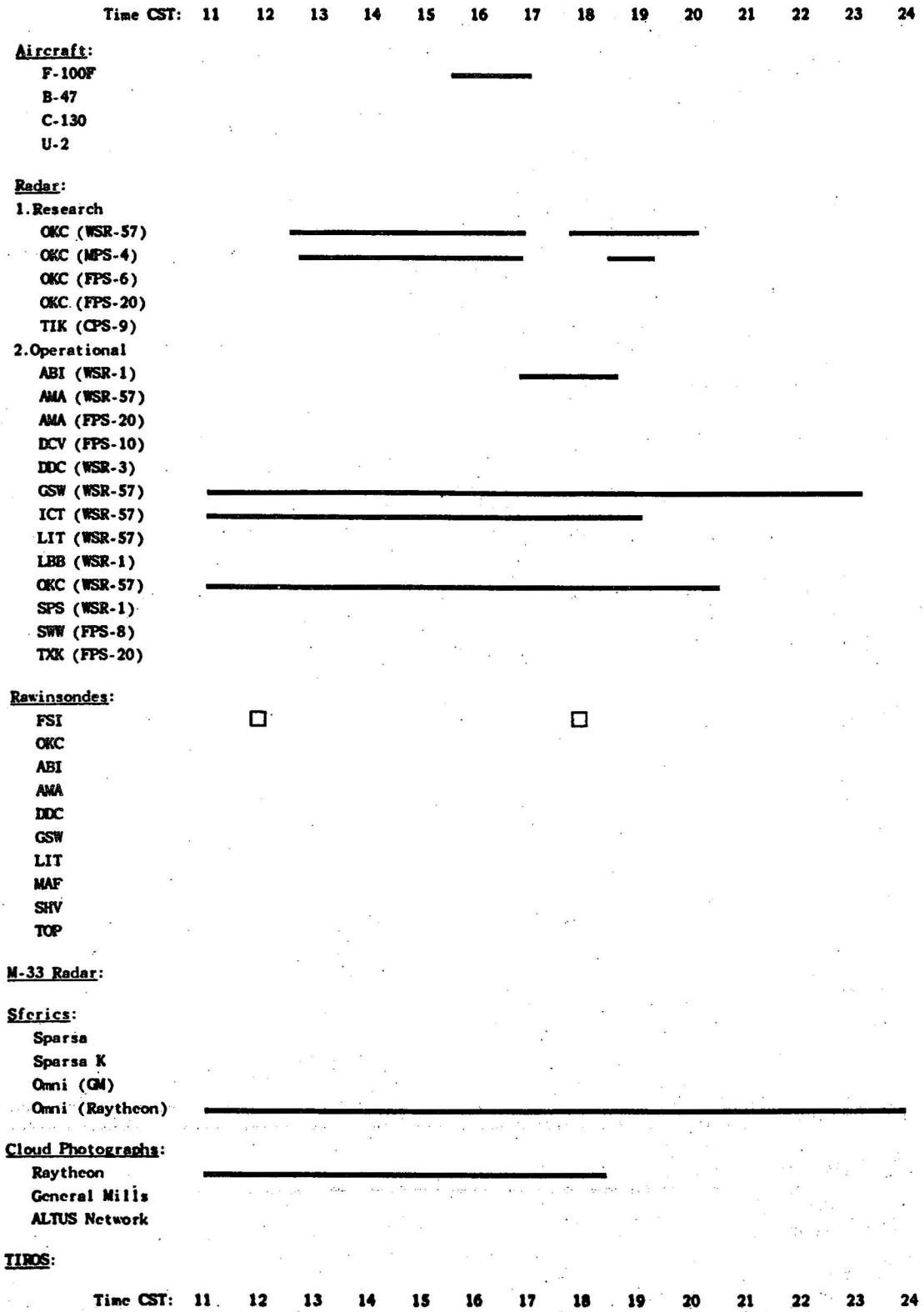
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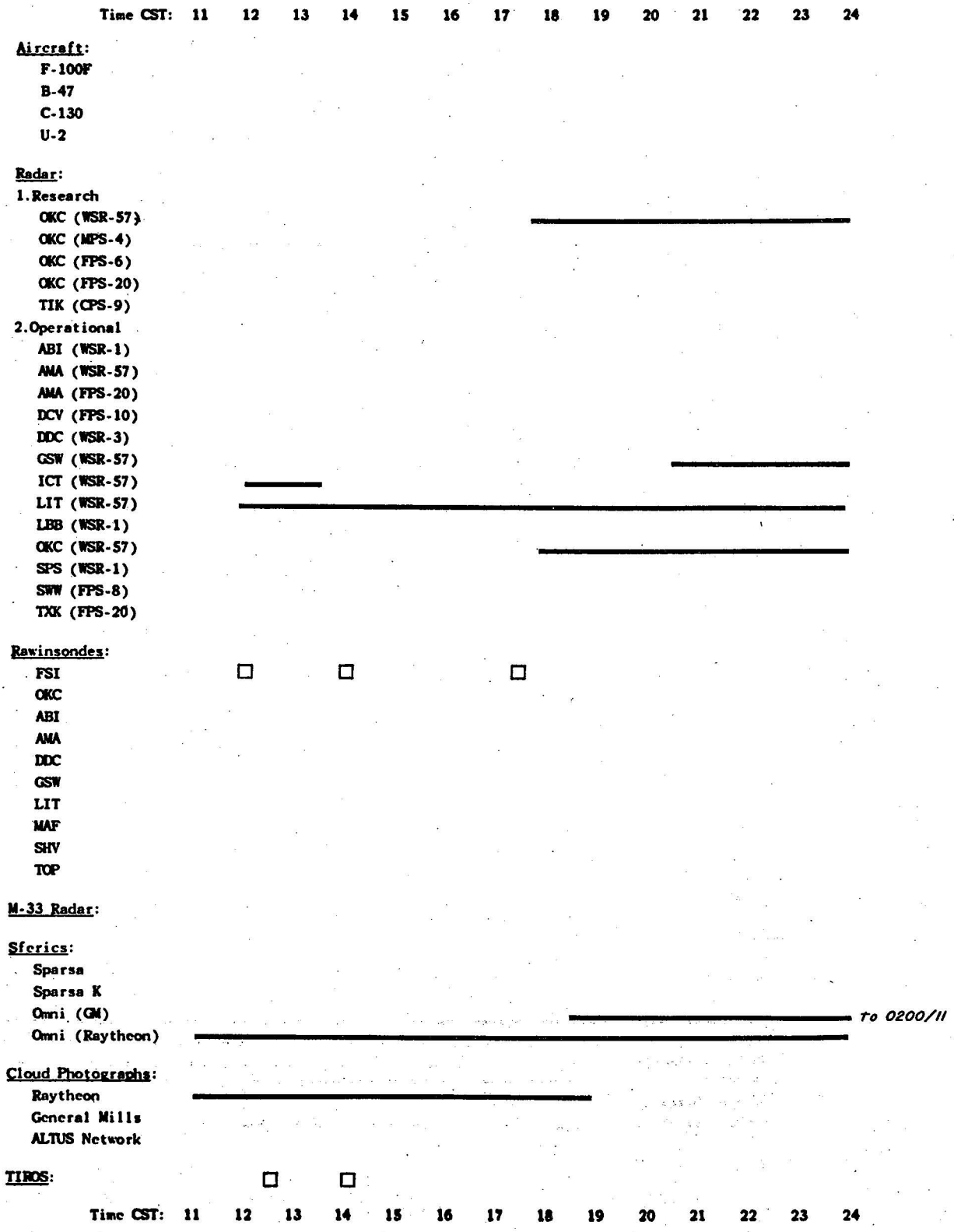
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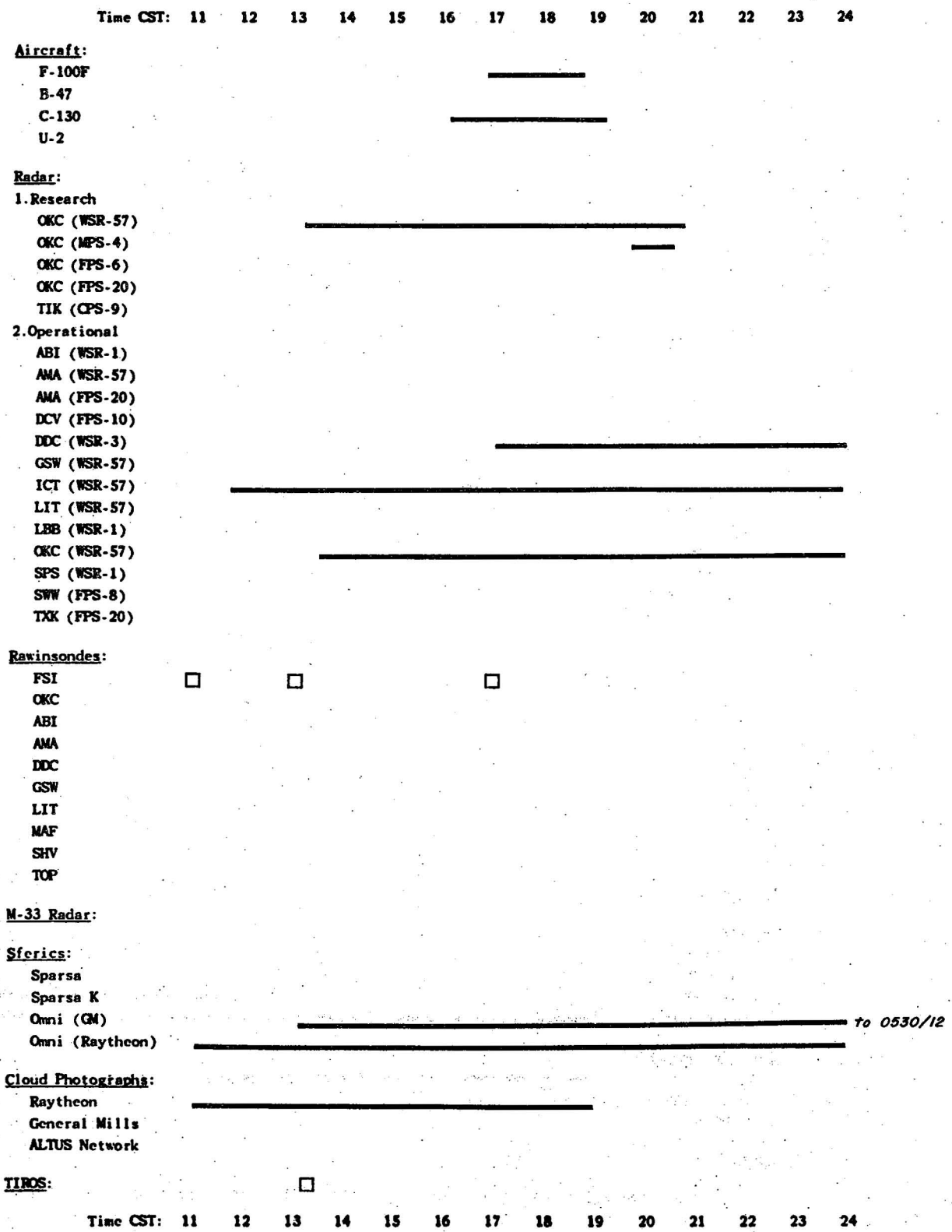
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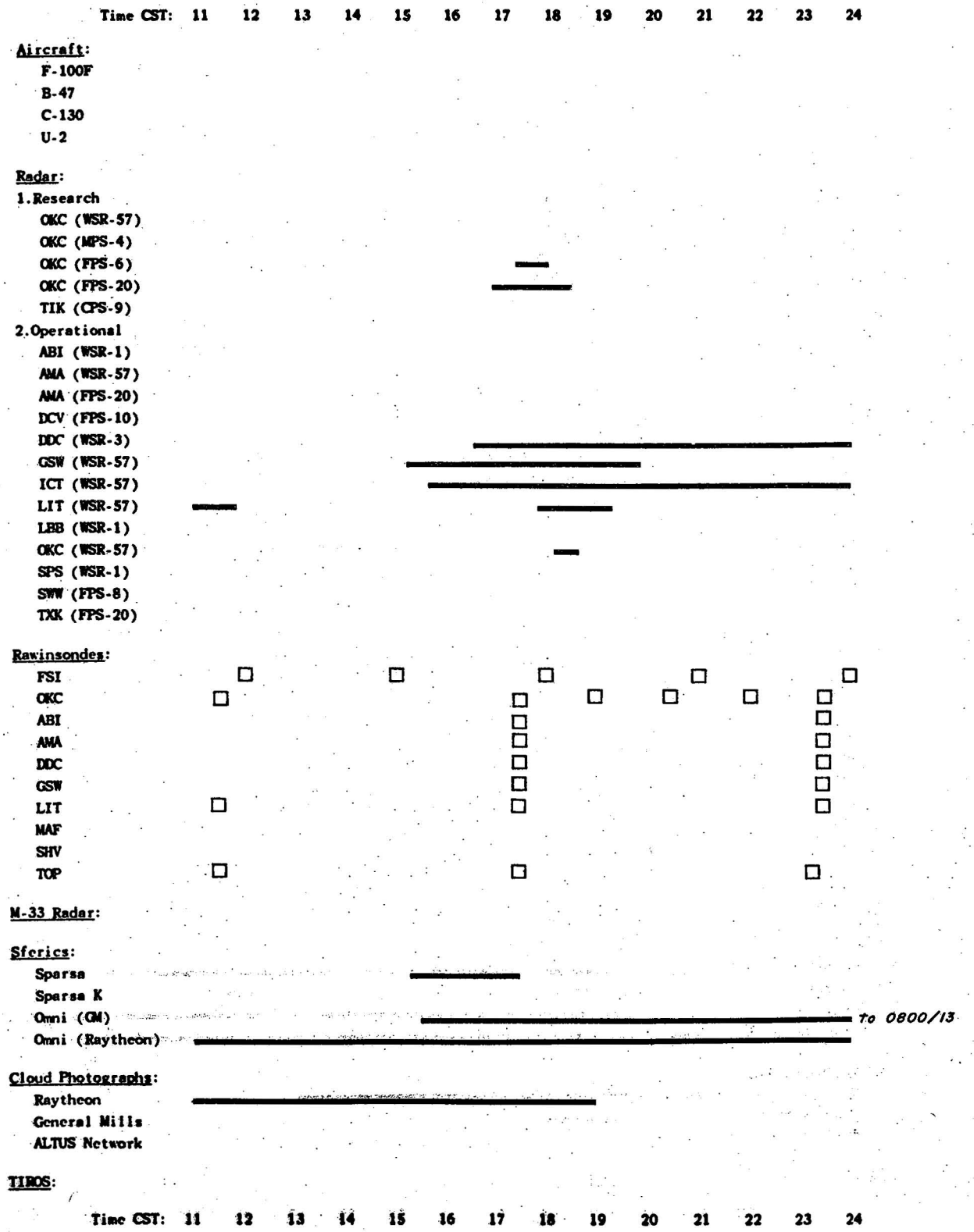
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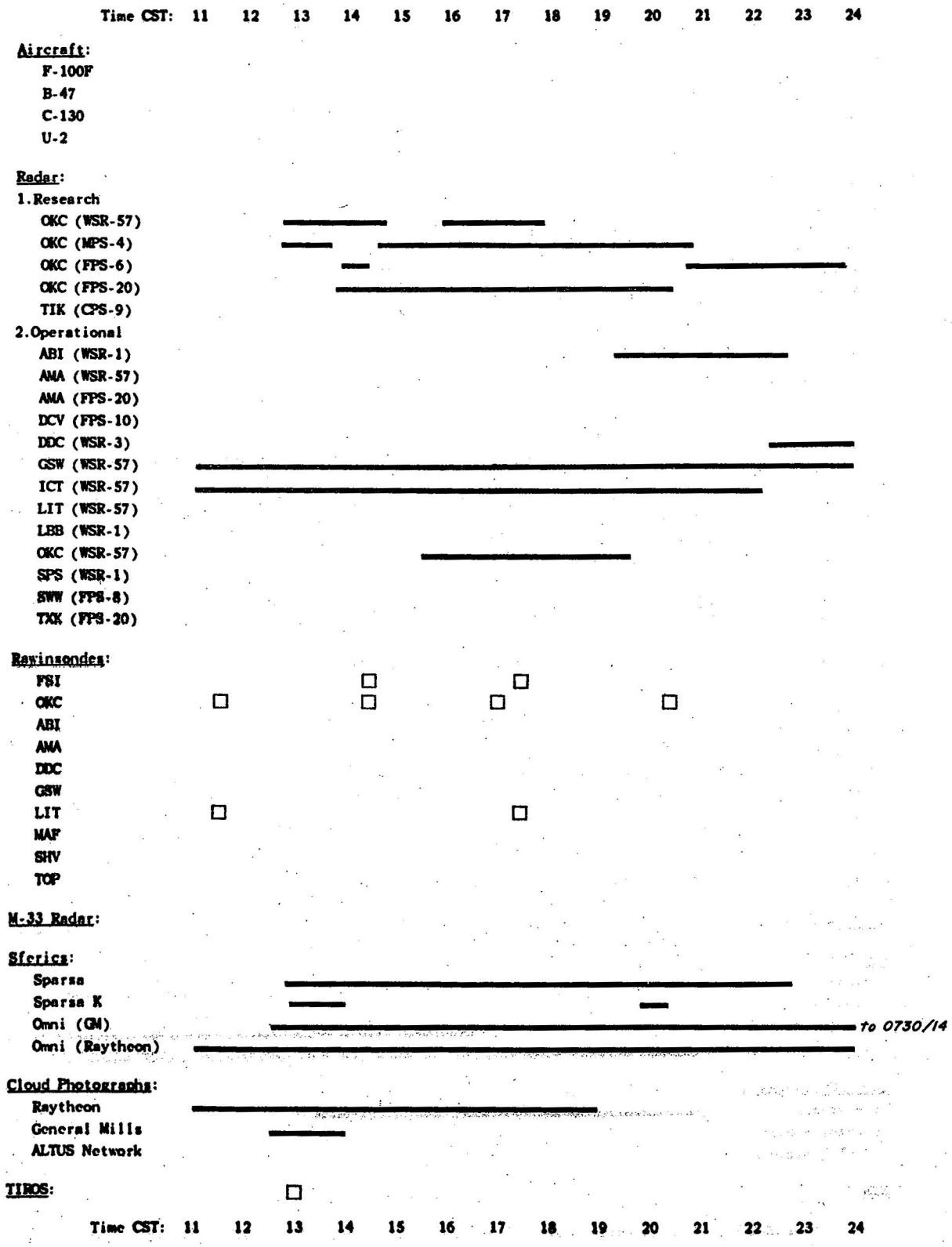
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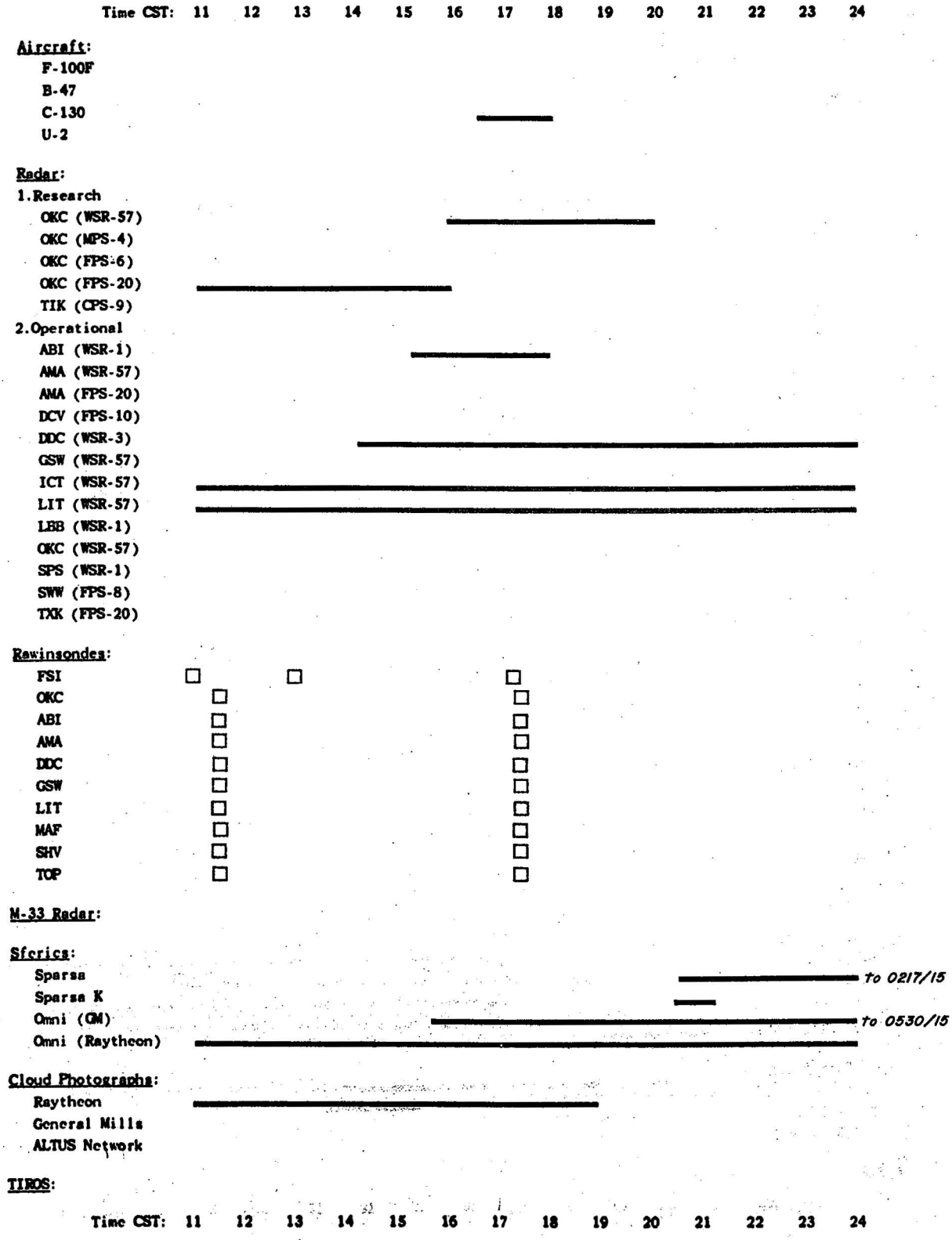
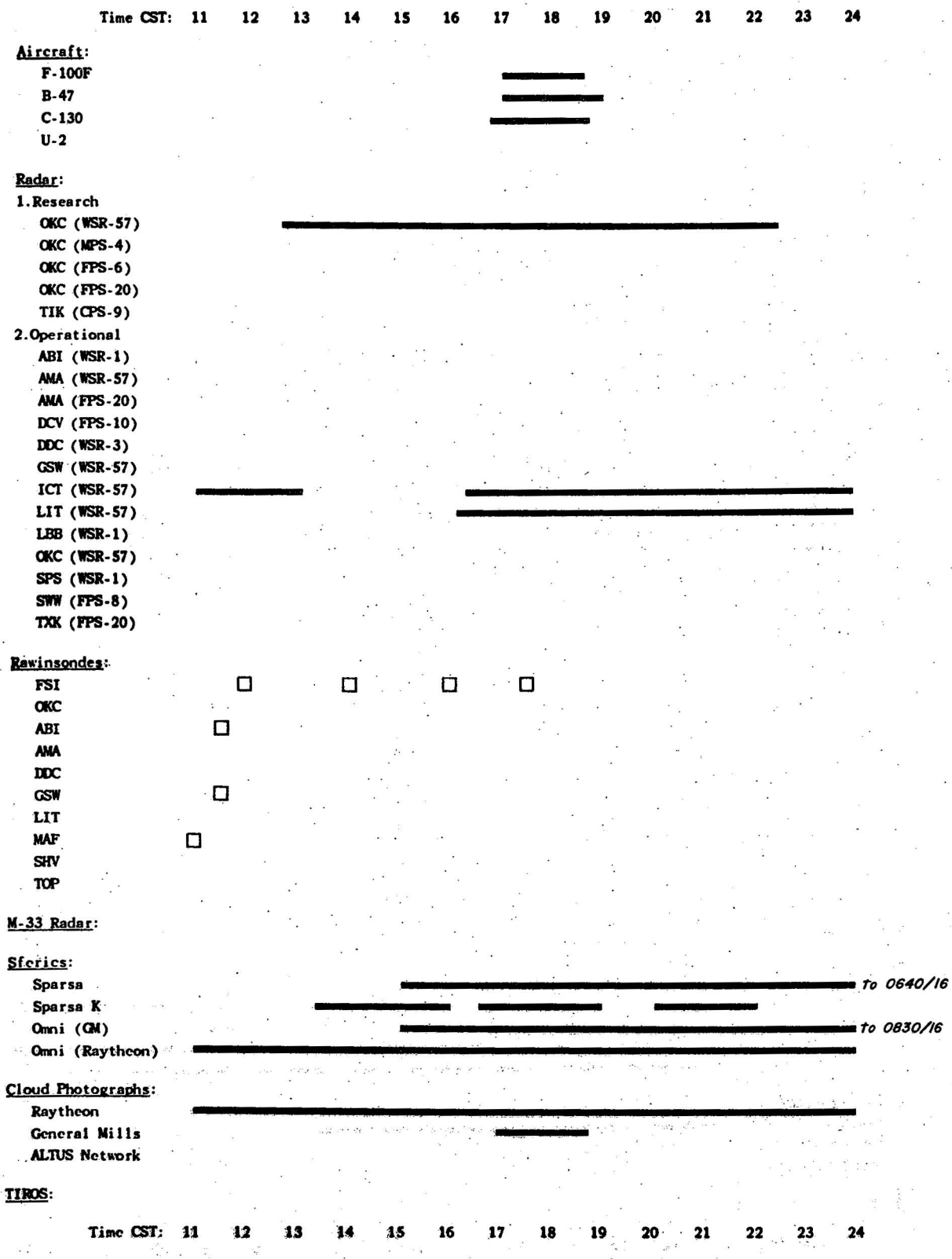
AMA (FPS-20)
DCV (FPS-10)
DDC (WSR-3)
GSW (WSR-57)
ICT (WSR-57)
LIT (WSR-57)
LBB (WSR-1)
OKC (WSR-57)
SPS (WSR-1)
SWW (FPS-8)
TXK (FPS-20)
Rawinsondes:
FSI
OKC
ABI
AMA
DDC
GSW
LIT
MAF
SHV
TOP
M-33 Radar:
Sferics:
Sparse
Sparse K
Omni (GM)
Omni (Raytheon)
to 0730/14
Cloud Photographs:
Raytheon
General Mills
ALTUS Network
TIROS:
Time CST: 11 12 13 14 15 16 17 18 19 20 21 22 23 24

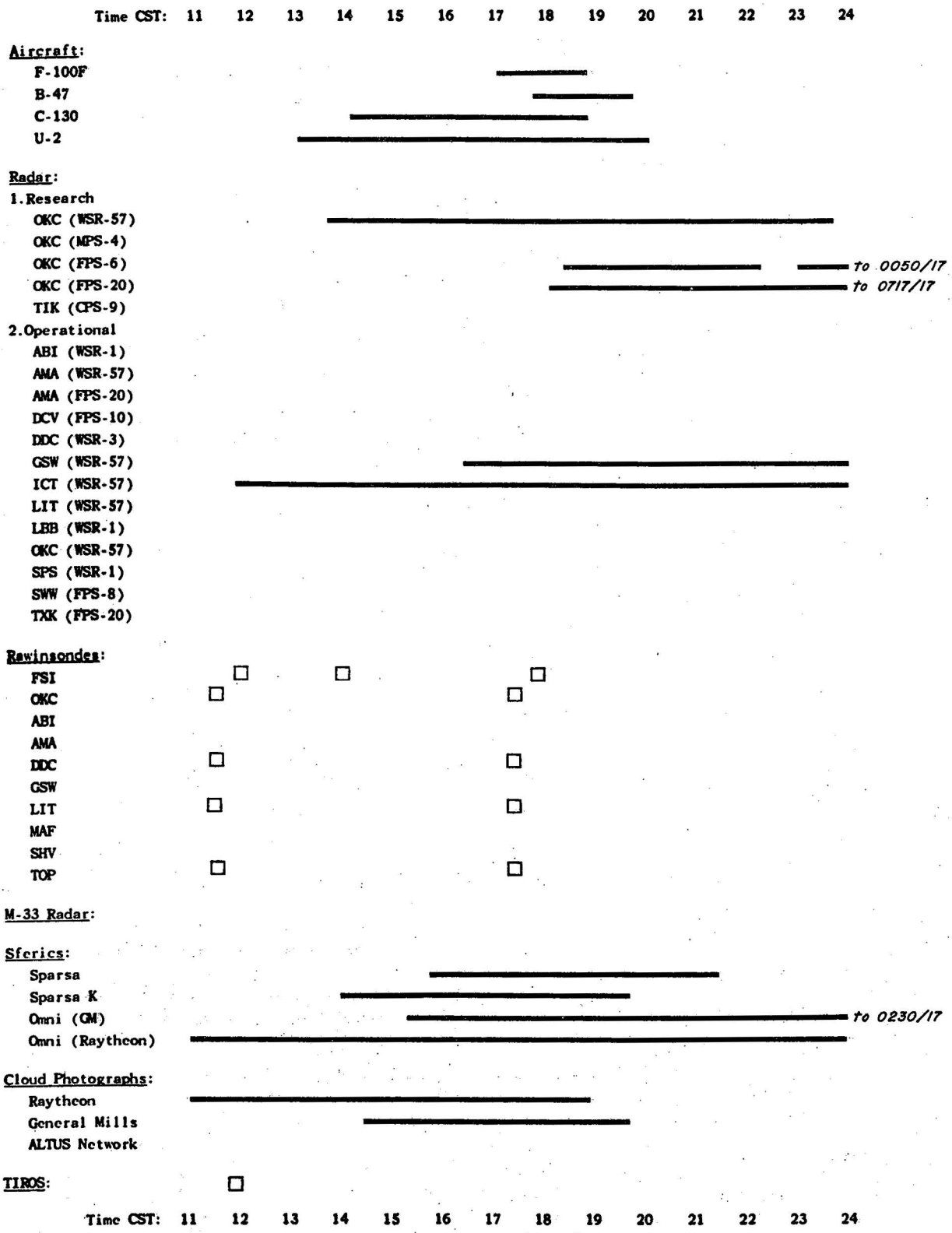
May 14, 1963


Time CST: 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Aircraft:
F-100F
B-47
C-130
U-2
Radar:
1.Research
OKC (WSR-57)
OKC (MPS-4)
OKC (FPS-6)
OKC (FPS-20)
TIK (CPS-9)
2.Operational
ABI (WSR-1)
AMA (WSR-57)
AMA (FPS-20)
DCV (FPS-10)
DDC (WSR-3)
GSW (WSR-57)
ICT (WSR-57)
LIT (WSR-57)
LBB (WSR-1)
OKC (WSR-57)
SPS (WSR-1)
SWW (FPS-8)
TXK (FPS-20)
Rawinsondes:
FSI
OKC
ABI
AMA
DDC
GSW
LIT
MAF
SHV
TOP
M-33 Radar:
Sferics:
Sparsa
Sparsa K
Omni (GM)
Omni (Raytheon)
to 0217/15
to 0530/15
Cloud Photographs:
Raytheon
General Mills
ALTUS Network
TIROS:
Time CST: 11 12 13 14 15 16 17 18 19 20 21 22 23 24

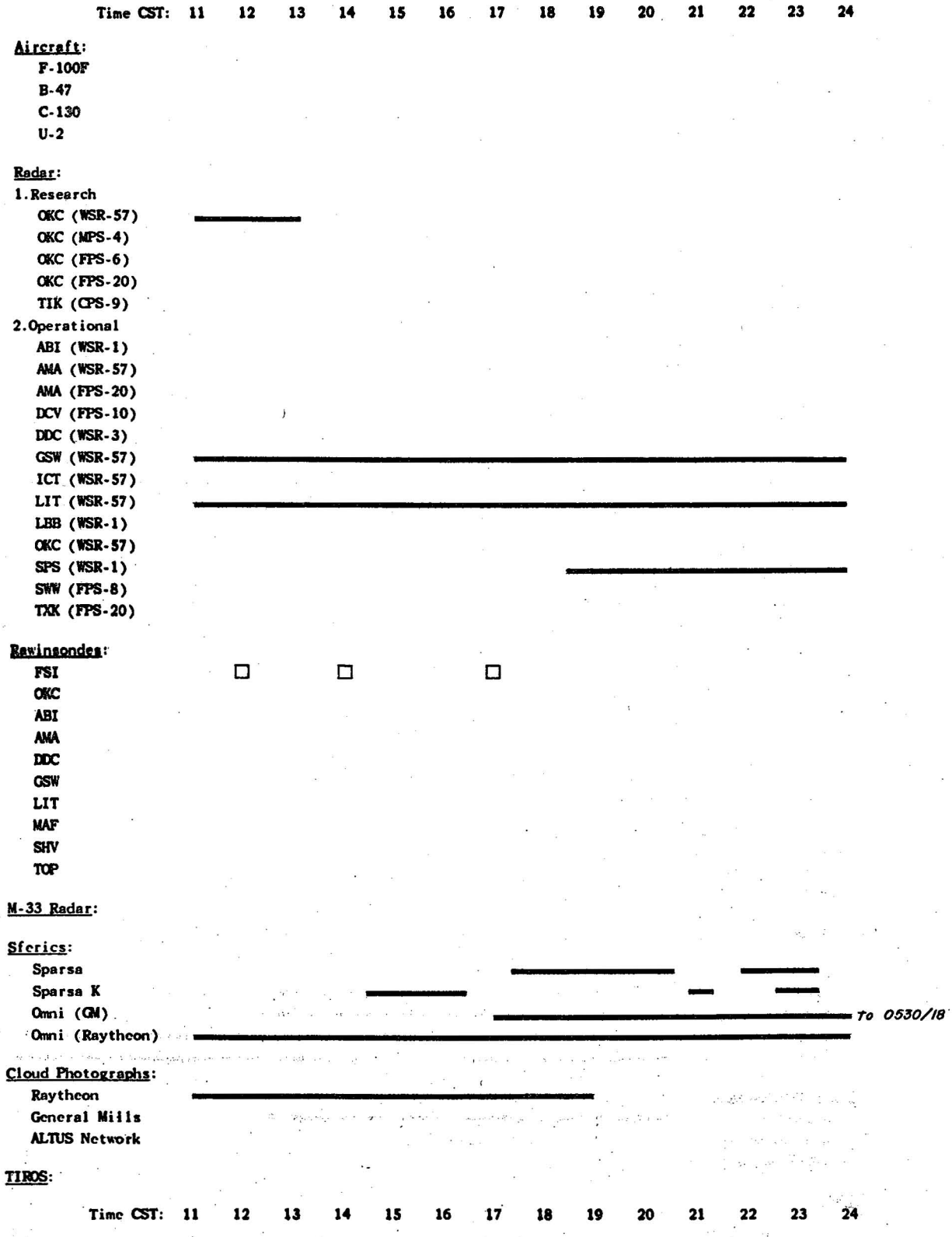
May 15, 1963


Time CST: 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Aircraft:
F-100F
B-47
C-130
U-2
Radar:
1.Research
OKC (WSR-57)
OKC (MPS-4)
OKC (FPS-6)
OKC (FPS-20)
TIK (CPS-9)
2.Operational
ABI (WSR-1)
AMA (WSR-57)
AMA (FPS-20)
DCV (FPS-10)
DDC (WSR-3)
GSW (WSR-57)
ICT (WSR-57)
LIT (WSR-57)
LBB (WSR-1)
OKC (WSR-57)
SPS (WSR-1)
SWW (FPS-8)
TXK (FPS-20)
Rawinsondes:
FSI
OKC
ABI
AMA
DDC
GSW
LIT
MAF
SHV
TOP
M-33 Radar:
Sferics:
Sparsa
Sparsa K
Omni (GM)
Omni (Raytheon)
to 0640/16
to 0830/16
Cloud Photographs:
Raytheon
General Mills
ALTUS Network
TIROS:
Time CST: 11 12 13 14 15 16 17 18 19 20 21 22 23 24

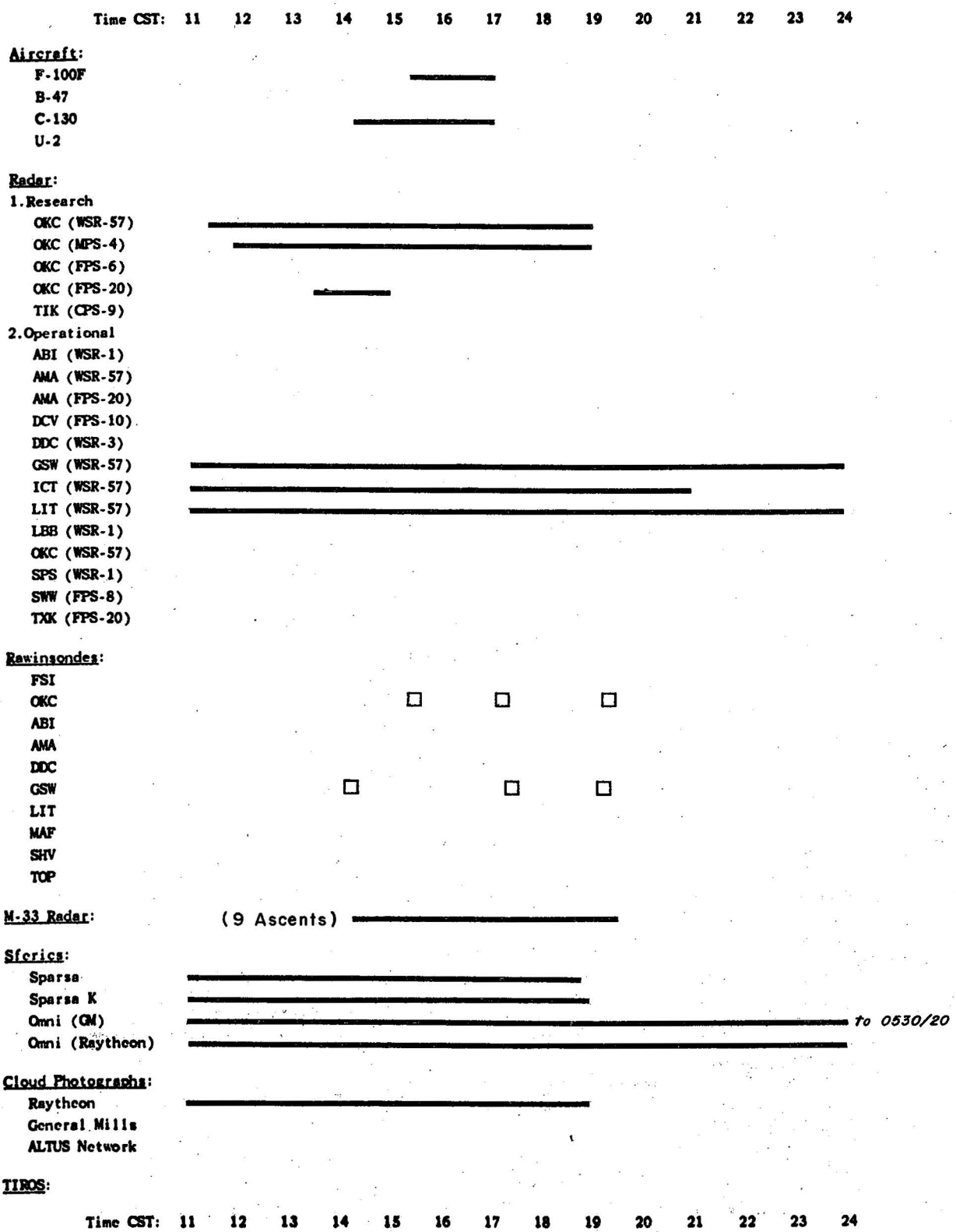
May 16, 1963


Time CST: 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Aircraft:
F-100F
B-47
C-130
U-2
Radar:
1. Research
OKC (WSR-57)
OKC (MPS-4)
OKC (FPS-6)
OKC (FPS-20)
TIK (CPS-9)
to 0050/17
to 0717/17
2. Operational
ABI (WSR-1)
AMA (WSR-57)
AMA (FPS-20)
DCV (FPS-10)
DDC (WSR-3)
GSW (WSR-57)
ICT (WSR-57)
LIT (WSR-57)
LBB (WSR-1)
OKC (WSR-57)
SPS (WSR-1)
SWW (FPS-8)
TXK (FPS-20)
Rawinsondes:
FSI
OKC
ABI
AMA
DDC
GSW
LIT
MAF
SHV
TOP
M-33 Radar:
Sferics:
Sparsa
Sparsa K
Omni (GM)
Omni (Raytheon)
to 0230/17
Cloud Photographs:
Raytheon
General Mills
ALTUS Network
TIROS:
Time CST: 11 12 13 14 15 16 17 18 19 20 21 22 23 24

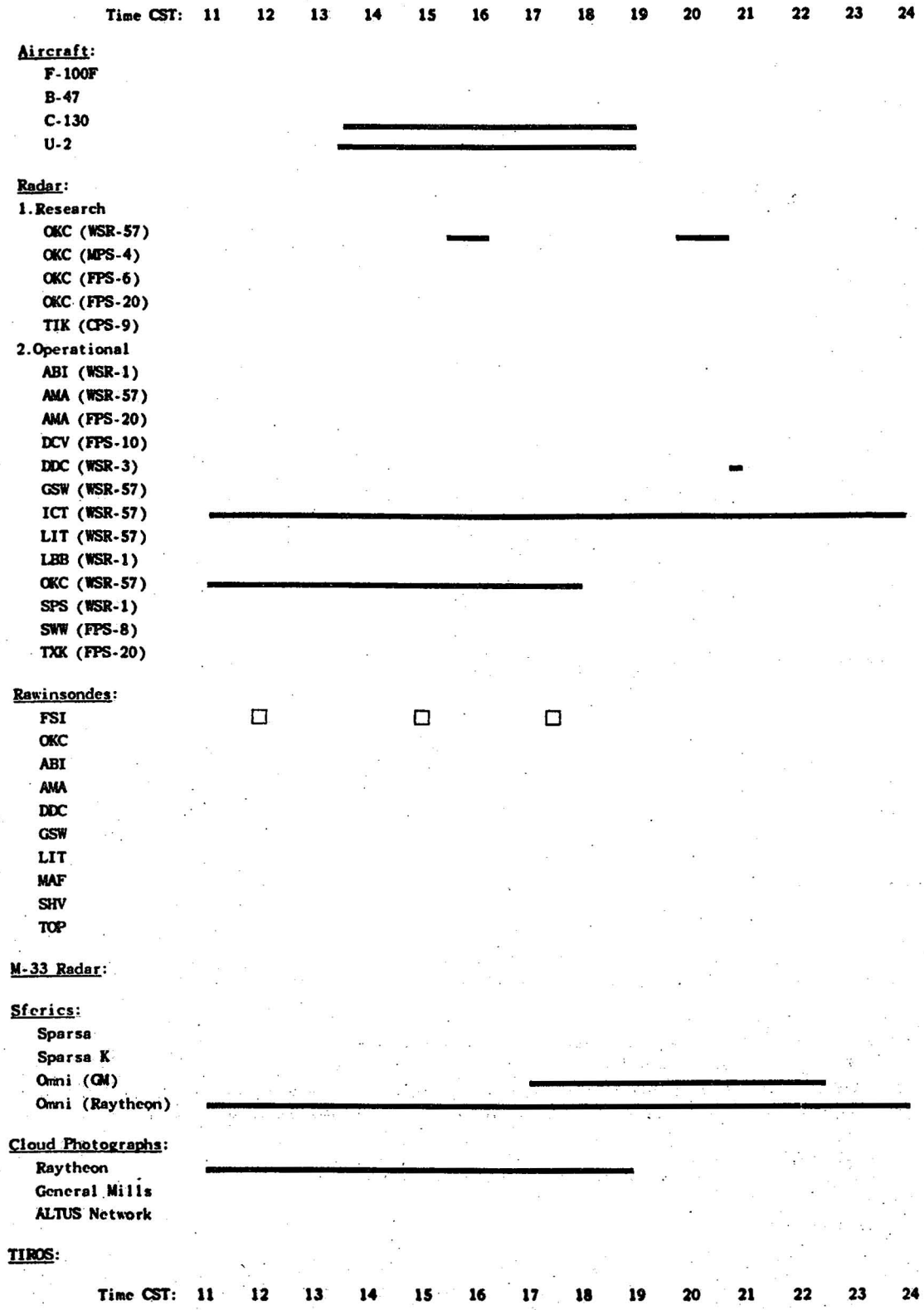
May 17, 1963


Time CST: 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Aircraft:
F-100F
B-47
C-130
U-2
Radar:
1.Research
OKC (WSR-57)
OKC (MPS-4)
OKC (FPS-6)
OKC (FPS-20)
TIK (CPS-9)
2.Operational
ABI (WSR-1)
AMA (WSR-57)
AMA (FPS-20)
DCV (FPS-10)
DDC (WSR-3)
GSW (WSR-57)
ICT (WSR-57)
LIT (WSR-57)
LBB (WSR-1)
OKC (WSR-57)
SPS (WSR-1)
SWW (FPS-8)
TXK (FPS-20)
Rawinsondes:
FSI
OKC
ABI
AMA
DDC
GSW
LIT
MAF
SHV
TOP
M-33 Radar:
Sferics:
Sparsa
Sparsa K
Omni (GM)
Omni (Raytheon)
To 0530/18
Cloud Photographs:
Raytheon
General Mills
ALTUS Network
TIROS:
Time CST: 11 12 13 14 15 16 17 18 19 20 21 22 23 24

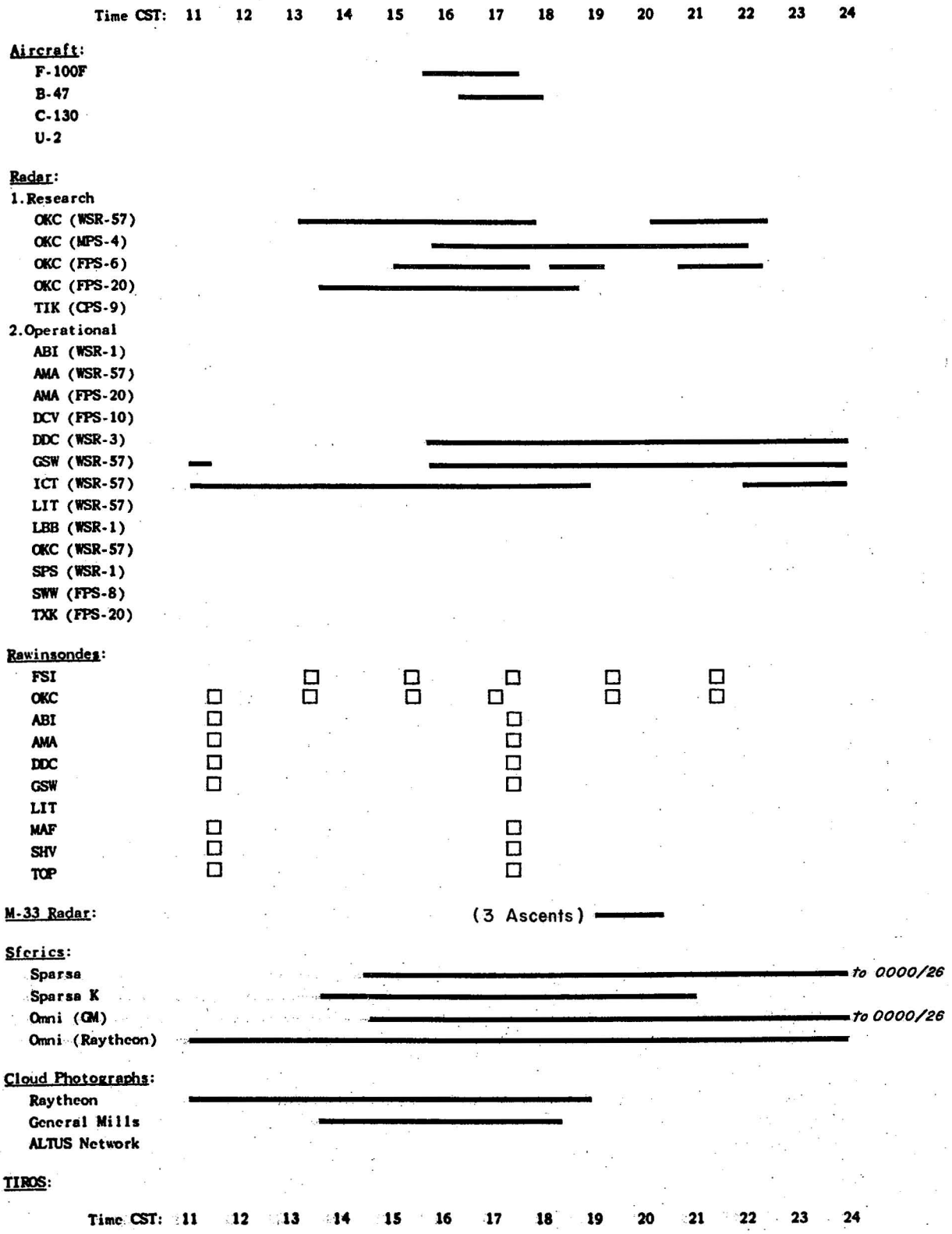
May 19, 1963


Time CST: 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Aircraft:
F-100F
B-47
C-130
U-2
Radar:
1. Research
OKC (WSR-57)
OKC (MPS-4)
OKC (FPS-6)
OKC (FPS-20)
TIK (CPS-9)
2. Operational
ABI (WSR-1)
AMA (WSR-57)
AMA (FPS-20)
DCV (FPS-10)
DDC (WSR-3)
GSW (WSR-57)
ICT (WSR-57)
LIT (WSR-57)
LBB (WSR-1)
OKC (WSR-57)
SPS (WSR-1)
SWW (FPS-8)
TXK (FPS-20)
Rawinsondes:
FSI
OKC
ABI
AMA
DDC
GSW
LIT
MAF
SHV
TOP
M-33 Radar:
(9 Ascents)
Sferics:
Sparsa
Sparsa K
Omni (GM)
Omni (Raytheon)
to 0530/20
Cloud Photographs:
Raytheon
General Mills
ALTUS Network
TIROS:
Time CST: 11 12 13 14 15 16 17 18 19 20 21 22 23 24

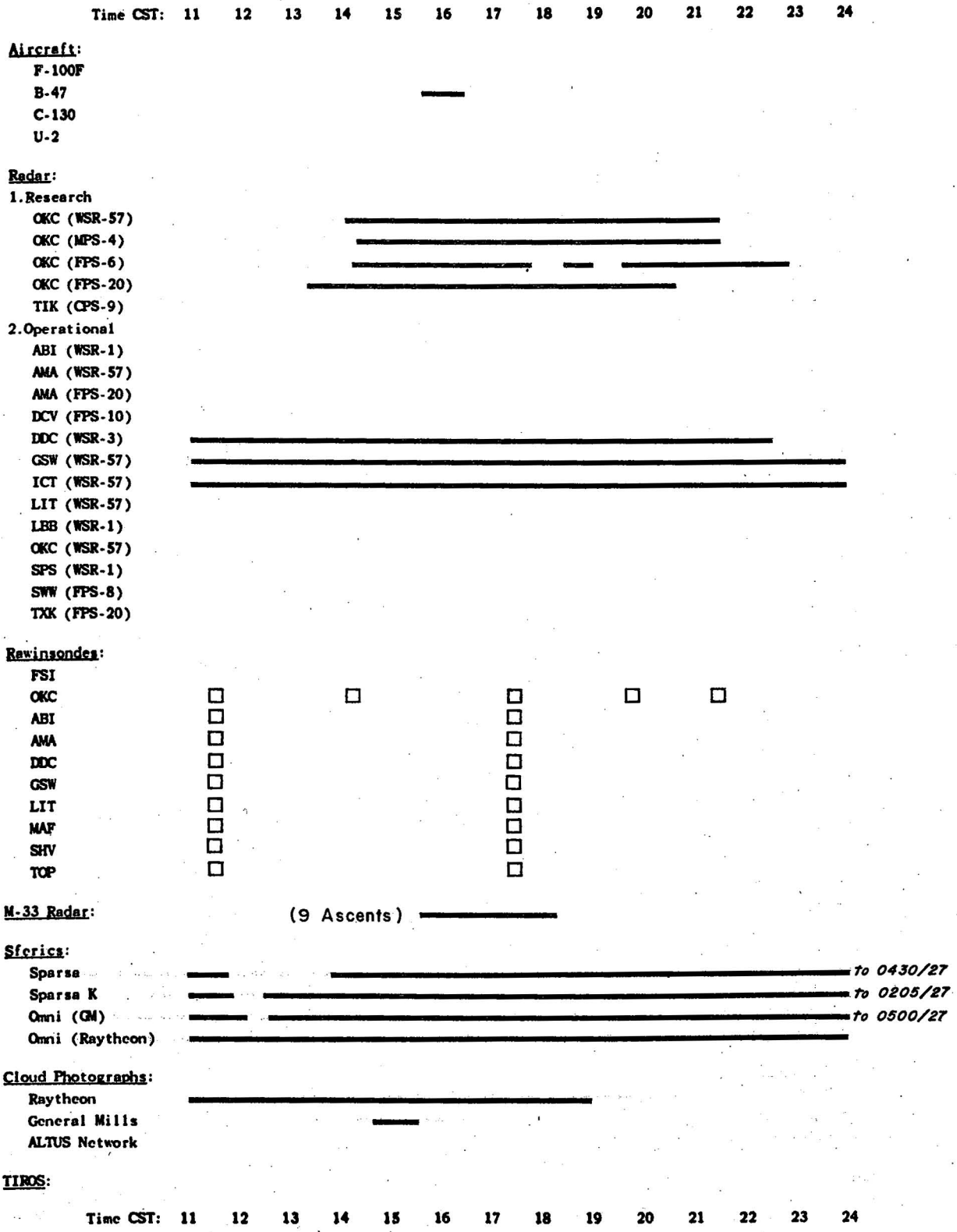
May 24, 1963


Time CST: 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Aircraft:
F-100F
B-47
C-130
U-2
Radar:
1.Research
OKC (WSR-57)
OKC (MPS-4)
OKC (FPS-6)
OKC (FPS-20)
TIK (CPS-9)
2.Operational
ABI (WSR-1)
AMA (WSR-57)
AMA (FPS-20)
DCV (FPS-10)
DDC (WSR-3)
GSW (WSR-57)
ICT (WSR-57)
LIT (WSR-57)
LBB (WSR-1)
OKC (WSR-57)
SPS (WSR-1)
SWW (FPS-8)
TXK (FPS-20)
Rawinsondes:
FSI
OKC
ABI
AMA
DDC
GSW
LIT
MAF
SHV
TOP
M-33 Radar:
Sferics:
Sparsa
Sparsa K
Omni (GM)
Omni (Raytheon)
Cloud Photographs:
Raytheon
General Mills
ALTUS Network
TIROS:
Time CST: 11 12 13 14 15 16 17 18 19 20 21 22 23 24

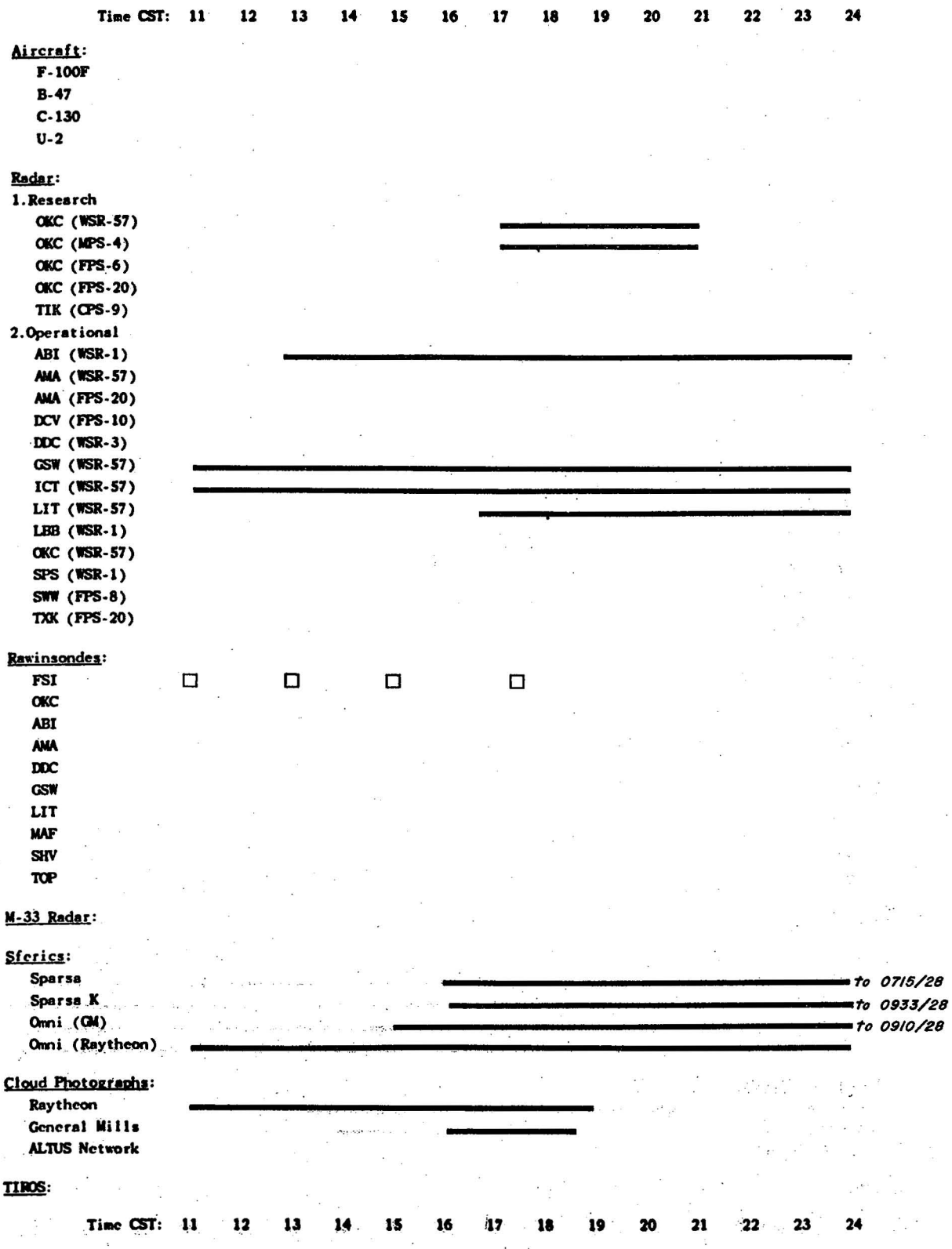
May 25, 1963


Time CST: 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Aircraft:
F-100F
B-47
C-130
U-2
Radar:
1. Research
OKC (WSR-57)
OKC (MPS-4)
OKC (FPS-6)
OKC (FPS-20)
TIK (CPS-9)
2. Operational
ABI (WSR-1)
AMA (WSR-57)
AMA (FPS-20)
DCV (FPS-10)
DDC (WSR-3)
GSW (WSR-57)
ICT (WSR-57)
LIT (WSR-57)
LBB (WSR-1)
OKC (WSR-57)
SPS (WSR-1)
SWW (FPS-8)
TXK (FPS-20)
Rawinsondes:
FSI
OKC
ABI
AMA
DDC
GSW
LIT
MAF
SHV
TOP
M-33 Radar:
(3 Ascents)
Sferics:
Sparse
Sparse K
Omni (GM)
Omni (Raytheon)
to 0000/26
to 0000/26
Cloud Photographs:
Raytheon
General Mills
ALTUS Network
TIROS:
Time CST: 11 12 13 14 15 16 17 18 19 20 21 22 23 24

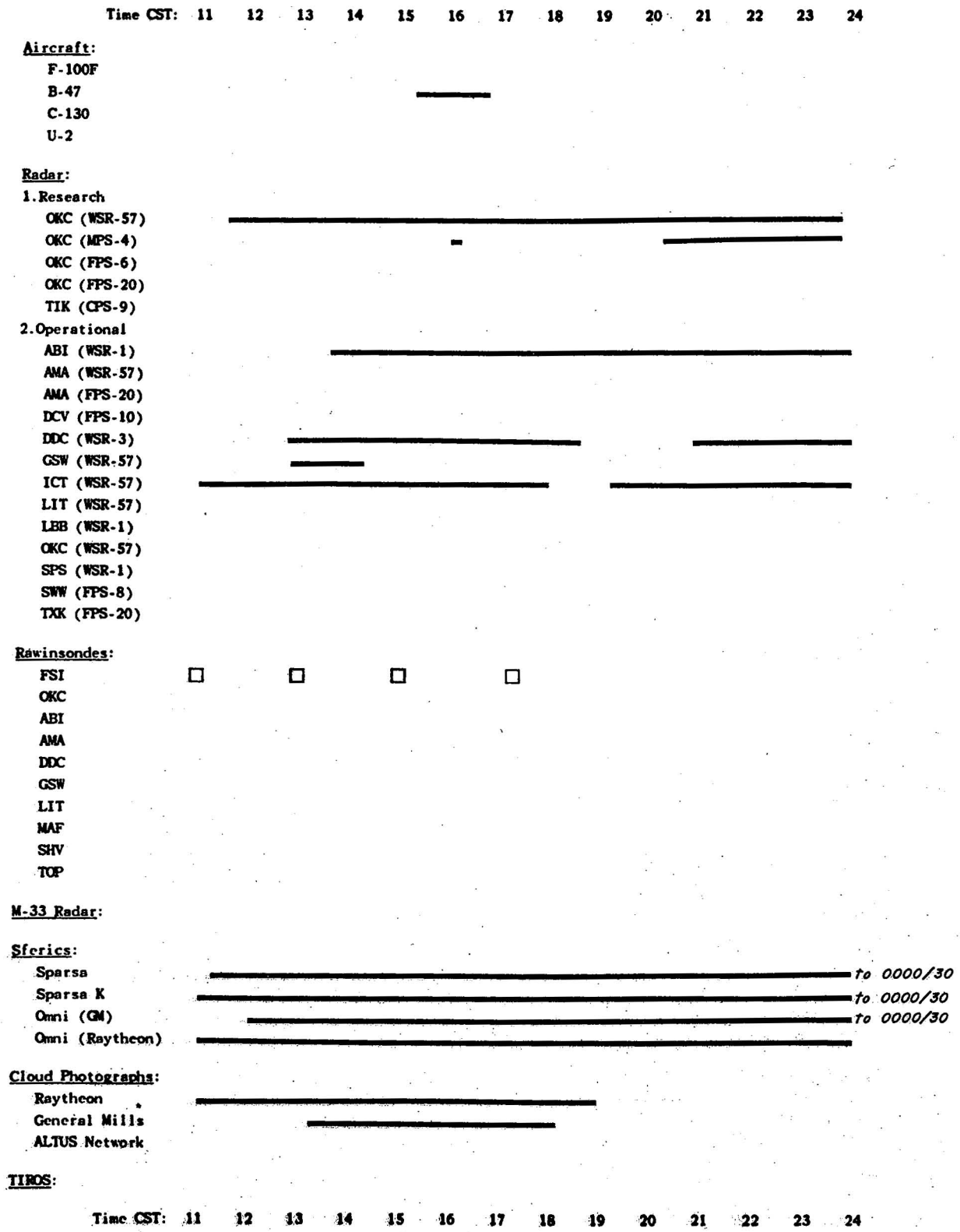
May 26, 1963


Time CST: 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Aircraft:
F-100F
B-47
C-130
U-2
Radar:
1.Research
OKC (WSR-57)
OKC (MPS-4)
OKC (FPS-6)
OKC (FPS-20)
TIK (CPS-9)
2.Operational
ABI (WSR-1)
AMA (WSR-57)
AMA (FPS-20)
DCV (FPS-10)
DDC (WSR-3)
GSW (WSR-57)
ICT (WSR-57)
LIT (WSR-57)
LBB (WSR-1)
OKC (WSR-57)
SPS (WSR-1)
SWW (FPS-8)
TXK (FPS-20)
Rawinsondes:
FSI
OKC
ABI
AMA
DDC
GSW
LIT
MAF
SHV
TOP
M-33 Radar:
(9 Ascents)
Sferics:
Sparse
Sparse K
Omni (GM)
Omni (Raytheon)
to 0430/27
to 0205/27
to 0500/27
Cloud Photographs:
Raytheon
General Mills
ALTUS Network
TIROS:
Time CST: 11 12 13 14 15 16 17 18 19 20 21 22 23 24

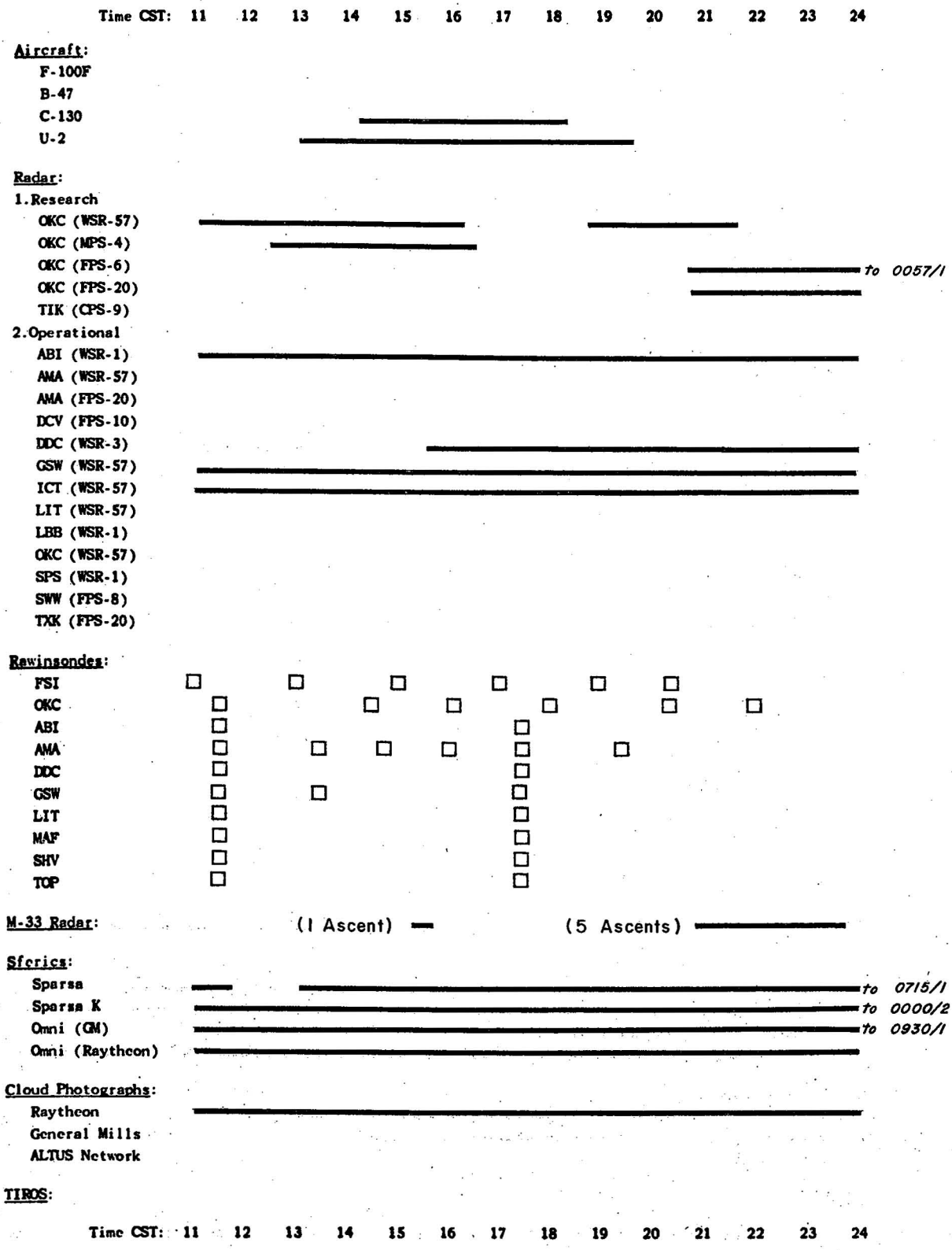
May 27, 1963


Time CST: 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Aircraft:
F-100F
B-47
C-130
U-2
Radar:
1.Research
OKC (WSR-57)
OKC (MPS-4)
OKC (FPS-6)
OKC (FPS-20)
TIK (CPS-9)
2.Operational
ABI (WSR-1)
AMA (WSR-57)
AMA (FPS-20)
DCV (FPS-10)
DDC (WSR-3)
GSW (WSR-57)
ICT (WSR-57)
LIT (WSR-57)
LBB (WSR-1)
OKC (WSR-57)
SPS (WSR-1)
SWW (FPS-8)
TXK (FPS-20)
Rawinsondes:
FSI
OKC
ABI
AMA
DDC
GSW
LIT
MAF
SHV
TOP
M-33 Radar:
Sferics:
Sparsa
Sparsa K
Omni (GM)
Omni (Raytheon)
to 0715/28
to 0933/28
to 0910/28
Cloud Photographs:
Raytheon
General Mills
ALTUS Network
TIROS:
Time CST: 11 12 13 14 15 16 17 18 19 20 21 22 23 24

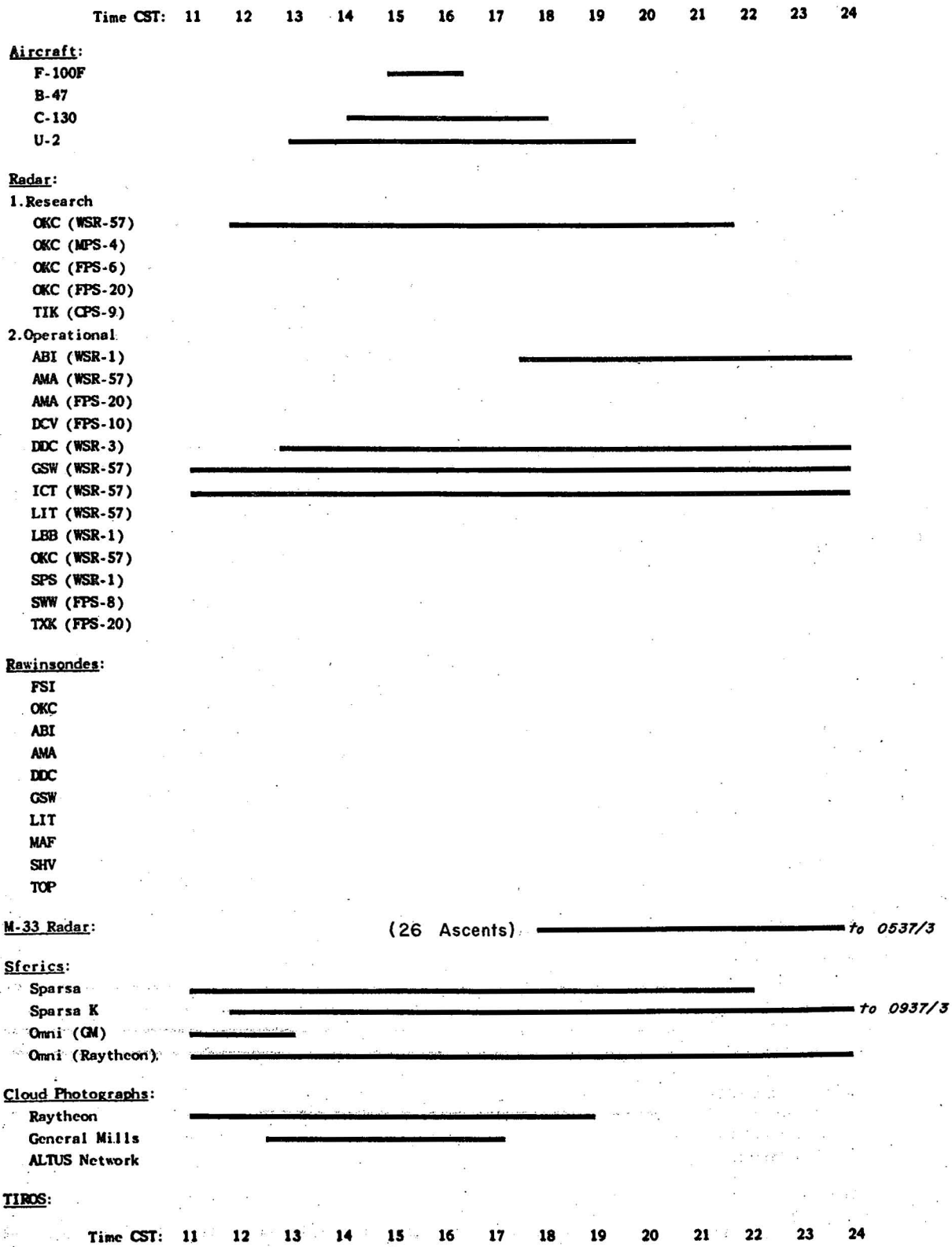
May 29, 1963


Time CST: 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Aircraft:
F-100F
B-47
C-130
U-2
Radar:
1. Research
OKC (WSR-57)
OKC (MPS-4)
OKC (FPS-6)
OKC (FPS-20)
TIK (CPS-9)
2. Operational
ABI (WSR-1)
AMA (WSR-57)
AMA (FPS-20)
DCV (FPS-10)
DDC (WSR-3)
GSW (WSR-57)
ICT (WSR-57)
LIT (WSR-57)
LBB (WSR-1)
OKC (WSR-57)
SPS (WSR-1)
SWW (FPS-8)
TXK (FPS-20)
Rawinsondes:
FSI
OKC
ABI
AMA
DDC
GSW
LIT
MAF
SHV
TOP
M-33 Radar:
Sferics:
Sparsa
Sparsa K
Omni (GM)
Omni (Raytheon)
to 0000/30
to 0000/30
to 0000/30
Cloud Photographs:
Raytheon
General Mills
ALTUS Network
TIROS:
Time CST: 11 12 13 14 15 16 17 18 19 20 21 22 23 24

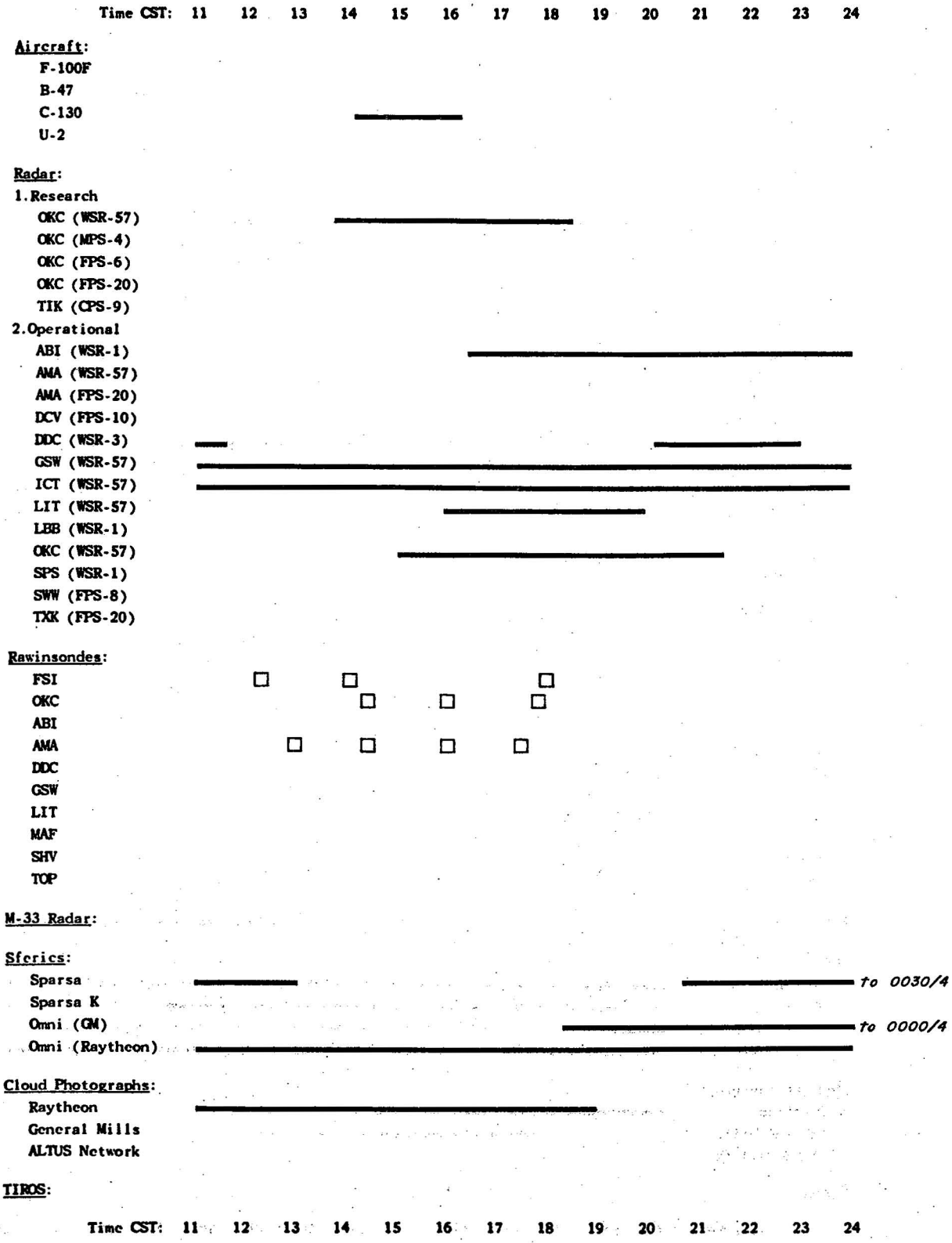
May 31, 1963


Time CST: 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Aircraft:
F-100F
B-47
C-130
U-2
Radar:
1. Research
OKC (WSR-57)
OKC (MPS-4)
OKC (FPS-6)
OKC (FPS-20)
TIK (CPS-9)
to 0057/1
2. Operational
ABI (WSR-1)
AMA (WSR-57)
AMA (FPS-20)
DCV (FPS-10)
DDC (WSR-3)
GSW (WSR-57)
ICT (WSR-57)
LIT (WSR-57)
LBB (WSR-1)
OKC (WSR-57)
SPS (WSR-1)
SWW (FPS-8)
TXK (FPS-20)
Rawinsondes:
FSI
OKC
ABI
AMA
DDC
GSW
LIT
MAF
SHV
TOP
M-33 Radar:
(1 Ascent)
(5 Ascents)
Sferics:
Sparsa
Sparsa K
Omni (GM)
Omni (Raytheon)
to 0715/1
to 0000/2
to 0930/1
Cloud Photographs:
Raytheon
General Mills
ALTUS Network
TIROS:
Time CST: 11 12 13 14 15 16 17 18 19 20 21 22 23 24

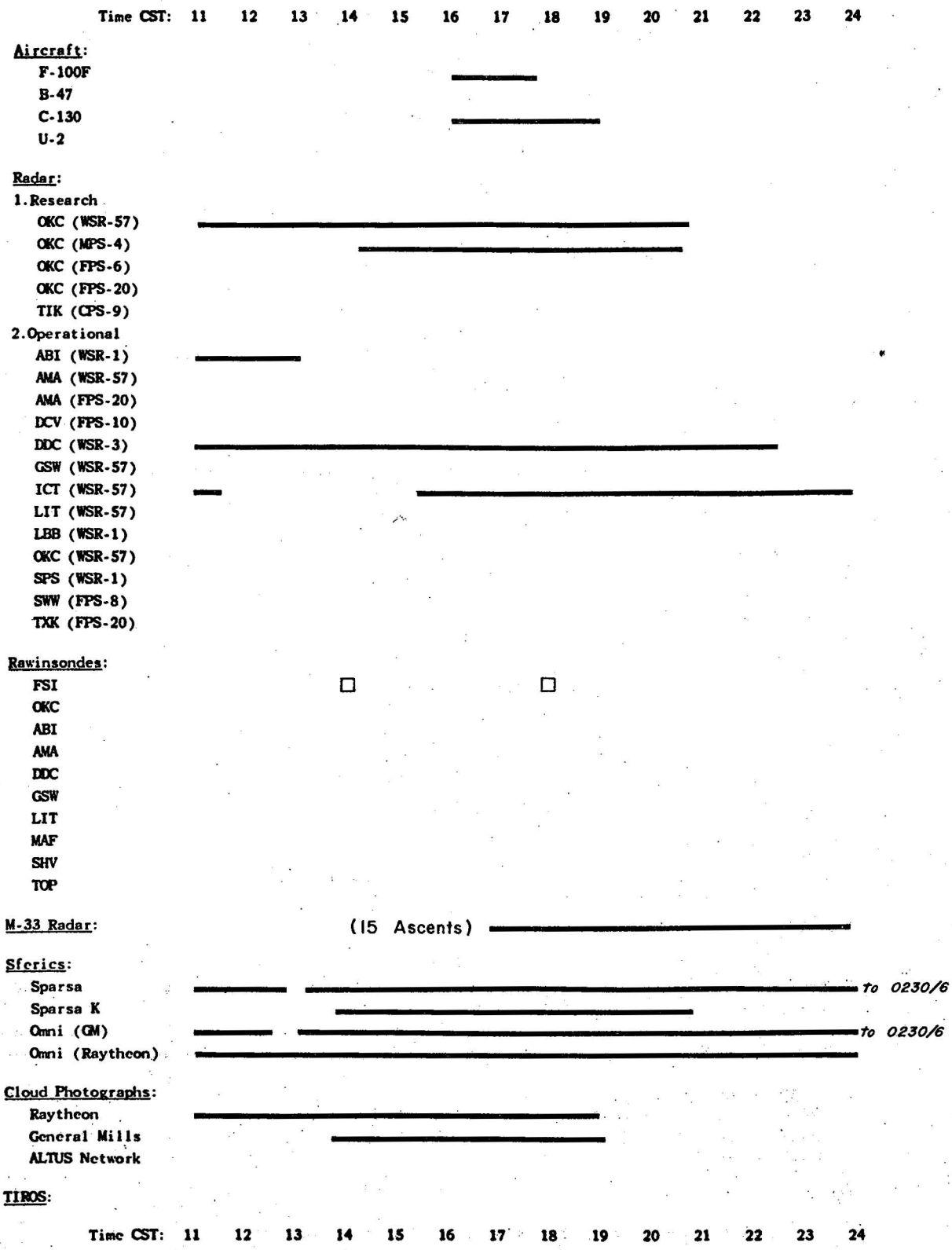
June 2, 1963


Time CST: 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Aircraft:
F-100F
B-47
C-130
U-2
Radar:
1. Research
OKC (WSR-57)
OKC (MPS-4)
OKC (FPS-6)
OKC (FPS-20)
TIK (CPS-9)
2. Operational
ABI (WSR-1)
AMA (WSR-57)
AMA (FPS-20)
DCV (FPS-10)
DDC (WSR-3)
GSW (WSR-57)
ICT (WSR-57)
LIT (WSR-57)
LBB (WSR-1)
OKC (WSR-57)
SPS (WSR-1)
SWW (FPS-8)
TXK (FPS-20)
Rawinsondes:
FSI
OKC
ABI
AMA
DDC
GSW
LIT
MAF
SHV
TOP
M-33 Radar:
(26 Ascents)
to 0537/3
Sferics:
Sparsa
Sparsa K
to 0937/3
Omni (GM)
Omni (Raytheon)
Cloud Photographs:
Raytheon
General Mills
ALTUS Network
TIROS:
Time CST: 11 12 13 14 15 16 17 18 19 20 21 22 23 24

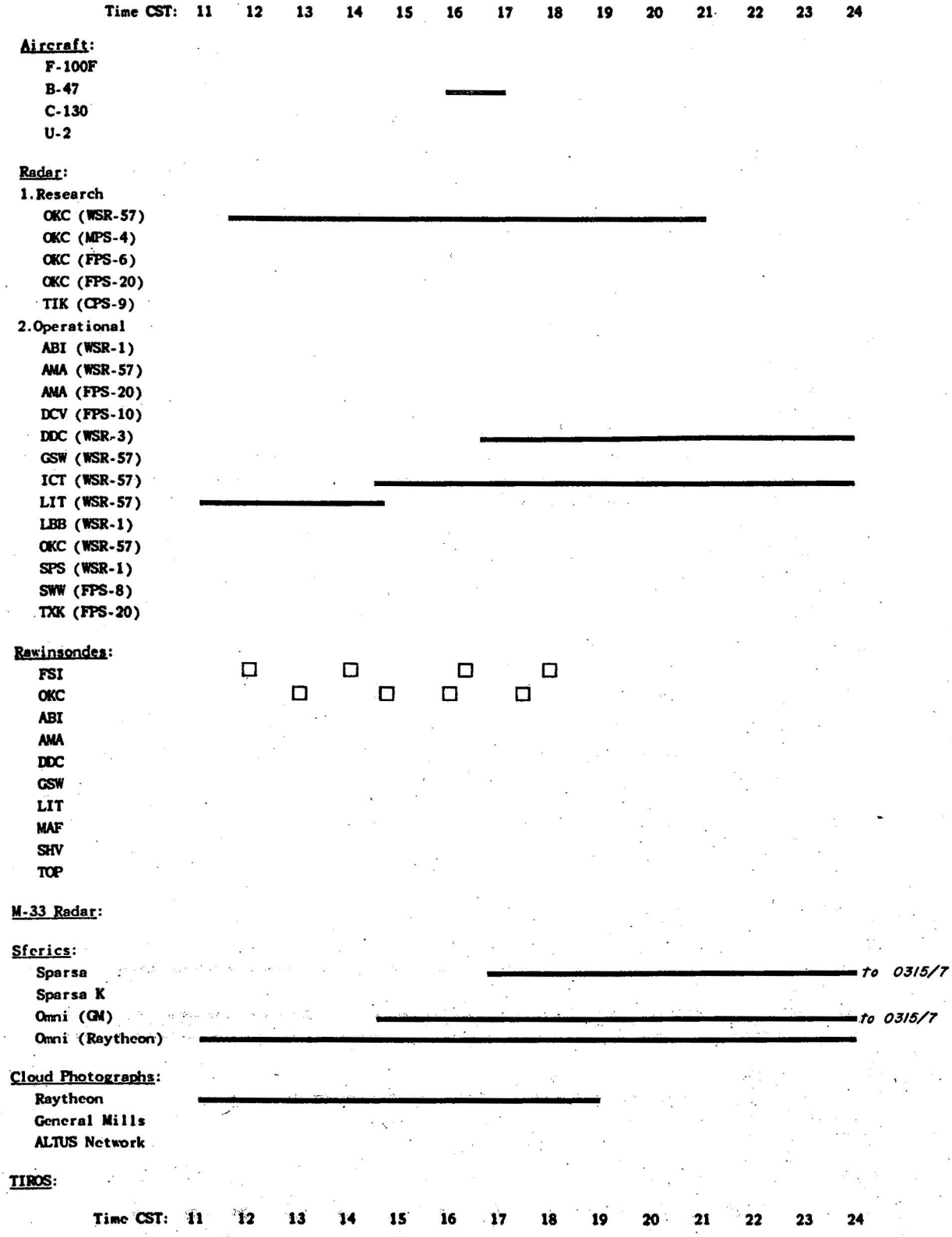
June 3, 1963


Time CST: 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Aircraft:
F-100F
B-47
C-130
U-2
Radar:
1. Research
OKC (WSR-57)
OKC (MPS-4)
OKC (FPS-6)
OKC (FPS-20)
TIK (CPS-9)
2. Operational
ABI (WSR-1)
AMA (WSR-57)
AMA (FPS-20)
DCV (FPS-10)
DDC (WSR-3)
GSW (WSR-57)
ICT (WSR-57)
LIT (WSR-57)
LBB (WSR-1)
OKC (WSR-57)
SPS (WSR-1)
SWW (FPS-8)
TXK (FPS-20)
Rawinsondes:
FSI
OKC
ABI
AMA
DDC
GSW
LIT
MAF
SHV
TOP
M-33 Radar:
Sferics:
Sparsa
Sparsa K
Omni (GM)
Omni (Raytheon)
to 0030/4
to 0000/4
Cloud Photographs:
Raytheon
General Mills
ALTUS Network
TIROS:
Time CST: 11 12 13 14 15 16 17 18 19 20 21 22 23 24

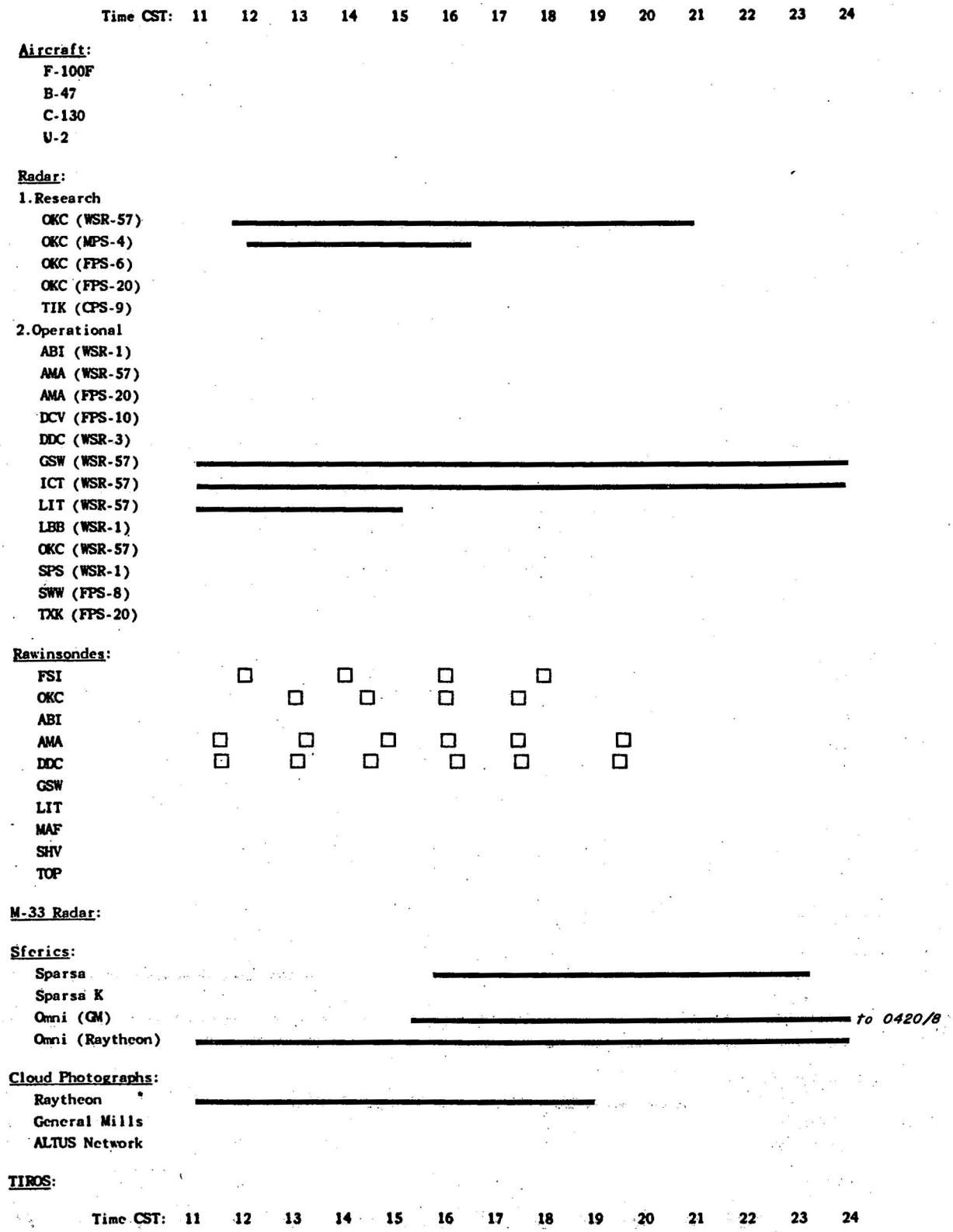
June 5, 1963


Time CST: 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Aircraft:
F-100F
B-47
C-130
U-2
Radar:
1.Research
OKC (WSR-57)
OKC (MPS-4)
OKC (FPS-6)
OKC (FPS-20)
TIK (CPS-9)
2.Operational
ABI (WSR-1)
AMA (WSR-57)
AMA (FPS-20)
DCV (FPS-10)
DDC (WSR-3)
GSW (WSR-57)
ICT (WSR-57)
LIT (WSR-57)
LBB (WSR-1)
OKC (WSR-57)
SPS (WSR-1)
SWW (FPS-8)
TXK (FPS-20)
Rawinsondes:
FSI
OKC
ABI
AMA
DDC
GSW
LIT
MAF
SHV
TOP
M-33 Radar:
(15 Ascents)
Sferics:
Sparsa
Sparsa K
Omni (GM)
Omni (Raytheon)
to 0230/6
to 0230/6
Cloud Photographs:
Raytheon
General Mills
ALTUS Network
TIROS:
Time CST: 11 12 13 14 15 16 17 18 19 20 21 22 23 24

June 6, 1963


Time CST: 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Aircraft:
F-100F
B-47
C-130
U-2
Radar:
1. Research
OKC (WSR-57)
OKC (MPS-4)
OKC (FPS-6)
OKC (FPS-20)
TIK (CPS-9)
2. Operational
ABI (WSR-1)
AMA (WSR-57)
AMA (FPS-20)
DCV (FPS-10)
DDC (WSR-3)
GSW (WSR-57)
ICT (WSR-57)
LIT (WSR-57)
LBB (WSR-1)
OKC (WSR-57)
SPS (WSR-1)
SWW (FPS-8)
TXK (FPS-20)
Rawinsondes:
FSI
OKC
ABI
AMA
DDC
GSW
LIT
MAF
SHV
TOP
M-33 Radar:
Sferics:
Sparsa
Sparsa K
Omni (GM)
Omni (Raytheon)
to 0315/7
to 0315/7
Cloud Photographs:
Raytheon
General Mills
ALTUS Network
TIROS:
Time CST: 11 12 13 14 15 16 17 18 19 20 21 22 23 24

June 7, 1963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B-47
C-130
U-2
Radar:
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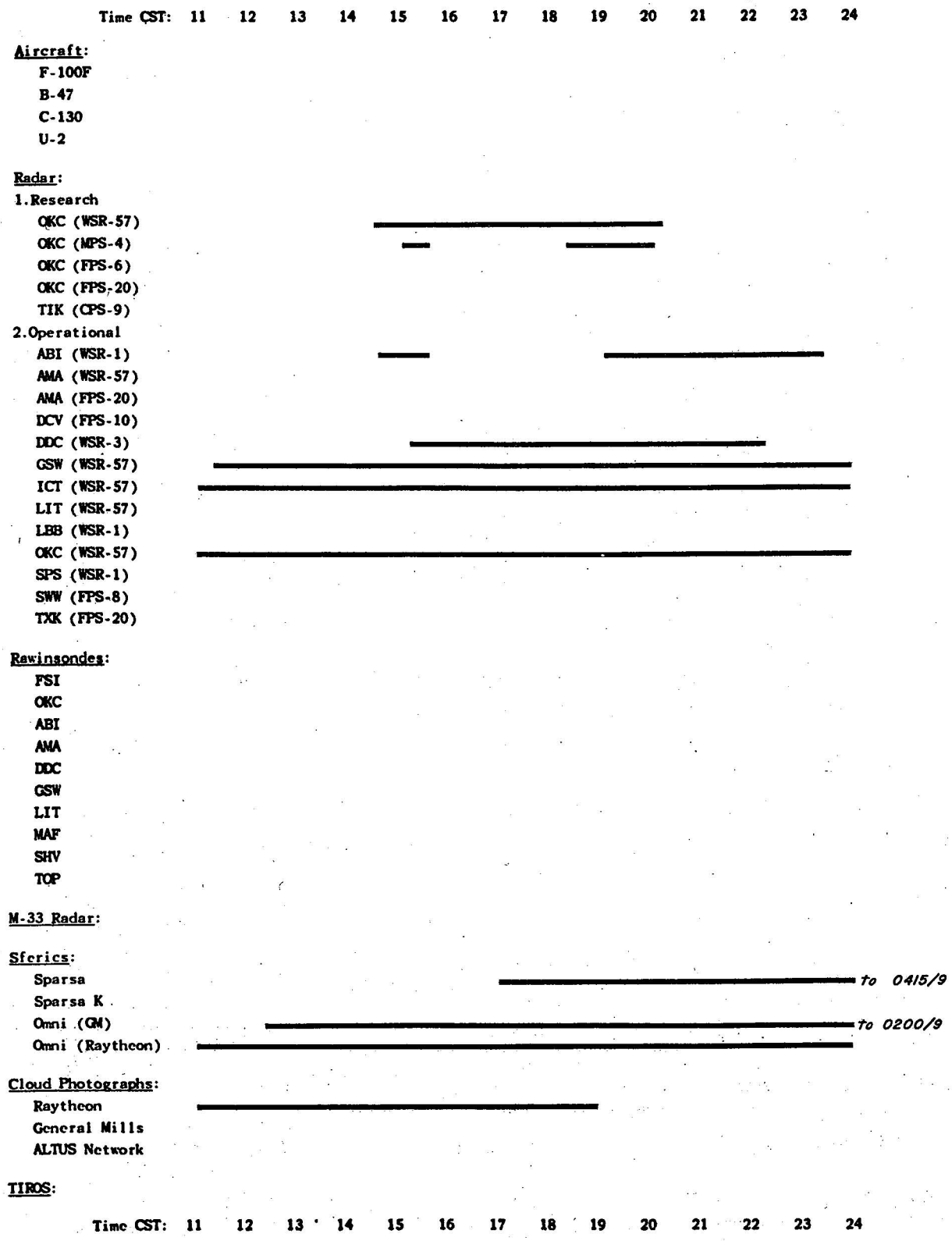
OKC (MPS-4)
OKC (FPS-6)
OKC (FPS-20)
TIK (CPS-9)
2. Operational
ABI (WSR-1)
AMA (WSR-57)
AMA (FPS-20)
DCV (FPS-10)
DDC (WSR-3)
GSW (WSR-57)
ICT (WSR-57)
LIT (WSR-57)
LBB (WSR-1)
OKC (WSR-57)
SPS (WSR-1)
SWW (FPS-8)
TXK (FPS-20)
Rawinsondes:
FSI
OKC
ABI
AMA
DDC
GSW
LIT
MAF
SHV
TOP
M-33 Radar:
Sferics:
Sparsa
Sparsa K
Omni (GM)
Omni (Raytheon)
to 0420/8
Cloud Photographs:
Raytheon
General Mills
ALTUS Network
TIROS:
Time CST: 11 12 13 14 15 16 17 18 19 20 21 22 23 24

June 8, 1963


Time CST: 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Aircraft:
F-100F
B-47
C-130
U-2
Radar:
1.Research
OKC (WSR-57)
OKC (MPS-4)
OKC (FPS-6)
OKC (FPS-20)
TIK (CPS-9)
2.Operational
ABI (WSR-1)
AMA (WSR-57)
AMA (FPS-20)
DCV (FPS-10)
DDC (WSR-3)
GSW (WSR-57)
ICT (WSR-57)
LIT (WSR-57)
LBB (WSR-1)
OKC (WSR-57)
SPS (WSR-1)
SWW (FPS-8)
TXK (FPS-20)
Rawinsondes:
FSI
OKC
ABI
AMA
DDC
GSW
LIT
MAF
SHV
TOP
M-33 Radar:
Sferics:
Sparsa
Sparsa K
Omni (GM)
Omni (Raytheon)
to 0415/9
to 0200/9
Cloud Photographs:
Raytheon
General Mills
ALTUS Network
TIROS:
Time CST: 11 12 13 14 15 16 17 18 19 20 21 22 23 24

APPENDIX IV

TIROS PHOTOGRAPHIC COVERAGE OF NSSP OPERATIONAL AREA

TIROS Photo Coverage for April 1963

TIROS*	Date	Time	Pass No.
T-VI	April 6	2120Z	2925
T-VI	April 7	2014Z	2938
T-V	April 13	2055Z	4276
T-V	April 14	2025Z	4290
T-VI	April 15	1735Z	3054
T-V	April 16	1922Z	4319
T-VI	April 16	1817Z	3069
T-V	April 17	1848Z	4333
T-V	April 18	1955Z	4348
T-VI	April 18	1758Z	3098
T-V	April 19	1925Z	4362
T-VI	April 20	1605Z	3126
T-VI	April 22	1551Z	3155
T-VI	April 23	1630Z	3170
T-VI	April 24	1534Z	3184
T-V	April 25	1740Z	4447
T-VI	April 25	1434Z	3198
T-V	April 28	1550Z	4488
T-VI	April 29	1402Z	3256

*T-V = TIROS V T-VI = TIROS VI

TIROS Photo Coverage for May and June 1963

TIROS	Date	Time	Pass No.
T-V	May 1	1555Z	4532
T-V	May 1	1415Z	4532
T-V	May 2	1525Z	4547
T-V	May 2	1343Z	4545
T-V	May 3	1450Z	4561
T-V	May 3	1310Z	4559
T-V	May 4	1420Z	4575
T-V	May 4	1235Z	4573
T-VI	May 7	1945Z	3377
T-VI	May 10	1835Z	3420
T-VI	May 10	2016Z	3420
T-VI	May 11	1914Z	3434
T-VI	May 13	1856Z	3463
T-VI	May 16	1752Z	3507
T-VI	May 20	1533Z	3563
T-VI	May 21	1620Z	3579
T-VI	May 23	1417Z	3606
T-VI	May 25	1400Z	3635
T-VI	May 25	1300Z	3649
T-VI	May 28	1244Z	3678
T-VI	May 30	1234Z	3708

TIROS	Date	Time	Pass No.
T-VI	June 25	2120Z	4092
T-VI	June 25	1937Z	4092
T-VI	June 26	2021Z	4106
T-VI	June 27	1919Z	4121
T-VI	June 28	2004Z	4135
T-VI	June 30	1802Z	4163

APPENDIX V

SIGNIFICANT FEATURES OF THE 1963 NSSP BETA NETWORK DATA

All data from the Beta network for the period March 1 - June 30, 1962, were examined and logs of pressure, temperature, relative humidity, rainfall, and wind features have been prepared. The logs describe the lines along which characteristic changes occurred. They were prepared from preliminary isochrone-amplitude analyses. Examples of the analyses are shown in figures 6-9.

A condensed tabulation of the features is shown in table 3. The features have been classified as follows:

1. Pressure. Pressure rise lines (beginning of the pressure rise) are identified as "H". Pressure fall lines (ending of the pressure fall) are identified as "L".

2. Temperature and relative humidity. Temperature rise lines (beginning of the temperature rise) are identified as "W". Temperature fall lines (beginning of the temperature fall) are identified as "C". Relative humidity rise lines (beginning of the rise) are identified as "M". Relative humidity fall lines (beginning of the fall) are identified as "D". In some instances there is a sharp fall in relative humidity followed by a rise. This feature is called the humidity dip and is identified as "DP".

3. Rainfall. Rainfall lines (beginning of rainfall are identified as "R".

4. Wind. The peak gust is the only feature of the wind that was logged. It was logged only if at least one station recorded a gust in excess of 40 kt. Actual values of the peak gust are listed.

The magnitudes of the features are given by change amounts, as follows:

Feature	Slight–(S)	Moderate–(M)	Large–(L)	Very Large–(VL)	Extremely Large–(EL)
Pressure	0.01–0.05"	0.06–0.10"	0.11–0.15"	0.16–0.20"	0.21" or more
Temperature	1–5°F.	6–10°F.	11–15°F.	16–20°F.	21°F. or more
Humidity	1–10%	11–20%	21–30%	31–40%	41% or more
Rainfall*	T–0.30"	0.31–1.00"	1.01–3.00"	3.01–5.00"	5.01" or more

*For rainfall the magnitudes are light (L), moderate (M), heavy (H), very heavy (VH), and extremely heavy (EH).

The tables which follow show the hours CST during which the features were present over the network. As an example, the entry for March 4 indicates that there was a moderate pressure rise (H-M) from 0605-0850 CST, an extremely large temperature fall (C-EL) and a moderate humidity dip (DP-M) from 0522-0904 CST, and moderate rainfall (R-M) from 0650-0840 CST. The changes in humidity were usually inverse to the changes in temperature, and the magnitude of the humidity change is given only for the few cases in which it was of special interest.

Table 3. Tabulation of Beta Network Features

March 1963

Date	Pressure	Temperature & Humidity			Rainfall	Peak Gust
	Time (CST)	Time (CST)	Temp.	Hum.	Time (CST)	Time (CST)
4	0605-0850 H-M	0522-0904	C-EL,	DP-M	0650-0840 R-M	
7	None	2113-2359	W-M,	D-	None	
8	1747-1935 H-VL 1914-2044 L-L	0000-0017 0210-0300 0408-0535 1757-1955	W-M, W-L, W-L, C-VL,	D- D- D- M-EL	1810-2000 R-M	
10	1225-1510 H-M 1330-1515 L-L 1653-1925 H-M 1833-2014 L-M	1812-2218	W-M,	D-	1200-2359 R-H	
16	2350-2359 H-W	2350-2359	W-M,	D-	None	
17	0000-0303 H-W	0000-0240	W-M,	D	None	
18	1334-1438 H-W	0340-0636 1250-1526 1235-1434	W-M, C-M, C-VL,	D- M- M-	1320-1500 R-M	
24	1810-1937 L-M	None			None	None over 40
25	None	0225-0650 0354-0654	-- W-L,	D-EL D-	None	None over 40
26	None	0034-0245 2150-2330 2350-2359	W-L, W-M, W-M,	D- D- D-	None	None over 40
27	None	0000-0130 2000-2359	W-M W-VL	D- D-	None	None over 40
28	None	0000-0500	W-VL,	D-	None	None over 40
29	None	2138-2359 2307-2359	W-M, W-M,	M- D-		None over 40
30	0010-0130 L-M 1605-1744 H-M 1606-1736 H-M 1640-1755 H-M 1710-2002 L-L 1738-1852 H-M 1907-2110 H-M 1911-2210 H-L 2115-2318 L-L	0000-0019 0000-0120 0010-1309 0055-0150 1200-1720 1343-1720 1916-2135	W-M, W-M, W-M, W-M, C-L, C-VL, C-M,	M- D- D- D- M- M- DP-S	1340-1755 R-H 1340-1830 R-H 1920-2125 R-H	0105-0223 48 1502-1656 50 1918-2109 50
31	0000-0107 L-M 0055-0153 L-L	None			0430-0510 R-L	None over 40

Table 3. Tabulation of Beta Network Features

April 1963

Date	Pressure	Temperature & Humidity			Rainfall	Peak Gust
	Time (CST)	Time (CST)	Temp.	Hum.	Time (CST)	Time (CST)
2	2344-2359 H-S	None			None	None over 40
3	0000-0112 H-S	0020-0422	C-S,	D-EL	None	None over 40
5	1408-1635 L-VL	None			1330-1510 R-L 1425-1540 R-M	None over 40
16	None	1424-1707	C-S,	M-L	None	None over 40
17	1935-2115 H-M 2048-2115 H-S 2115-2252 H-M 2243-2359 L-M 2340-2359 H-M	1906-2115 2115-2325 2143-2240	C-M, M- C-M, M- W-M, D-		2115-2330 R-H	1919-2114 48
18	0000-0005 L-M 0000-0048 H-M 0038-0110 L-M	1830-2355 2335-2359	— —	M-EL D-EL	None	None over 40
19	0022-0135 H-M	0000-0157	—	D-EL	None	None over 40
24	0732-0946 L-M 0744-0955 H-M 0934-1123 H-M 1142-1355 L-M 2343-2359 H-S	0716-1016	C-S,	M-	0725-1000 R-H 1010-1105 R-L 1135-1245 R-L 2345-2359 R-L	0856-0920 44
25	0000-0115 H-S 0505-0745 H-S	0037-0227 0612-1055 0919-1102	W-S, D- C-S, M- C-S, M-		0000-0120 R-L 0015-0040 R-M	None over 40
26	0640-0824 H-M 0658-0840 L-S 1247-1421 H-S 1548-1645 L-M 1604-1755 H-M 1700-1850 L-M 1800-1922 H-M 1830-1935 H-S 1838-2013 H-S 1913-2110 L-S 2100-2235 L-S	None			0645-0825 R-H 0655-0735 R-L 1525-1920 R-H	1734-1751 41
28	0900-1145 L-L 0900-1154 H-M 0920-1053 H-M 1045-1210 L-L	0847-1117 1010-1036 1052-1138	W-S, D- C-S, M- C-S, M-		1030-1045 R-L	0857-1128 41 1035-1222 51
29	0240-0432 H-S	0303-0752	C-S,	D-EL	None	None over 40

Table 3. Tabulation of Beta Network Features

May 1963

Date	Pressure	Temperature & Humidity			Rainfall	Peak Gust
	Time (CST)	Time (CST)	Temp.	Hum.	Time (CST)	Time (CST)
2	0331-0438 H-S	None			0500-1100 R-L	None over 40
4	1940-2120 H-L	1944-2133	C-L	DP-	1930-2130 R-M	1915-2129 42
	1940-2150 H-M	1950-2152	C-VL	M-	2105-2359 R-H	1925-2124 50
	2100-2359 H-L	2135-2330	W-M	D-		2332-2359 46
	2108-2317 L-M	2239-2359	C-L	M-		
	2340-2359 L-VL					
5	0000-0020 H-L	0000-0015	C-L	M-	0000-0025 R-H	0000-0210 46
	0000-0305 L-VL	0137-0245	W-S	D-	0715-0740 R-L	
	0033-0145 H-M	0750-0848	W-M	D-		
	0505-0650 H-L					
	0837-0925 L-M					
	1315-1509 H-M					
6	None	1201-1533	C-L	M-	1210-1540 R-H	None over 40
		1458-1706	C-L	M-	1540-1635 R-H	
		1623-1821	C-L	M-	1700-1830 R-M	
14	0130-0325 H-M	0130-0250	C-M	M-	None	None over 40
	0217-0337 L-M	0222-0302	W-S	D-		
	0320-0429 H-S					
15	2105-2215 H-S	None			None	None over 40
19	0945-1030 H-S	0954-1502	C-EL	M-	1145-1355 R-M	1017-1148 56
	1420-1620 H-M	1030-1257	W-L	D-	1335-1730 R-H	1517-1655 44
	1530-1805 L-M	1220-1540	W-L	D-		
	1532-1635 L-M	1350-1637	C-VL	M-		
	1552-1810 L-M					
26	1705-1721 H-VL	1340-1955	W-S	D-L	None	None over 40
	2040-2115 H-M	1713-1903	C-EL	M-		
28	0010-0150 H-M	None			None	None over 40
	0125-0410 L-M					
30	0115-0322 H-M	0016-0340	C-M	M-	-- -- RH	0130-0347 47
31	0300-0605 H-S	1230-1500	C-M	M-	-- -- RH	None over 40
	1225-1516 L-VL	2322-2359	C-M	M-	2355-2359 R-H	
	2230-2325 H-S					
	2335-2359 H-M					

Table 3. Tabulation of Beta Network Features

June 1963

Date	Pressure	Temperature & Humidity			Rainfall	Peak Gust
	Time (CST)	Time (CST)	Temp.	Hum.	Time (CST)	Time (CST)
1	0000-0250 H-M 0252-0407 L-M	0000-0240	C-M	M-	0000-0225 R-H	None over 40
3	0200-0435 H-S	0200-0520	C-L	DP-VL	0200-0440 R-H	None over 40
5	0255-0352 L-M	None			1825-2125 R-L	None over 40
8	1403-1543 H-M 2210-2359 H-M	1335-1647 2224-2359	C-VL C-L	M- M-	1315-1525 R-H 2225-2345 R-H	1403-1545 47 2215-2359 42
9	0000-0005 H-M 0130-0222 L-M	0000-0122	C-L	M-	None	0000-0050 42
10	1628-1857 H-M 1645-1915 H-EL 1750-2043 L-VL	1700-1855 1715-1912 1735-1838	C-EL C-VL W-VL	M- M- D-	1637-1650 R-M 1700-1855 R-M 1800-1835 R-M	1700-1837 62
11	2050-2312 H-L	2008-2325	C-L	DP-	2135-2310 R-H	2004-2315 48
16	0305-0454 H-VL 0948-1110 H-M 1141-1315 L-L	0320-0452	C-VL	M-	0310-0435 R-H	0305-0456 64
19	0117-0228 H-S	None			None	None over 40
22	None	2145-2359	C-M	M-	None	None over 40
23	0353-0625 H-M 0540-0815 L-M	0400-0918	C-M	DP-	0135-0752 R-H 0815-1040 R-H	None over 40
25	None	1232-1351	C-VL	M-	None	None over 40
30	None	1305-1550	C-EL	M-	None	None over 40

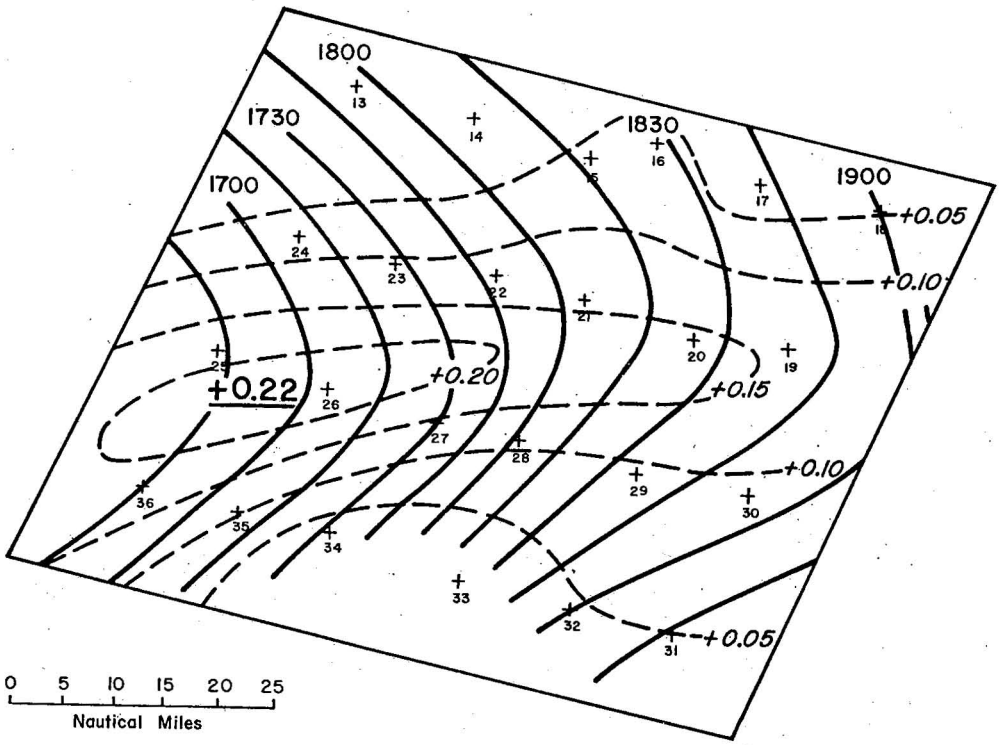


Figure 6.— Preliminary isochrone-amplitude analysis of a pressure rise line that passed over the southern half of the Beta network on June 10, 1963. Solid lines are isochrones of beginning of rise in CST; dashed lines show amount of rise in in. Hg.

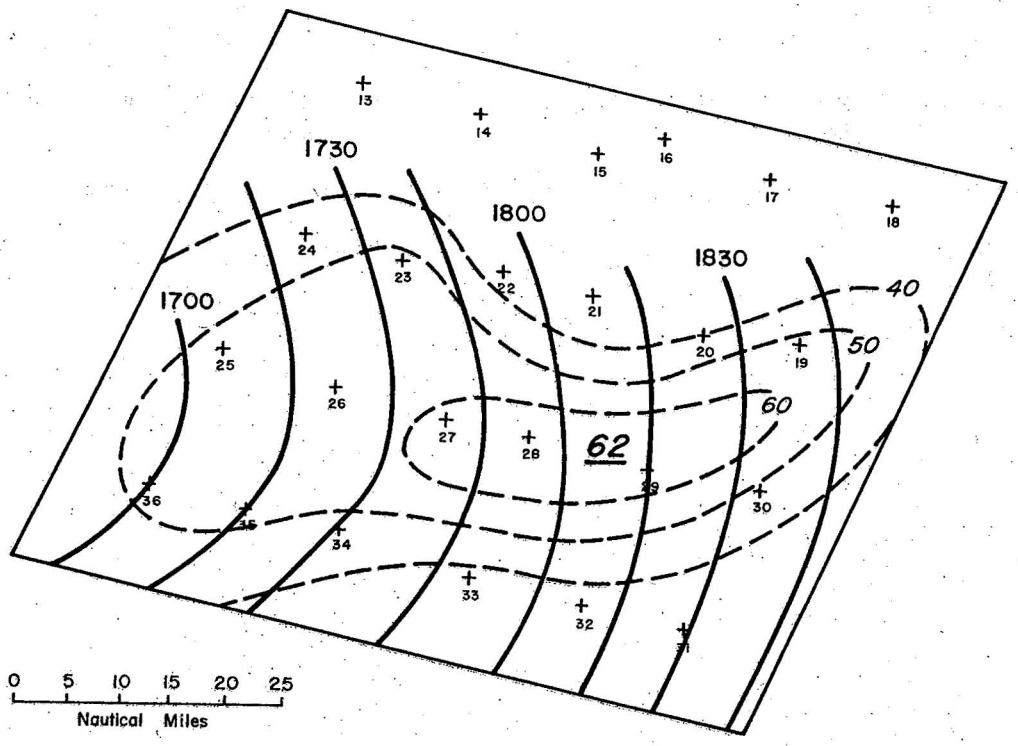


Figure 7.— Preliminary isochrone-amplitude analysis of a peak gust line associated with the pressure rise line in figure 1. Dashed lines show amount of the gust in kt.

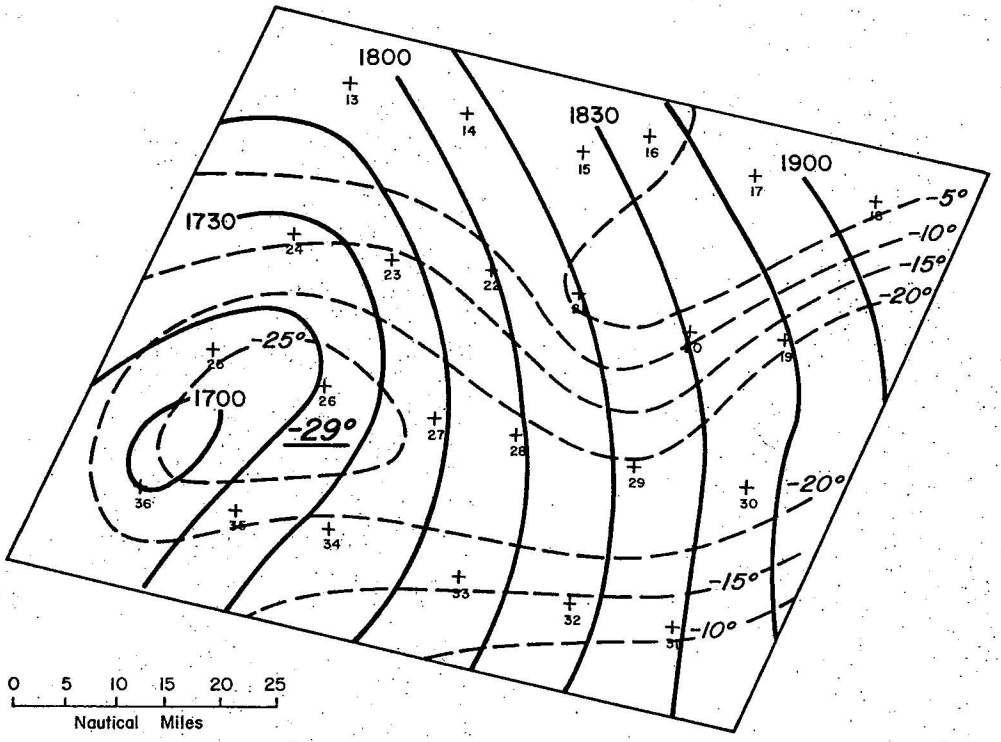


Figure 8.— Preliminary isochrone-amplitude analysis of a temperature fall line associated with the pressure rise line and peak gust line in figures 1 and 2. The cold air appeared to generate at a point near stations 25 and 36, so the 1700 CST isochrone is closed. Dashed lines show amount of temperature fall in °F.

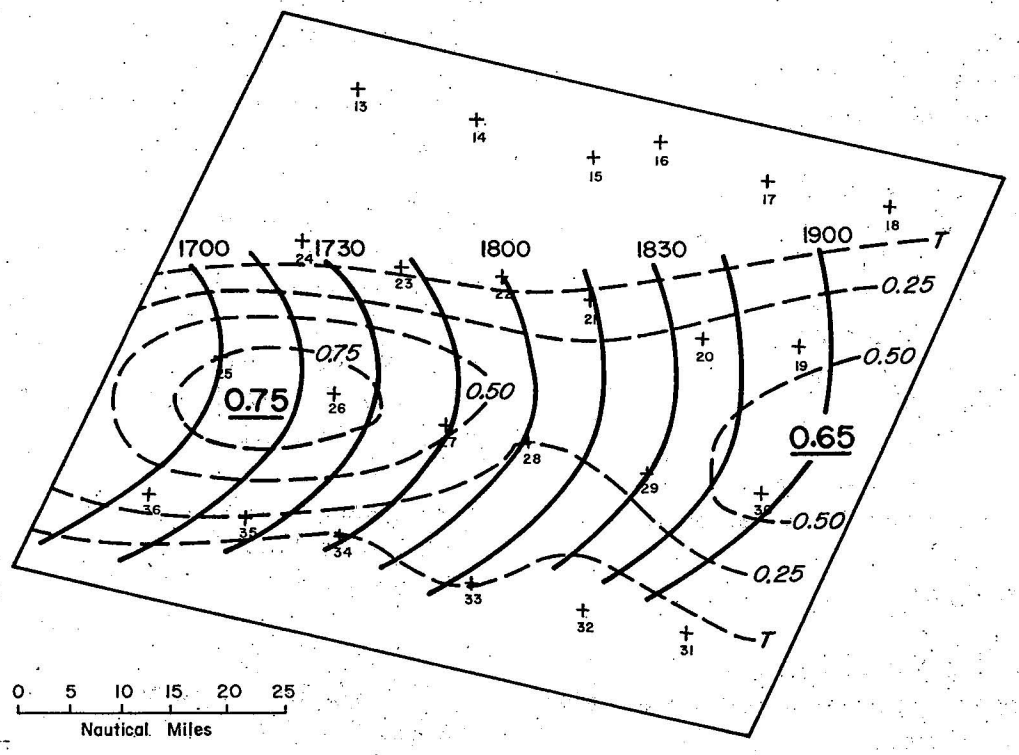


Figure 9.— Preliminary isochrone-amplitude analysis of rainfall line associated with the pressure rise, peak gust, and temperature fall lines in figures 1, 2, and 3. Dashed lines show amounts of rainfall in in.

APPENDIX VI

ATTENDEES, 1963 NSSP SPRING OPERATIONAL CONFERENCE
31 JAUNARY - 1 FEBRUARY 1963

Mr. A. B. Arnett
National Severe Storms Project
Kansas City, Mo.

Mr. Abraham Arnold
U. S. Army Electronics
Res. & Dev. Laboratory
Fort Monmouth, N. J.

Prof. F. C. Bates
University of Kansas
Lawrence, Kansas

Mr. Stuart Bigler
U. S. Weather Bureau
Washington, D. C.
NSSP Weather Radar Laboratory
Norman, Oklahoma

Mr. E. T. Binckley
Aeronautical Systems Division
Wright-Patterson AFB, Ohio

Cdr. P. J. Bloom, USN
Federal Aviation Agency
Atlantic City, N.J.

Mr. D. C. Chilcoat
Federal Aviation Agency
Fort Worth, Texas

Dr. R. M. Cunningham
Geophysics Research Directorate
AFCRL
Bedford, Mass.

Mr. R. J. Donaldson, Jr.
Geophysics Research Directorate, AFCRL
Sudbury, Mass.

Mr. James Fankhauser
National Severe Storms Project
Kansas City, Mo.

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Mr. B. B. Goddard
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Wright-Patterson AFB, Ohio

Mr. W. E. Hardy
National Severe Storms Project
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Mr. Henry Harrison
United Air Lines
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Mr. D. C. House
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Mr. R. E. Elkins
Ft. Worth ARTC Center
Drawer C
Euless, Texas

Mr. Douglas A. Kohl
General Mills, Inc.
Minneapolis 13, Minn.

Mr. Duane A. Lea
Navy Weather Research Facility
Naval Air Station
Norfolk, Va.

Mr. J. T. Lee
National Severe Storms Project
Kansas City, Mo.

Mr. H. S. Lieb
U. S. Weather Bureau
Washington, D. C.

Mr. J. E. Miller
General Mills, Inc.
Minneapolis 13, Minn.

Mr. George Mills, II
Aeronautical Systems Division
Wright-Patterson AFB, Ohio

Mr. H. H. Murphy
Oklahoma City RAPCON/TWR
Midwest City, Okla.

Dr. C. W. Newton
National Severe Storms Project
Kansas City, Mo.

Mr. R. L. Peace
Cornell Aeronautical Laboratory
Buffalo, New York

Mr. R. J. Pilie
Cornell Aeronautical Laboratory
Buffalo, New York

Mr. Hugh L. Jones, III
National Severe Storms Project
Kansas City, Mo.

Prof. Walter J. Saucier
University of Oklahoma
Norman, Okla.

Mr. Paul W. J. Schumacher
Aeronautical Systems Division
Wright-Patterson AFB, Ohio

Dr. P. H. Silberg
Raytheon Co.
Wayland, Mass.

Mr. Roy Steiner
National Aeronautics and Space
Administration
Langley Research Center
Hampton, Virginia

Mr. Glenn E. Stout
Illinois State Water Survey
Urbana, Illinois

Mr. B. R. Tripp
Cornell Aeronautical Laboratory
Buffalo, N. Y.

Lt. E. B. Underwood, Jr.
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Mr. D. T. Williams
National Severe Storms Project
Kansas City, Mo.

Mr. A. W. Youmans
U. S. Weather Bureau
Washington, D. C.

USCOMM-WB-DC