CHAPTER II

EVALUATION OF TECHNIQUES

A. GENERAL

Aerial reconnaissance is the only method available which provides sufficient data for the proper analysis of a tropical system. Land stations in the Tropical Pacific are widely scattered and ship reports are concentrated along the shipping lanes which do not generally pass through areas of formation and development of tropical systems. Since most of the ships which are near developing systems take evasive action as soon as the first warning is issued, surface data is generally sparse in the vicinity of a typhoon. Aerial reconnaissance, being mobile, provides the position, intensity, indications of past movement, significant features such as eye shape, size and slope, and any changes which occur while the aircraft is near the storm. By using dropsondes or making an ascent or descent sounding, the reconnaissance aircraft are able to obtain the lapse rate profile to the surface, sea level pressure, and surface temperature and dew point at any point.

The accuracy of warnings is directly related to the quality and quantity of aircraft reconnaissance of tropical systems. Continuous surveillance is required on all tropical systems so that initial warnings may be issued in time to insure proper preparations for safeguarding life and property. In the future, part of this early surveillance may be covered by use of satellites equipped with Automatic Picture Transmission (APT).

B. SURVEILLANCE METHODS

During 1965, two aircraft squadrons were assigned the primary responsibility for tropical reconnaissance under the requirements of the Joint Typhoon Warning Center, Guam. These units were the U. S. Navy Airborne Early Warning Squadron ONE (VW-1) which is based at Naval Air Station, Agana, Guam, and the U. S. Air Force 54th Weather Reconnaissance Squadron (54WRS) which is based at Andersen Air Force Base, Guam.

The U. S. Air Force 56th Weather Reconnaissance Squadron (56WRS) based at Yokota Air Base, Japan, was the primary backup for the 54WRS and provided all low level fixes assigned to the 54WRS until mid-year 1965.

The aircraft used by the various squadrons were the EC121K Warning Star by VW-1, the WB-50 by 56WRS, and the WB-47 by 54WRS until mid-year, when the WC-130 was phased into the inventory as a replacement for the WB-47.

Land radar was utilized as a backup for aerial reconnaissance when a tropical system was within radar range. This information was available from various weather radar and tactical radar sites and proved to be very useful.

TIROS satellite reports were also utilized during the 1965 season and were useful to JTWC in locating areas of possible storm formation.

C. EVALUATION OF AERIAL RECONNAISSANCE

During the 1965 season four fixes per day were scheduled on all typhoons and at least two fixes per day on all tropical storms. Tropical depressions were scheduled for one or more fixes per day depending on location and potential. To allow sufficient lead time for aircraft deployment on developing systems, many tropical storms, which were expected to develop into typhoons within 24 hours or were in critical areas, were also scheduled for four fixes per day. In general low or intermediate (1500 ft or 700mb) level fixes were made by VW-1 at 0900Z and 1500Z while intermediate (700mb) level fixes were provided by the 54WRS and 56WRS at 0300Z and 2100Z. During the first half of the season the 54WRS made high (300mb) level fixes using the WB-47 aircraft.

Both VW-1 and 54WRS flew synoptic tracks and investigations throughout the season.

In spite of problems associated with higher priority missions, a large percentage of the fixes and investigations requested were completed.

D. EVALUATION OF DATA

1. Aerial Reconnaissance Data

Aerial reconnaissance data can be divided into three categories: peripheral data, eye data from penetration, and eye data from radar.

Peripheral data is all information reported enroute to and outside the eye of the storm. It includes weather, sea level pressure if aircraft is at low level or pressure-height if at mid or high-level, complete description of clouds including types, amount and height of bases and tops if feasible, flight altitude wind, temperature and dew point, and the surface wind if the sea surface is visible. Dropsonde data was also provided by the WB-50 and WC-130 aircraft and by the EC121K as feasible. This same type of data is provided on all synoptic tracks and investigations. All of the peripheral data obtained by the WB-47 aircraft was at the 30,000 ft level. The WB-50 and the WC-130 usually flew at 700mb but on occasion flew at 500mb, or 1500 ft. EC121K aircraft normally flew either at 1500 feet or 700mb, but at times mountainous terrain required the flight to be at 500mb.

Eye data from penetration includes all information reported in peripheral data plus eye size, shape, description, slope, cloudiness, maximum flight level wind, surface wind and surge, if any, and other remarks which might be of help to the forecaster such as feeder band description, direction and speed of movement of the center, etc. If possible, a dropsonde is also made in the eye. If the wind, cloud, pressure and radar eye do not coincide, the type eye reported is specified and bearing and distance given to any others.

Eye data from radar provides a description of the radar eye and its location, including description of spiral bands and height and width of the wall clouds. Also included is the aircraft position at the time the radar observation is taken and the maximum observed winds if possible.

On all eye messages a center selection evaluation of either Positive, Fair or Poor is given along with an estimate of the navigation accuracy of the fix and a statement of the type of navigation fix used by the aircraft. These were used by JTWC as a guide in evaluating fix accuracy. With radar fixes from a considerable distance, attenuation can distort the radar image; therefore, this must be considered when evaluating a fix.

During 1965 daylight penetrations were made on all but a few of the most severe storms. When possible, EC121K aircraft also penetrated the storms, mainly on the evening fixes but often at nighttime also. These penetrations were normally made at 1500 ft or below on the evening fix and 700mb at night.

The data obtained by the various squadrons was accurate and complete with a very few exceptions. Crew experience varied widely through all the squadrons, with mostly "old hands" remaining from the 1964 season at VW-1. Due to the phase-in of a new type aircraft, crew experience in typhoon work was low in the 54WRS early in the year. However, there was a rapid increase in effectiveness during the latter half of the season. One difficulty faced by all three squadrons was that of obtaining good navigation fixes in those areas where loran navigation is poor.

COMPARISON OF RECON FIXES AND BEST TRACK POSITIONS

(Average Distance of Fix from Best Track)

For Tropical Depressions	17 miles
For Tropical Storms	16 miles
For Typhoons	11 miles
Average for all fixes on all storms by all squadrons for the 1965 season	13 miles

The information received from all reconnaissance aircraft was continually checked for consistency and accuracy. Where possible, JTWC graphs and other aids were used to check and compare fix data with previous reports. Verification was requested from the observing aircraft on any apparent discrepancy in the data.

2. Land Radar

Land radar reports were used in conjunction with aircraft reports whenever possible. These reports included range and bearing of the eye from the reporting station, eye characteristics and occasionally the direction and speed and movement of the eye. A combination of attenuation, operator inexperience and the fact that the radar could see only the top of the storm made distance land radar reports often inaccurate. However, as the storm approached the station, the accuracy usually improved markedly.

3. Satellite Reports

Miscellaneous satellite bulletins giving information on tropical systems were received periodically throughout the season. While many of these bulletins provided only a verification of previous fixes by other methods, on a few occasions they were very useful as the basis for scheduling investigative missions, and led indirectly to the location of a few tropical storms. Satellite bulletins would be much more useful to JTWC if their receipt were more timely. In most instances, several hours elapsed between the time of observation and the time of receipt of the bulletin.

It is interesting to note that during the 1965 season Tropical Depression 23 and Tropical Storm DOREEN were fixed visually by Lieutenant Colonel COOPER on the Gemini Five flight while passing over the Central Pacific. This is thought to be a first in fixes on tropical cyclones.

E. COMMUNICATIONS

The primary means of communications between ground and aircraft was voice single sideband for the 54WRS from both the WC-130 and the WB-47 aircraft. For VW-1 and the 56WRS, the primary means was radiotelegraph (CW). For all aircraft, AIE2, Andersen AFB, Guam was the primary air to ground contact, with AIF8, Yokota AB, Japan; AIF2, Fuchu Air Station, Japan; and AIC2, Clark AB, Republic of the Philippines acting as secondary stations. Data received by AIE2 was relayed to JTWC via local circuit 3L28. This circuit also serves VW-1 and the 54WRS. When the data was first received by one of the secondary stations, it was transmitted primarily by DCS addressed message to JTWC. Also there is an "on call" pony loop RATT circuit connecting Japan with AIE2 which may be used as necessary.

When aircraft were in contact with AIE2, most reports were received in JTWC in sufficient time to enable the forecaster to make a comprehensive study of the data before warning time. However, when the aircraft was working secondary stations, many times the reports were unavailable at JTWC before warning time and had to be tracked down by the forecaster through use of long distance telephone links or "wirenotes." This was especially true of AIC2, where the use of regular DCS addressed messages often led to a delay of up to 24 hours in time of receipt. This situation was encountered with practically all fixes in the South China Sea and, without the use of Fleet Weather Facility Sangley Point as an alternate relay point, it would have been even more of a problem. The establishment of the cable connection between Guam and the Philippines has helped reduce this problem in 1965.

The following are some revealing statistics on communications delays encountered in 1965 along with figures from previous years for comparison.

DELAYS IN RECEIPT OF TYPHOON
RECONNAISSANCE FIX DATA

	1963	1964	1965
MAX DELAY TIME	5 hrs.10 min	6 hrs.45 min	60 hrs.09 min
AVG DELAY TIME	1 hr. 02 min	1 hr. 14 min	1 hr. 05 min
MIN DELAY TIME	"few minutes"	8 minutes	9 minutes
% OF EYE MESSAGES DELAYED MORE THAN 1 HOUR	33%	59%	39%
NUMBER RECEIVED AFTER WARNING TIME	22	46	34
% RECEIVED AFTER WARNING TIME	5%	8%	6%

F. SUMMARY OF RECONNAISSANCE SUPPORT

In an effort to make the crediting of the reconnaissance effort more objective and meaningful, a system was devised to credit fixes and investigative flights as to their timeliness. First of all, the problems of why a fix was missed, early or late, although of interest and concern to JTWC, belong to the Tropical Cyclone Reconnaissance Coordinator (TCRC). The criteria used were dictated by warning times and communications delays. Obviously it would be desirable to have the fix delayed to as near warning time as possible, but the communications delays have been such that fixes must be made about 3 hours before warning time. This allows ample time to digest the information after receipt of the data. This system is described below:

DEFINITIONS OF RECONNAISSANCE CREDITS
FIXES

CLASS	DEFINITION	CRITERIA
1	Full Credit	From 1 hour before to ½ hour after levied time
2	Full Credit	No center or eye found, but otherwise falls into Class 1 above
3	Early/Late	Greater than 1 hour but not more than 1½ hours before levied time or greater than ½ hour but not more than 2 hours after levied time
4	Very Early or Late	Greater than 1½ hours before or 2 hours after the levied fix time

CLASS	DEFINITION	CRITERIA
5	Attempted but missed fix	Attempt made by squadron with no eye/center fix made, but some useful peripheral data provided. Reasons may be clearance problems, mechanical problems, etc., etc.
6	Missed Fix	Due to complete abort, aircraft that got airborne but provided no useful data, basic restrictions, refused by squadron for unspecified reasons, etc.

INVESTIGATIVE FLIGHTS

CLASS	DEFINITION	CRITERIA
A	Full Credit	Satisfactory job of reconnaissance and made a fix on a tropical cyclone
B	Full Credit	Satisfactory job of reconnaissance, but no fix made
C	Early/Late	In area as specified in Class 3 above, and did a satisfactory job of reconnaissance
D	Very Early or Late Inves.	Greater than 1½ hours before or 2 hours after levied time to be in suspect area
E	Attempted but missed Inves.	Attempt made by squadron but thorough investigation of suspect area not accomplished. Some peripheral data was provided. Reasons may have been clearance problems, mechanical problems, etc., etc.
F	Missed Inves.	Due to complete abort, aircraft that got airborne but provided no useful data, basic restrictions, refused by squadron for unspecified reasons, etc.

This system, although as objective as possible, requires subjective evaluation of some fixes. For example, a plane could be in the area assigned on time when the storm had accelerated unexpectedly and could not be reached within the normal time limits by the reconnaissance aircraft. In this case, full credit would be given with no penalty for being late.

Applying the above criteria for the 1965 season, the following statistics are obtained:

EVALUATION OF TIMELINESS OF RECONNAISSANCE FOR 1965

FIXES		INVESTIGATIONS		FIXES & INVESTIGATIONS
Class	Number	Class	Number	TOTALS
1	503	A	27	530
2	36	B	46	82
3	40	C	--	40
4	13	D	1	14
5	9	E	1	10
6	27	F	--	27

When more than one aircraft made a fix at the same levied time, only one fix was credited.

JTWC plans to use punch cards and automate as much as possible the crediting of reconnaissance efforts during 1966 so that, in years to come, exact comparisons can be made.

As a matter of interest, there were 240 synoptic tracks flown in 1965. Synoptic tracks include "trans-Pac", training flights that make weather observations, etc. and are flights that are requested by the squadrons. It is estimated that somewhere between 10% and 20% of the synoptic flights cover an area that might have required an investigative flight.

G. EVALUATION OF NUMERICAL WEATHER PRODUCTS

During 1965 operational steering forecasts based on numerical prognoses were received at JTWC from the Fleet Numerical Weather Facility (FNWF) Monterey, California, and occasionally from the National Meteorological Center (NMC), Suitland, Maryland. Due to the proximity of most typhoon tracks to the boundary of the NMC grid, the NMC forecasts were of limited use.

Operational steering predictions were furnished by FNWF on all Tropical Cyclones during 1965. Computations were provided at two different steering levels, 500mb and 1000mb, and also a modified combination of these two. The steering predictions proved very helpful for comparison with other data.

H. EVALUATION OF OPERATIONAL FORECAST PROCEDURES

The basic forecasting technique used throughout the 1965 season was a subjective modification of the numerical steering prediction. Modifications were based on climatology (see Chapter I), and subjective evaluations of micro-analyzed 700, 500, 300 and 200mb charts, with emphasis on the 700mb chart.

If the steering forecast looked reasonable, it was then checked for consistency with climatology and past history. The upper air charts were checked for areas of maximum divergence, areas offering the least resistance to the forward motion of the storm and the 700mb height criteria of Wang. An AROWA grid computation was made on both the 700mb and 500mb charts for most forecasts. In addition, a FAIRLESS computation was made on the surface chart for most forecasts, especially in the early stages.

A subjective integration of all the factors listed above was then used to establish or modify the forecast track of the system. Speed of movement was then forecast from history, climatology, and the steering forecast.