2. RECONNAISSANCE AND FIXES

2.1 GENERAL

JTWC depends primarily on two reconnaissance platforms, satellite and radar, to provide necessary, accurate, and timely meteorological information in support of advisories, alerts and warnings. In data-rich areas, synoptic data are also used to supplement the above. As in past years, the optimal use of all available reconnaissance resources to support JTWC's products remains a primary concern. Weighing the specific capabilities and limitations of each reconnaissance platform, and the tropical cyclone's threat to life and property both afloat and ashore, continue to be important factors in careful product preparation.

2.2 RECONNAISSANCE AVAILABILITY

2.2.1 SATELLITE — Fixes from Air Force/Navy ground sites and Navy ships supply day and night coverage in JTWC's AOR. Interpretation of this satellite imagery yields tropical cyclone positions, and estimates of current and forecast intensities using the Dvorak technique. The Special Sensor Microwave/Imager (SSM/I) data are used to determine the extent of the 35-kt (18-m/sec) winds near the tropical cyclone and to aid in tropical cyclone positioning, especially when the center is obscured by clouds.

2.2.2 RADAR — Interpretation of land-based radar, which remotely senses and maps precipitation within tropical cyclones, provides positions in the proximity (usually within 175 nm (325 km) of radar sites in the Philippine Islands, Taiwan, Hong Kong, China, Japan, South Korea, Kwajalein, Guam, Thailand, Australia, and India.

2.2.3 AIRCRAFT - Four tropical cyclone fixes were received from the weather reconnaissance aircraft associated with the TCM-92 mini-field experiment conducted at JTWC from 21 July to 20 August 1992.

2.2.4 SYNOPTIC — JTWC also determines tropical cyclone positions based on the analysis of surface/gradient-level synoptic data. These positions are an important supplement to fixes provided by remote sensing platforms, and become invaluable in situations where neither satellite nor radar fixes are available or representative.

2.3 SATELLITE RECONNAISSANCE SUMMARY

The Air Force provides satellite reconnaissance support to JTWC through the DMSP Tropical Cyclone Reporting Network (DMSP Network), which consists of tactical sites and a centralized facility. The personnel of Det 1, 633 OSS (hereafter referred to as Det 1), collocated with JTWC at Nimitz Hill, Guam, coordinate required tropical cyclone reconnaissance support with the following units:

15 ABW/WE, Hickam AFB, Hawaii
18 OSS/WE, Kadena AB, Japan
603 ACCS/WE, Osan AB, Republic of Korea
Air Force Global Weather Central,
Offutt AFB, Nebraska

The tactical sites provide a combined coverage from polar orbiting satellites that includes most of the western North Pacific, from near the international date line westward to Southeast Asia. The Naval Oceanography Command Detachment, Diego Garcia, furnishes interpretation of low resolution NOAA polar orbiting satellite coverage in the central Indian Ocean, and Navy ships equipped for direct satellite readout contribute supplementary support.

Also, civilian contractors with the U.S. Army at Kwajalein Atoll provide satellite fixes on tropical cyclones in the Marshall Islands that supplement Det 1's satellite coverage.

Additionally, DMSP low resolution satellite mosaics are available from the FNOC via the NEDN and NESN lines. These mosaics are used to metwatch the areas not included in the area covered by the DMSP tactical sites. They provide JTWC forecasters with the capability to "see" what AFGWC's satellite image analysts have been fixing, after the fact.

In addition to polar orbiter imagery, Det 1 uses high resolution geostationary imagery to support the reconnaissance mission. Animation of these geostationary images is invaluable for determining the location of cloud system centers and their motion, particularly in the formative stages. Animation is also valuable in assessing environmental, or ambient, changes affecting tropical cyclone behavior. Det 1 is able to receive and process high resolution digital geostationary data through its Meteorological Imagery, Data Display and Analysis System (MIDDAS), and through the Navy's Geostationary Satellite Receiving System (GSRS). Det 1 can process imagery on a daily basis from at least four polar orbiting and one geostationary spacecraft.

AFGWC is the centralized member of the DMSP network. In support of JTWC, AFGWC processes stored imagery from DMSP and NOAA spacecraft. Imagery is recorded by the various spacecraft as they orbit the earth, and is later relayed to AFGWC by a network of communication satellites and command readout sites. This enables AFGWC to obtain the recorded coverage necessary to fix all tropical cyclones within JTWC's AOR.

The hub of the DMSP network is Det 1. Based on available satellite coverage, Det 1 is responsible for coordinating satellite reconnaissance requirements with JTWC and tasking the individual network sites for the necessary tropical cyclone fixes, current intensity estimates, and SSM/I surface wind information. When a particular satellite pass is selected to support the development of JTWC's next tropical cyclone warning, two sites are tasked to fix the tropical cyclone from the same pass. This "dual-site" concept provides the necessary redundancy that virtually guarantees JTWC a satellite fix to support each warning. It also supplies independent assessments of the same data to provide JTWC forecasters a measure of confidence in the location and intensity information.

The network provides JTWC with several products and services. The main service is to monitor the AOR for indications of tropical cyclone development. If development is suspected, JTWC is notified. Once JTWC issues either a Tropical Cyclone Formation Alert or a warning, the network provides tropical cyclone positions and current intensity estimates, with a forecast intensity estimate implied in the intensity estimation code. Each satellite-derived tropical cyclone position is assigned a Position Code Number (PCN), which is a measure of positioning confidence. The PCN is determined by a combination of (1) the availability of visible landmarks in the image that can be used as references for precise gridding and (2) the degree of organization of the tropical cyclone's cloud system (Table 2-1). Once the tropical cyclone's intensity is assessed as having reached 50 knots (26 m/sec), information of the distribution of 35-kt (18-m/sec) winds is provided using SSM/I data. Through the technique development efforts at AFGWC, a PCN has been developed to indicate the confidence in microwave imagery-derived position reports.

TABLE 2-1 **POSITION CODE NUMBERS (PCN)**

PCN	METHOD FOR CENTER DETERMINATION/GRIDDING
1	EYE/GEOGRAPHY
2	EYE/EPHEMERIS
3	WELL DEFINED CIRCULATION CENTER/GEOGRAPHY
4	WELL DEFINED CIRCULATION CENTER/EPHEMERIS
5	POORLY DEFINED CIRCULATION CENTER/GEOGRAPHY
6	POORLY DEFINED CIRCULATION CENTER/EPHEMERIS

Det 1 provides at least one estimate of the tropical cyclone's current intensity every 6 hours once JTWC is in alert or warning status. Current intensity estimates are made using the Dvorak (1975, 1984) technique for both visible and enhanced infrared imagery (Figure 2-1). On mature tropical cyclones, the enhanced infrared technique is preferred due to its objectivity; however, the visible technique is used to supplement this information during the daylight hours, primarily as a measure of consistency. The standard relationship between tropical cyclone "T-number", maximum sustained surface wind speed, and minimum sea-level pressure (Atkinson and Holliday, 1977) for the Pacific is shown in Table 2-2. For subtropical cyclones, intensity estimates are made using the Hebert and Poteat (1975) technique.

2.3.1 SATELLITE PLATFORM SUMMARY

Figure 2-2 shows the status of operational polar orbiting spacecraft. Of the four NOAA spacecraft in orbit, NOAA 10, 11, and 12 provided imagery throughout 1992, while NOAA 9 remained in a standby mode.

Of the four DMSP spacecraft: F8 provided only horizontally polarized 85 GHz channel

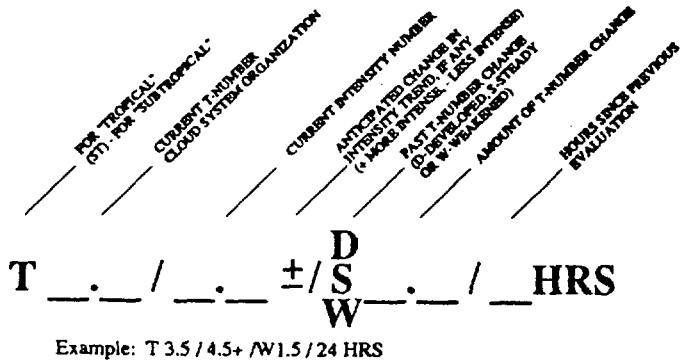

Figure 2-1. Dvorak code for communicating estimates of current and forecast intensity derived from satellite data. In the example, the current "T-number" is 3.5, but the current intensity is 4.5. The cloud system has weakened by 1.5 "T-numbers" since the previous evaluation conducted 24-hours earlier. The plus (+) symbol indicates an expected reversal of the weakening trend or very little further weakening of the tropical cyclone during the next 24-hour period.

from its SSM/I sensor; F9 failed on 21 February 1992; F10 supplied imagery, but continued to present satellite analysts with gridding problems due to the eccentricity of its orbit; and, F11 performed well all year.

2.3.2 STATISTICAL SUMMARY

During 1992, information from the DMSP network was the primary input to JTWC's warnings. Virtually all warnings were based on satellite reconnaissance data. JTWC received a total of 5557 satellite fixes during 1992: of these, 3663 were for the western North Pacific, 438 for the North Indian Ocean, and 1456 for the Southern Hemisphere. Of all the fixes, 37 percent were from polar orbiters and 63 percent were from the geostationary platform. Once again, there was an increase in the total number of fixes over the previous year. This is attributable to an increased use of the MIDDAS, which was tasked heavily for hourly positions when tropical cyclones approached major DOD facilities or heavily populated areas.

No DMSP network site experienced significant outages in 1992, compared to the 51 percent down-time reported for 1991. At Nimitz Hill, during periods when the site temporarily could only receive data, but not produce a film copy, the MIDDAS ingested the data and provided the needed images, preventing impacts experienced in the pre-MIDDAS period. A

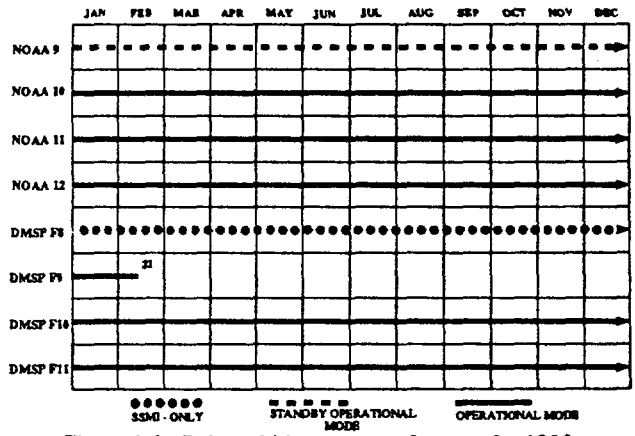

Figure 2-2. Polar orbiting spacecraft status for 1992.

comparison of satellite fixes from all data sources with their corresponding best track positions is shown in Table 2-3.

2.3.3 APPLICATION OF NEW TECHNOLOGY

By early 1992, all tactical sites in the DMSP network had received the Mission Sensor Tactical Imaging Computer (MISTIC) for processing the SSM/I, however, the AFGWC Tropical Section continued to provide the majority of the SSM/I support to JTWC. High resolution, 256 gray shade, SSM/I data became available at AFGWC for interpretation via AFGWC's Satellite Data Handling System on 1 March 1992. AFGWC, Det 1, and 18 OSS/WE (Kadena AB) provided bulletins to JTWC describing the distribution of 35-kt (18-m/sec) winds near tropical cyclones. The MISTIC II, which is an expanded and upgraded version of the MISTIC system, was to be installed at the tactical network sites in early 1993. MISTIC II is designed to supply co-registered OLS and full resolution, 256 gray shade, SSM/I data.

2.3.4 FUTURE OF SATELLITE RECONNAISSANCE

The MIDDAS, which was formally accepted for operational use by Det 1 on 1 April 1992, has proven invaluable for providing JTWC with tailored satellite support. Work on the development and application of more user-friendly, interactive software designed for the MIDDAS continues. The Det 1 goal is to establish a fully integrated satellite system with interfaces to the Automated Weather Distribution System (AWDS), NEXRAD, MIDDAS, MISTIC II, TESS 3, and the MARK IVB.

Plans and work have progressed on installation of the MARK IVB at DMSP network sites. Projected completion dates for the Nimitz Hill, Hickam AFB, and Kadena AB sites will be in 1994. Until the projected October 1993 installation of AWDS, conventional weather data will continue to come through the Automated Weather Network (AWN).

TABLE 2-2 **MAXIMUM SUSTAINED WIND SPEED (KT) AS A FUNCTION OF DVORAK CURRENT AND FORECAST INTENSITY NUMBER AND MINIMUM SEA-LEVEL PRESSURE (MSLP)**

TROPICAL CYCLONE INTENSITY NUMBER	WIND SPEED	MSLP (MB) (NW PACIFIC)
0.0	25	- - - -
0.5	25	- - - -
1.0	25	- - - -
1.5	25	- - - -
2.0	30	1000
2.5	35	997
3.0	45	991
3.5	55	984
4.0	65	976
4.5	77	966
5.0	90	954
5.5	102	941
6.0	115	927
6.5	127	914
7.0	140	898
7.5	155	879
8.0	170	858

2.4 RADAR RECONNAISSANCE SUMMARY

Fourteen of the 33 significant tropical cyclones in the western North Pacific during 1992 passed within range of land-based radar with sufficient precipitation and organization to be fixed. A total of 364 land-based radar fixes were logged at JTWC, and one airborne radar fix was provided by a TCM-92 WC-130 aircraft.

The WMO radar code defines three categories of accuracy: good [within 10 km (5 nm)], fair [within 10 - 30 km (5 - 16 nm)], and poor [within 30 - 50 km (16 - 27 nm)]. Of the 363 radar fixes encoded in this manner, 132 were good, 102 were fair, and 129 were poor. Excellent support for the radar network through timely and accurate radar fix positioning allowed JTWC to track and forecast tropical cyclone movement during even the most erratic track changes. Ten radar reports were logged for tropical cyclones in the North Indian Ocean, and none were logged for tropical cyclones in the Southern Hemisphere.

Due to the loss of radar at Andersen AFB, Guam during Typhoon Omar, the NEXRAD installation was accelerated to occur in February 1993. During the period without weather radar coverage on Guam, supplemental data was provided from the Federal Aviation Administration's Center-Radar Approach Control located on Andersen AFB.

TABLE 2-3 **MEAN DEVIATION (NM) OF ALL SATELLITE DERIVED TROPICAL CYCLONE POSITIONS FROM JTWC BEST TRACK POSITIONS (NUMBER OF CASES IN PARENTHESES)**

NORTHWEST PACIFIC OCEAN

PCN	1982-1991 AVERAGE	1992 AVERAGE
1&2	13.5 (5136)	15.5 (972)
3&4	20.9 (5456)	27.4 (942)
5&6	36.2 (11919)	43.3 (1749)
Totals:	**27.13 (22511)**	**31.8 (3663)**

NORTH INDIAN OCEAN

PCN	1982-1991 AVERAGE	1992 AVERAGE
1&2	13.5 (134)	12.6 (33)
3&4	29.4 (89)	35.8 (28)
5&6	39.6 (978)	34.2 (377)
Totals:	**36.0 (1201)**	**32.6 (438)**

WESTERN SOUTH PACIFIC AND SOUTH INDIAN OCEAN

PCN	1982-1991 AVERAGE	1992 AVERAGE
1&2	16.3 (1556)	14.3 (415)
3&4	26.9 (1299)	27.0 (369)
5&6	35.9 (7275)	38.2 (672)
Totals:	**31.7 (10130)**	**28.6 (1456)**

2.5 TROPICAL CYCLONE FIX DATA

Table 2-4A delineates the number of fixes per platform for each individual tropical cyclone for the western North Pacific. Totals and percentages are also indicated. Similiar information is provided for the North Indian Ocean in Table 2-4B, and for the South Pacific and South Indian Oceans in Table 2-4C.

TABLE 2-4A **1992 NORTHWEST PACIFIC OCEAN FIX PLATFORM SUMMARY**

NORTHWEST PACIFIC		SATELLITE	RADAR	SYNOPTIC	AIRCRAFT	TOTAL
TS Ekeka	(01C)	88	0	0	0	88
TY Axel	(01W)	123	0	0	0	123
TY Bobbie	(02W)	120	43	2	0	165
TY Chuck	(03W)	90	0	0	0	90
TS Deanna	(04W)	101	0	0	0	101
TY Eli	(05W)	88	0	2	0	90
TS Faye	(06W)	56	0	0	0	56
TY Gary	(07W)	88	12	4	0	104
TS Helen	(08W)	37	0	0	0	37
TY Irving	(09W)	61	31	3	0	95
TY Janis	(10W)	119	71	7	1	198
STY Kent	(11W)	217	37*	0	1	255
TS Lois	(12W)	114	0	0	1	115
TS Mark	(13W)	81	4	20	0	105
TS Nina	(14W)	45	0	0	0	45
STY Omar	(15W)	249	20	0	0	269
TS Polly	(16W)	104	4	4	0	112
TY Ryan	(17W)	196	11	0	0	207
TY Sibyl	(18W)	120	0	0	0	120
TY Ted	(19W)	109	0	5	0	114
TS Val	(20W)	67	0	1	0	68
TY Ward	(21W)	113	0	0	0	113
TS Zack	(22W)**	77	0	0	0	77
STY Yvette	(23W)	178	0	0	0	178
TY Angela	(24W)**	122	0	5	0	127
TY Brian	(25W)	147	13	0	0	160
TY Colleen	(26W)	160	0	0	0	160
TY Dan	(27W)	123	0	0	0	123
STY Elsie	(28W)	154	26	0	0	180
TD 29W	(29W)	14	0	0	0	14
TY Forrest	(30W)	133	14	0	0	147
STY Gay	(31W)	282	56	1	0	339
TY Hunt	(32W)	99	21	0	0	120
	Totals:	**3875**	**363**	**54**	**3**	**4295**
Percentage of Total:		**90%**	**8%**	**1%**	**0%**	**100%**

* One Airborne radar fix included
** Regenerated

TABLE 2-4B **1992 NORTH INDIAN OCEAN FIX PLATFORM SUMMARY**

NORTH INDIAN OCEAN	SATELLITE	RADAR	SYNOPTIC	TOTAL
TC 01B (01B)	52	0	0	52
TC 02A (02A)	32	10	0	42
TC 03B (03B)	28	0	1	29
TC 04B (04B)	28	0	0	28
TC 05B (05B)	17	0	0	17
TC 06A (06A)	14	0	1	15
TC 07B (07B)	24	0	0	24
TC 08B (08B)	16	0	0	16
TC 09B (09B)	63	0	0	63
TC 10B (10B)	41	0	2	43
TC 11A (11A)	20	0	0	20
TC 12A (12A)	25	0	0	25
Forrest (30W)	79	0	0	79
Totals:	**439**	**10**	**4**	**453**
Percentage of Total:	**97%**	**2%**	**1%**	**100%**

TABLE 2-4C **1992 SOUTH PACIFIC AND SOUTH INDIAN OCEANS FIX PLATFORM SUMMARY**

TROPICAL CYCLONES		SATELLITE	SYNOPTIC	RADAR	TOTAL
TC 01S	- - - -	17	0	0	17
TC 02S	- - - -	32	0	0	32
TC 03P	Tia	95	0	0	95
TC 04S	- - - -	25	0	0	25
TC 05S	Graham	110	0	0	110
TC 06P	Val	85	0	0	85
TC 07P	Wasa	0	0	0	0
TC 08P	Arthur	0	0	0	0
TC 09S	Alexandra	35	0	0	35
TC 10S	Bryna	21	0	0	21
TC 11P	Betsy	120	0	0	120
TC 12P	Mark	36	0	0	36
TC 13P	- - - -	3	0	0	3
TC 14P	Cliff	0	0	0	0
TC 15P	Celesta	12	0	0	12
TC 16S	- - - -	45	0	0	45
TC 17P	Daman	70	0	0	70
TC 18P	- - - -	19	0	0	19
TC 19S	Davilia	6	0	0	6
TC 20S	Harriet	137	0	0	137
TC 21P	Esau	111	0	0	111
TC 22S	Farida	36	0	0	36
TC 23S	Ian	79	0	0	79
TC 24S	Gerda	15	0	0	15
TC 25P	Fran	156	0	0	156
TC 26P	Gene	22	0	0	22
TC 27P	Hettie	0	0	0	0
TC 28S	Neville	115	0	0	115
TC 29S	Jane/Irna	130	0	0	130
TC 30P	Innis	55	0	0	55
	Totals:	**1587**	**0**	**0**	**1587**
	Percentage of Total:	**100%**	**0%**	**0%**	**100%**