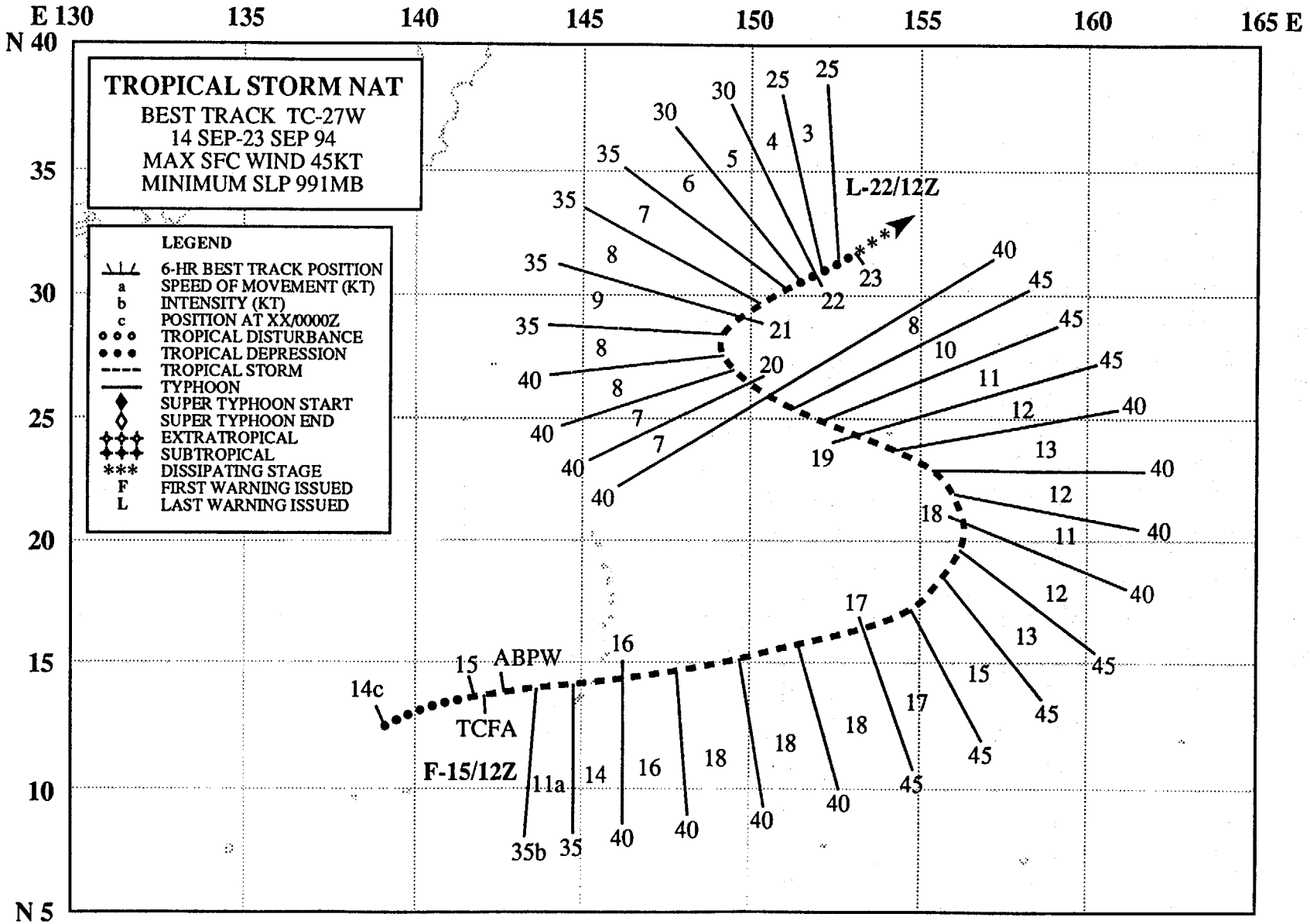
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TROPICAL STORM NAT
BEST TRACK TC-27W
14 SEP-23 SEP 94
MAX SFC WIND 45KT
MINIMUM SLP 991MB
LEGEND
6-HR BEST TRACK POSITION
a SPEED OF MOVEMENT (KT)
b INTENSITY (KT)
c POSITION AT XX/0000Z
TROPICAL DISTURBANCE
TROPICAL DEPRESSION
TROPICAL STORM
TYPHOON
SUPER TYPHOON START
SUPER TYPHOON END
EXTRATROPICAL
SUBTROPICAL
*** DISSIPATING STAGE
F FIRST WARNING ISSUED
L LAST WARNING ISSUED
L-22/12Z
TCFA
F-15/12Z
ABPW
14c
35b
11a

TROPICAL STORM NAT (27W)

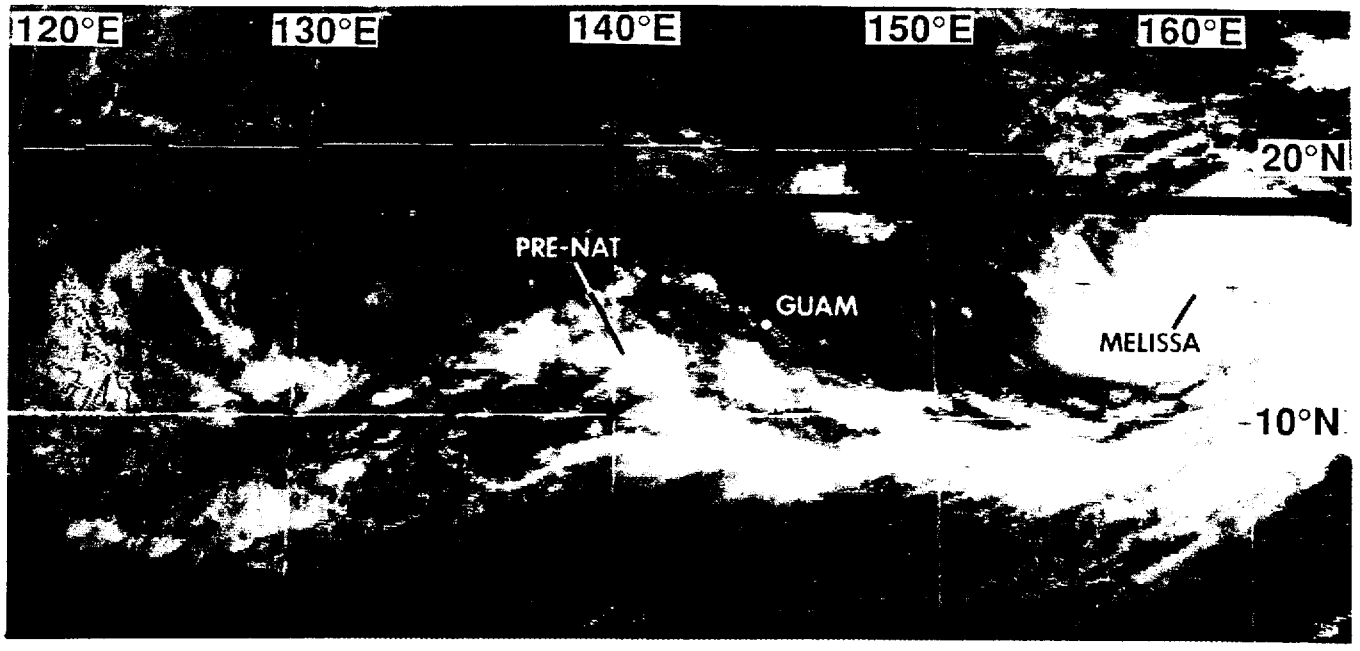

Figure 3-27-1 A monsoon cloud band stretches from the Philippines eastward toward Typhoon Melissa (26W). The first sign of organization of the tropical disturbance which became Nat is seen in the bulge of deep convection west of Guam (132331Z September visible GMS imagery).

I. HIGHLIGHTS

Nat was a small and relatively short-lived tropical cyclone that exhibited unusual "S" motion (Lander 1995a). Moving eastward at low latitude on the first leg of its "S" track, Nat passed to the north of Guam, and within range of Guam's NEXRAD.

II. TRACK AND INTENSITY

By 14 September, a monsoon cloud band stretched from the Philippines eastward to the large cloud system associated with Super Typhoon Melissa (26W) (Figure 3-27-1). In response to the formation of a tropical disturbance to the west of Guam (Figure 3-27-2), a Tropical Cyclone Formation Alert was issued at 150230Z September that stated, in part:

". . . surface pressures in the Marianas have fallen significantly over the past 24 hours, and winds on the south side of this 'monsoon depression' type of disturbance are approaching gale-force intensity. . . . This disturbance should continue to move east-northeastward with the prevailing southwest monsoon flow . . ."

The first warning on Tropical Depression 27W was issued at 151200Z when the system was located about 60 nm (110 km) west-northwest of Guam. It was upgraded to Tropical Storm Nat at 161200Z. In post-analysis, it was determined that Nat had most probably reached tropical storm intensity at 150000Z, and thus it was at minimal tropical storm intensity when it passed 40 nm (75 km) north of Guam at 151800Z. Wind and pressure measurements from conventional recording instruments located on Guam, and wind measurements obtained from Guam's NEXRAD, were the basis of the final best-track intensity estimates.

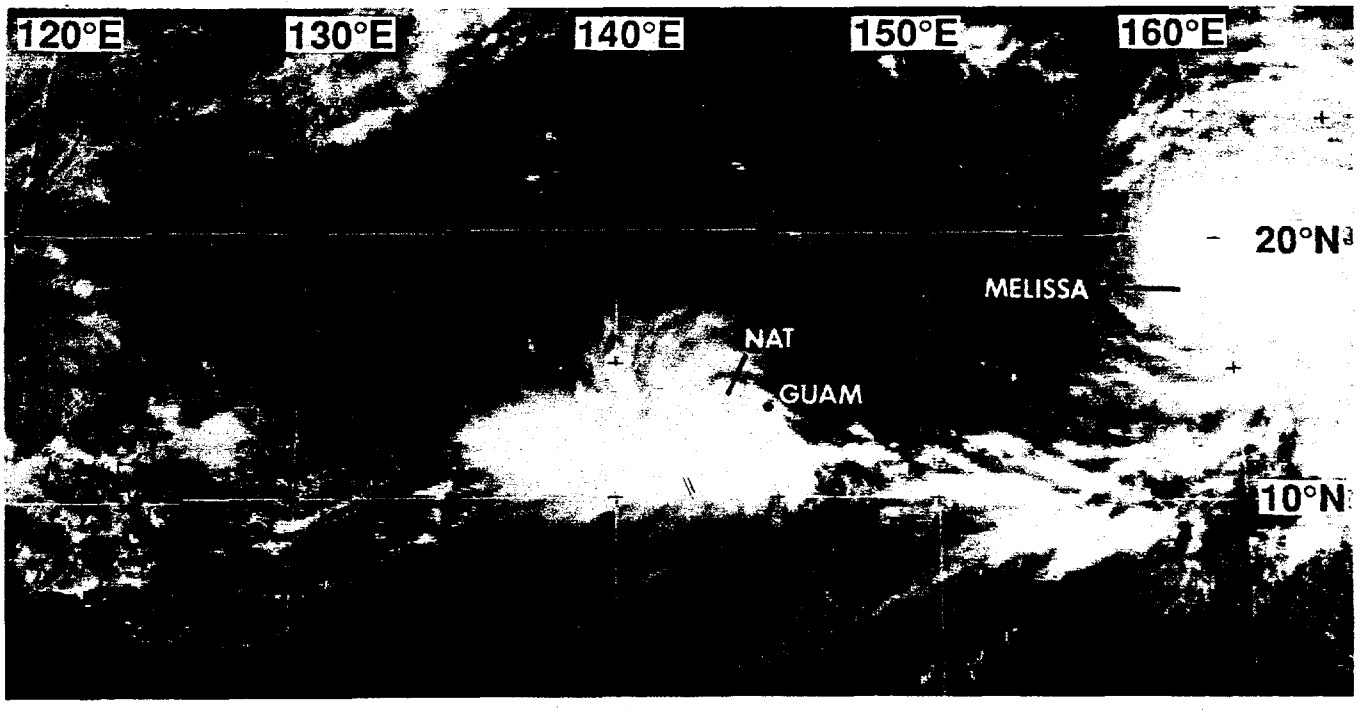

Figure 3-27-2 An area of deep convection has become organized west of Guam. Post analysis indicated that this system had already reached tropical storm intensity (150031Z September visible GMS imagery).

In the prognostic reasoning message (WDPN31 PGTW 151500) written to support the first warning, it was stated that:

"[the] track forecast philosophy is for this system to be a part of the overall monsoon surge that continues to move into Melissa (26W) . . . dynamic forecast aids indicate that the steering will be northeastwards where the system will be absorbed into [Melissa]. . . . We expect this system [Nat] to be weak throughout its existence."

As Nat continued on its northeastward track, it slowly intensified to a peak of 45 kt (23 m/sec). Considerable easterly shear appeared to be the major factor limiting Nat's intensification (Figure 3-27-3). Nat was not absorbed into Melissa's larger circulation as suggested earlier, but did remain weak throughout its life.

Between 170000Z and 190000Z, Nat's heading backed from northeastward to northwestward. Then, between 190000Z and 220000Z, Nat's heading veered from northwestward to northeastward to complete a nearly perfect "S" - shaped track. As Nat moved along the upper half of its "S" track, it separated from the major monsoon cloud band to the south, and decayed over open water near 30°N ; 150°E. The final warning was issued at 221200Z.

III. DISCUSSION

Nat was one of a very small percentage of tropical cyclones that move eastward at low latitude in the western North Pacific during the active months of July through September. Such cases of eastward motion most often occur when a tropical cyclone is embedded in the deep southwesterly flow of a very active monsoon. While on the lower east-bound leg of its "S"-shaped track, Nat passed 40 nm (74 km) to the north of Guam. Guam's NEXRAD provided a unique look at the structure of this unusual tropical cyclone.

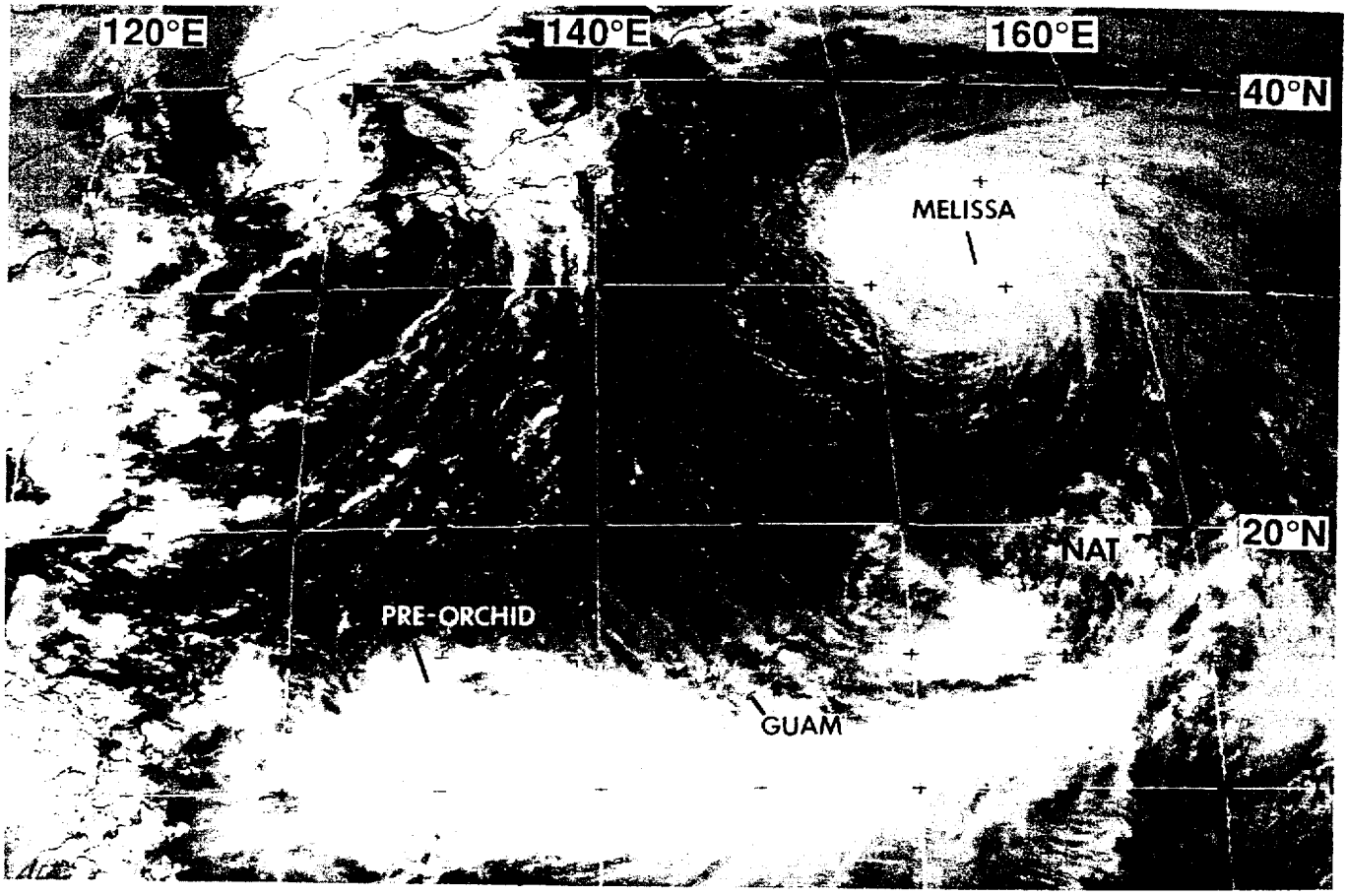

Figure 3-27-3 Nat's low-level circulation center is located to the east of its deep convection under the influence of easterly shear (170531Z September visible GMS imagery).

a. NEXRAD's view of a monsoon squall

On the morning of 15 September (at approximately 150000Z), a cloud band on the outer fringes of Nat's circulation (see Figure 3-27-2) passed over Guam from the southwest and was accompanied by a sudden wind squall. Peak gusts reached 48 Kt (24 m/sec) at the JTWC atop Nimitz Hill (see Figure 3-27-4). Using the "base velocity" product on the NEXRAD, the inbound squall was detected when it was about 40 nm (75 km) south of the island, or about one-half hour before its passage over Guam. A vertical cross section of the radial velocity, looking southwestward straight through the oncoming squall line, showed that the peak inbound winds with a velocity near 50 kt (25 m/sec) were confined within the lowest 10,000 feet of the troposphere. Shortly after the passage of the squall, the "velocity azimuth display" (VAD) product obtained from the NEXRAD showed another commonly observed property of high-wind events associated with the monsoon or with tropical cyclones affecting Guam: very deep unidirectional flow extending to at least 40,000 ft (200 mb).

b. Locating the center of Nat's poorly defined circulation

Nat's closest point of approach to Guam was 40 nm (75 km) to the north at 151800Z. This was well-within the 124 nm (230 km) range of the NEXRAD's capability to observe radial velocity. Nat was poorly organized while passing to the north of Guam, and locating the center with the radar was difficult. Several radar products were examined in order to increase the confidence of the fix; these includ-

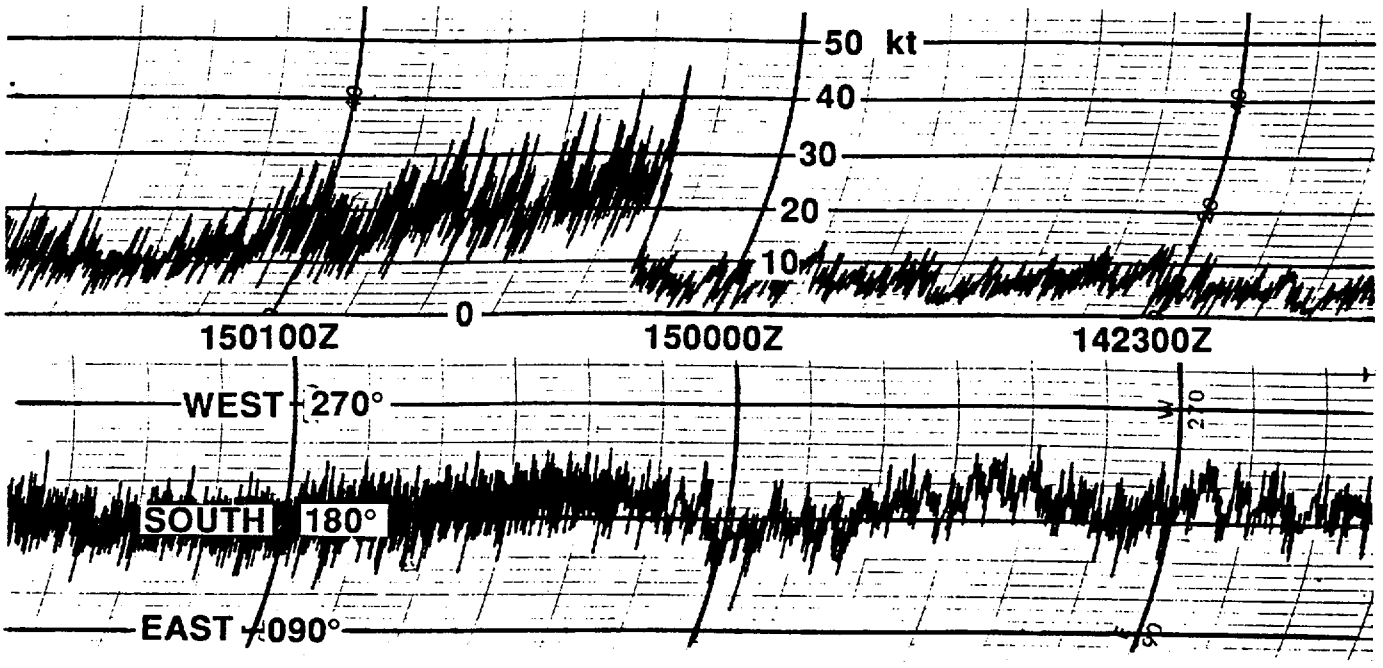

Figure 3-27-4 Recording anemometer trace at the JTWC showing the sudden onset of wind in the first squall associated with Nat.

ed: the base reflectivity, the base velocity, animation of the base reflectivity, convective cell tracking, and the one- and three-hour integrated rainfall products. In Nat's case, the distribution of deep convection as depicted by satellite (Figure 3-27-5a), and by the base reflectivity from the NEXRAD (Figure 3-27-5b), was poorly organized . The isodop (line of zero radial velocity) was useful for estimating the bearing of the center to the site (Figure 3-27-5c). The most striking depiction of the wind pattern in Nat was obtained from the three-hour precipitation product (Figure 3-27-5d). Despite the disorganized appearance of the cloud elements in satellite imagery and on the NEXRAD'S base reflectivity product, the short-term (i.e., one-hour and three-hour) integrated rainfall products showed a high degree of organization and helped increase the confidence of the estimated low-level center postition.

IV. IMPACT

Throughout its entire life, Nat remained at sea and reached a peak intensity of only 45 kt (23 m/sec). However, for such a weak system, it had a disproportionate impact on the island of Guam, mostly in the form of freak accidents. As Nat approached the island of Guam on September 15, a squall line in the outer circulation of Nat passed across the island. Winds gusted to 48 kt (25 m/sec) at the JTWC as this squall passed. Two tourists who were parasailing were seriously injured when winds in this squall snapped the tow rope which attached their parasail to the boat. A second squall later in the evening damaged power lines, causing a half-hour loss of power to several villages. Strong winds on the morning of 16 September, when Nat was located about 100 nm (185 km) to the northeast of Guam, knocked a security guard off a gangplank and into the water at the commercial port. The man, who could not

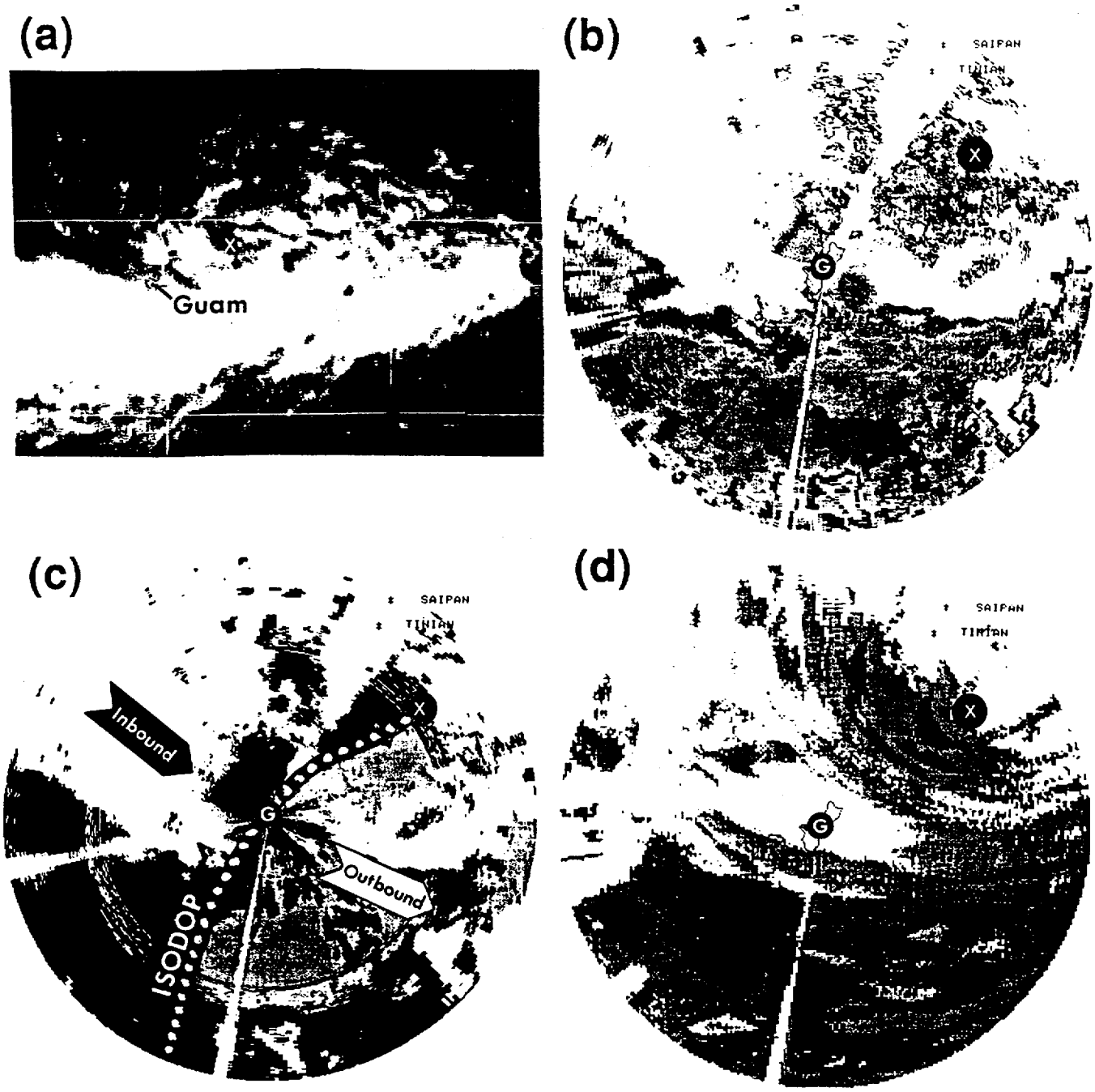

Figure 3-27-5 A combination of products from satellite and weather radar were used to locate the center of the poorly organized Nat as it passed north of Guam. (a) Nat's poorly organized central convection as seen by satellite (160031Z September visible GMS imagery), and (b) by Guam's NEXRAD (160058Z September NEXRAD base reflectivity). (c) The isodop (line of zero radial velocity) extends towards Nat's estimated center location (160058Z September NEXRAD base velocity). (d) Note the higher degree of organization apparent on the three-hour precipitation product (160058Z September NEXRAD three-hour precipitation). Nat's estimated center location is indicated by the small white "x" within the black dot.

swim, drowned. Two of his co-workers also were knocked into the water and nearly drowned. Later, on the morning of 17 September, when Nat was located about 500 nm (925 km) northeast of Guam, a thunderstorm developed over Guam in weak northwesterly wind flow. Lightning in this thunderstorm struck at a track meet and injured about 20 people. Most were treated for light electric shock and dizziness. Another lightning bolt from this same thunderstorm struck the commercial power line feeding Guam's NEXRAD, knocking the system out for over one month and causing $90,000 worth of damage.