

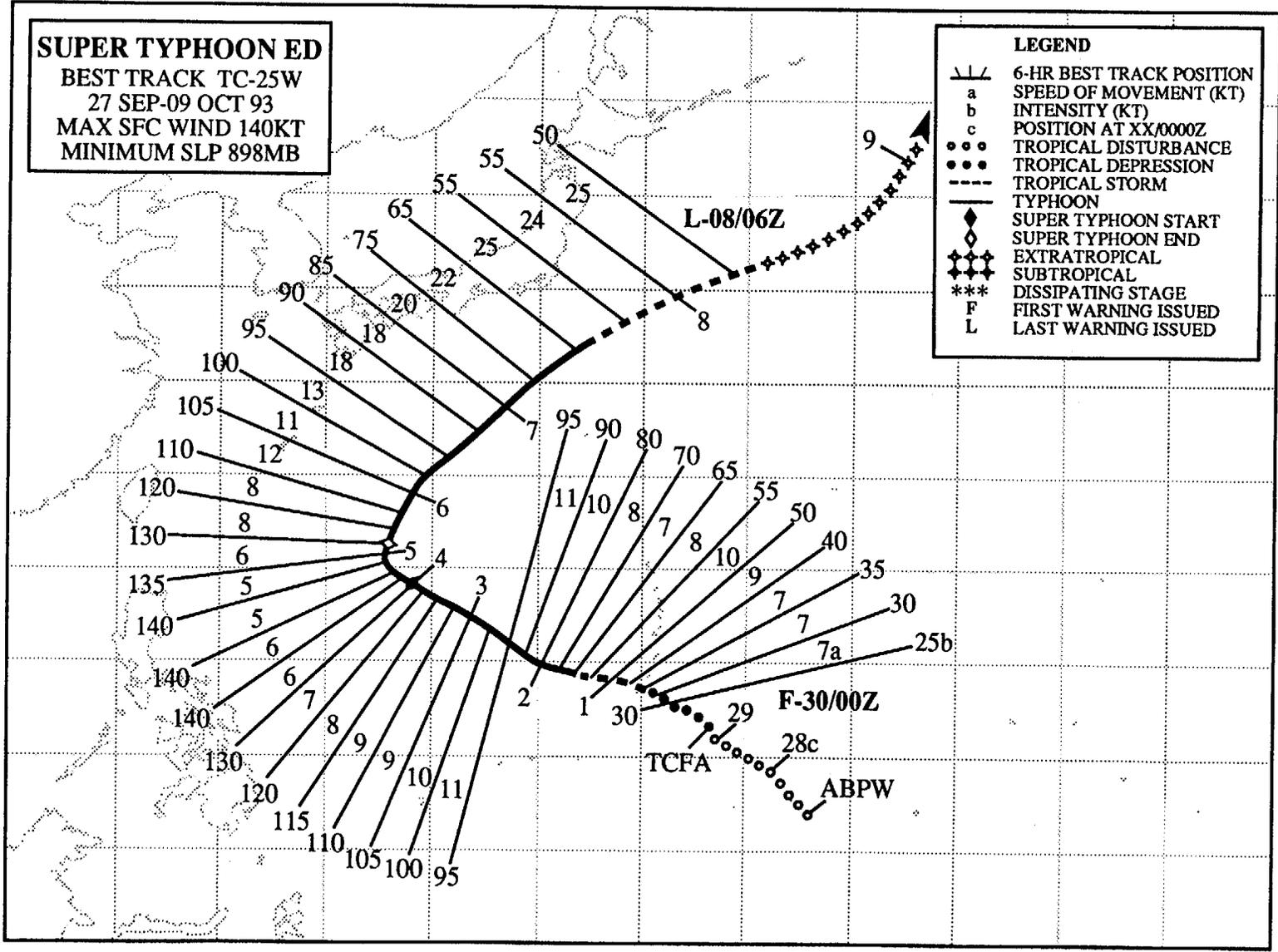
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N 50

**SUPER TYPHOON ED**  
 BEST TRACK TC-25W  
 27 SEP-09 OCT 93  
 MAX SFC WIND 140KT  
 MINIMUM SLP 898MB

**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



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## SUPER TYPHOON ED (25W)

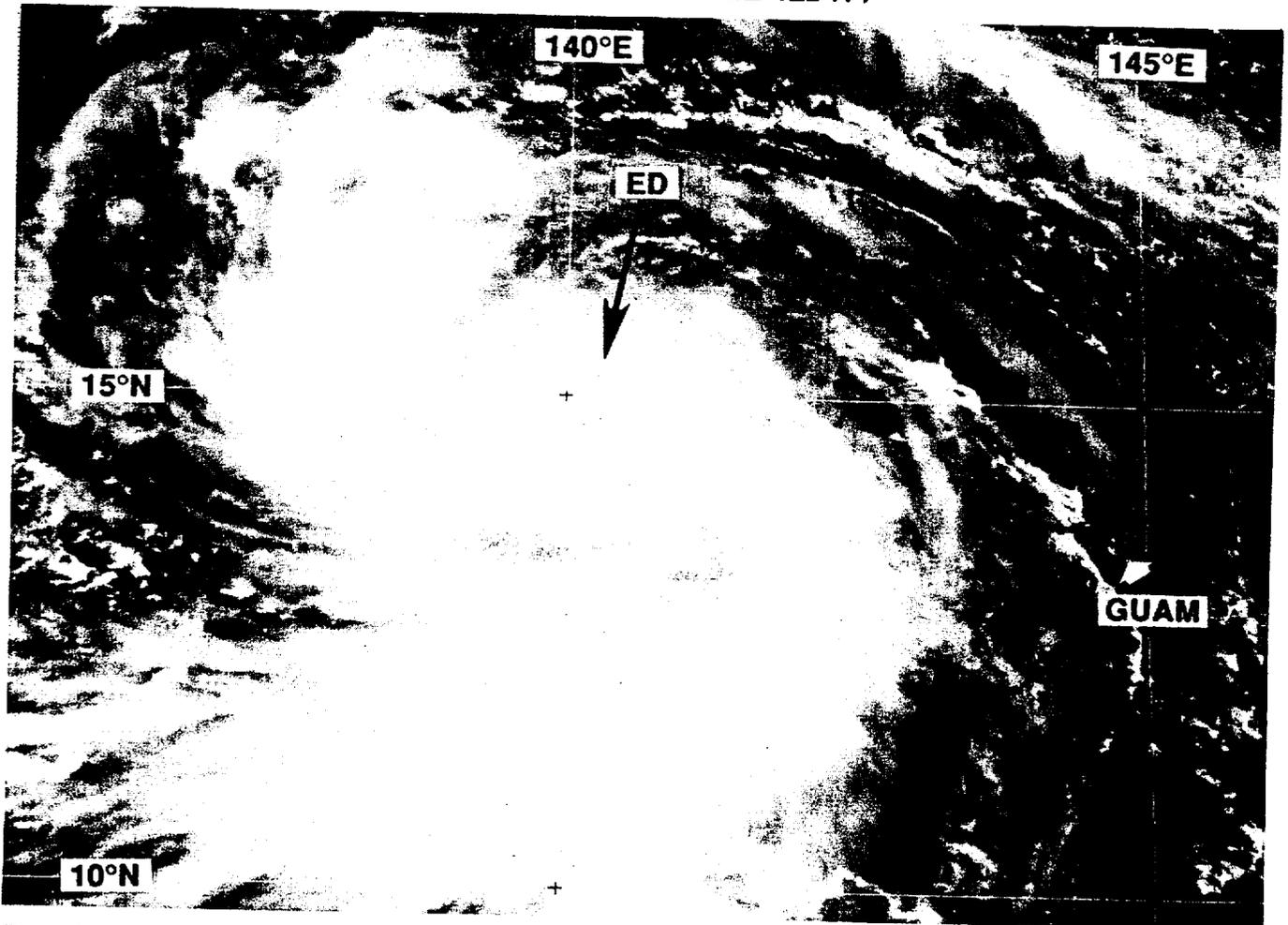


Figure 3-25-1 On the satellite imagery, a small eye becomes visible shortly after Ed reaches typhoon intensity (020031Z October visual GMS imagery).

### I. HIGHLIGHTS

The second tropical cyclone to threaten the Mariana Islands within a week, Ed, passed directly over the NEXRAD Doppler weather radar on Guam. Initially forming in the Caroline Islands, Ed steadily developed from a tropical depression to super typhoon intensity within five days. During its intensification from a typhoon to a super typhoon, Ed possessed a small eye (Figure 3-25-1). During most of Ed's lifetime, it underwent binary interaction with Typhoon Flo (26W).

### II. CHRONOLOGY OF EVENTS

September

270600Z - An area of persistent convection within the monsoon trough near Chuuk, in the eastern Caroline Islands, resulted in the first mention of the disturbance in the Significant Tropical Weather Advisory.

290600Z - A Tropical Cyclone Formation Alert was issued following an increase in convection near an exposed low-level circulation center.

300000Z - The first warning was issued based upon increased convective curvature and a satellite intensity estimate of 25 kt (13 m/sec).

301800Z - Based upon a satellite intensity estimate of 45 kt (23 m/sec), Ed was upgraded to a tropical storm.

October

011200Z - The appearance of a warm spot in the cold CDO and the resulting satellite intensity estimate of 65 kt (33 m/sec) prompted JTWC to upgrade Ed to a typhoon.

040000Z - A small eye deeply embedded in the CDO and a satellite intensity estimate of 127 kt (65 m/sec) led JTWC to upgrade Ed to a super typhoon.

080600Z - The final warning was issued on Ed as it transitioned into an extratropical low well to the east of Japan.

### III. IMPACT

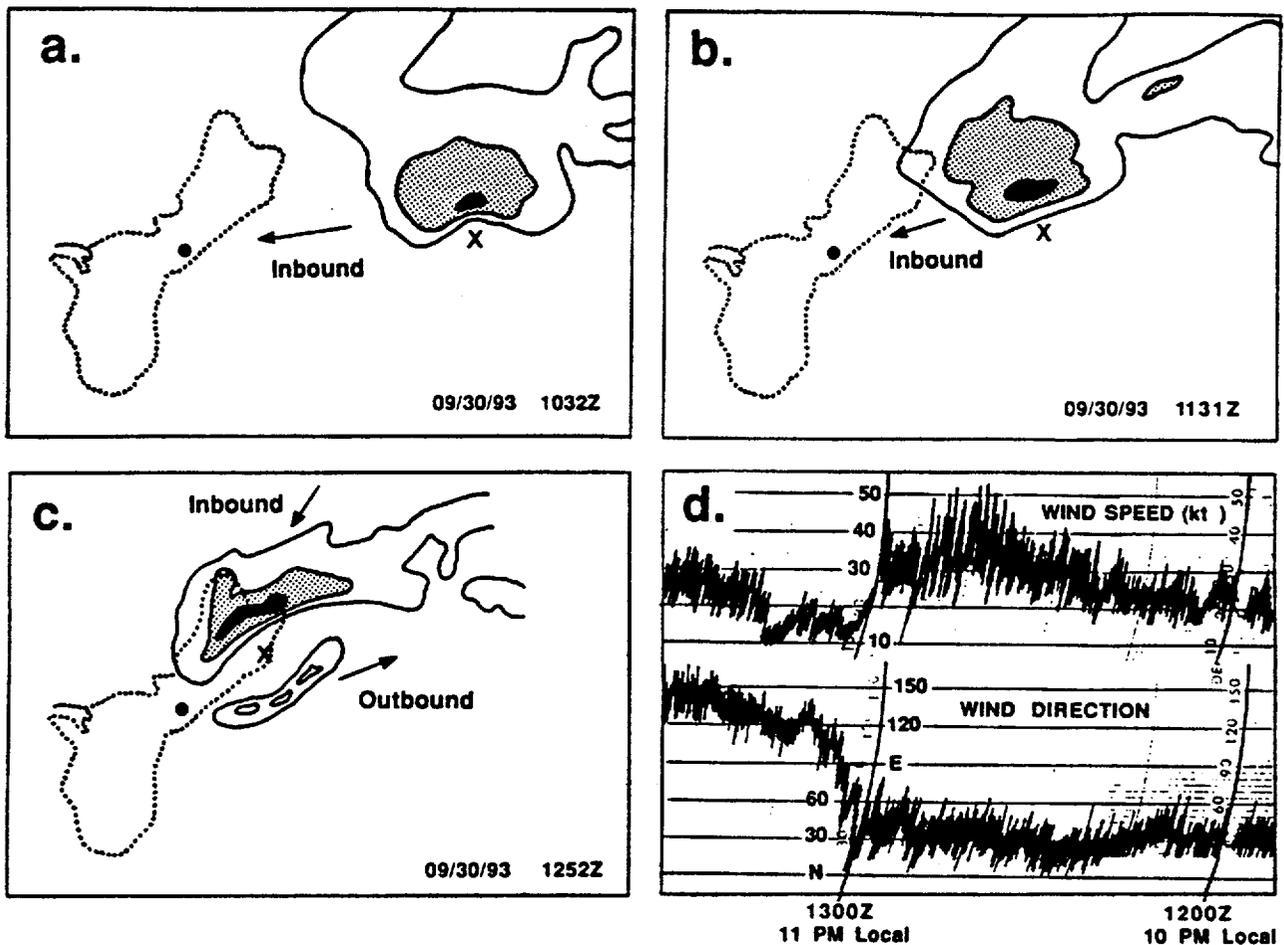
Ed brought badly needed heavy rainfall to Guam which resulted in some localized flooding on the island. A peak gust of 53 kt (27 m/sec) was reported at Andersen AFB as the tropical storm passed directly over Guam.

### IV. DISCUSSION

a) NEXRAD — The passage of Ed's center over northern Guam, just after it had intensified to a tropical storm, resulted in the first-ever direct passage of a tropical cyclone over a NEXRAD Doppler weather radar. Guam's NEXRAD played a key role in short-term local forecasts as Ed approached the island. About 12 hours prior to landfall on Guam, the velocity dipole, or couplet, associated with the tightly curved wind flow around the small central calm area, became evident on the radial velocity product (RVP) generated by the NEXRAD. Three hours prior to landfall, it became evident from the NEXRAD fixes that Ed's center would pass directly over northern Guam. The RVP showed a small area of gales with an embedded peak velocity of 50 kt (26 m/sec) moving steadily towards the north end of Guam (Figure 3-25-2). Forecasters at Andersen Air Force Base, used this information to give what would turn out to be a very accurate short-range forecast of a brief period of gales with maximum gusts to 50 kt (26 m/sec). Andersen experienced gale-force sustained winds for about a half an hour (from 301230Z to 301300Z September) (Figure 3-25-2d). Wind gusts to 50 kt (26 m/sec) occurred for 10 minutes (1240Z to 1250Z) with a peak gust to 53 kt (27 m/sec) at 1242Z. The light wind core of Ed, during its passage over Guam, is herein referred to as an "eye"; the quotation marks indicating that it did not have an eye in the conventional sense of a central core — free of deep cloud — encircled at least 50% by a wall of tall cumulonimbus cloud. Abruptly, at 1300Z, the winds dropped to 10-15 kt (5-8 m/sec) as the "eye" of Ed passed just to the south of Andersen. These light winds lasted for about 15 minutes as the wind direction veered quickly from 030 degrees to 140 degrees. After the "eye" passage at Andersen, the wind speed increased to 25-30 kt (13-15 m/sec) with gusts to 35 kt (18 m/sec).

The structure of Ed as it passed over Guam, as revealed by the NEXRAD and from eyewitness reports, was very similar to that of a mature tropical cyclone — even though Ed had only just achieved minimal tropical storm intensity. It had a very small "eye" as revealed by the reflectivity pattern (see cover illustration), and its highest winds were packed very tightly along the northern periphery of the "eye". Also, the satellite image at this time showed that Ed possessed a curved band type cloud structure; which, using the Dvorak satellite intensity technique yielded 35 kt (18 m/sec). Nevertheless, the radar reflectivity, the radar Doppler velocity, and the recorded wind and pressure during Ed's passage over Guam all revealed a structure very much like that of a mature tropical cyclone.

The NEXRAD can process its reflectivity data through an algorithm to estimate rainfall rates, which are presented as 1-hour, 3-hour or storm total precipitation products. NEXRAD estimates of storm total

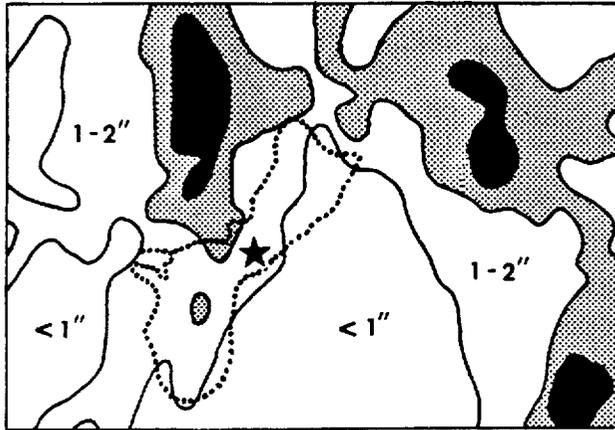


**Figure 3-25-2** Radial velocities detected by the NEXRAD Doppler radar as Ed approached Guam: a) Illustration of the radial velocity display for 301032Z, b) 301131Z, c) 301252Z September, and d) the anemometer chart from Andersen AFB (WMO 91218) during the period (301200Z - 301300Z) which includes the gales preceding Ed's landfall. In panels a), b) and c), the outer contour encloses values  $\geq 26$  kt (13 m/sec), shaded area  $\geq 36$  kt (19 m/sec), and black areas indicate  $\geq 50$  kt (26 m/sec). The black dot locates the NEXRAD. Arrows indicate radial velocities as inbound or outbound with respect to the radar. Ed's circulation center is indicated by the x.

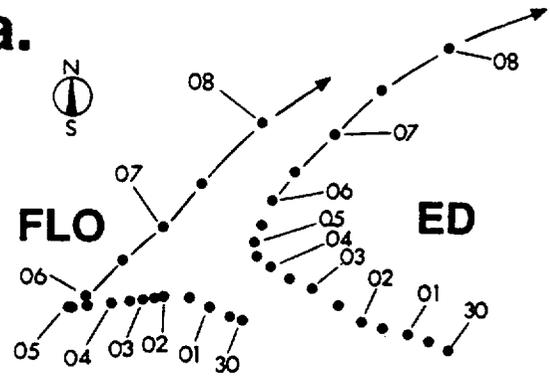
precipitation during Ed's passage over Guam (Figure 3-25-3a) were about 50% less than the rainfall actually measured by rain gauges on Guam (Figure 3-25-3b). The gradients of the NEXRAD integrated rainfall agreed with the relative magnitudes of the rainfall at the rain gauges: driest in the northeast of Guam and wettest on the west and southwest of Guam. The large observed error of total integrated rainfall may be due to the algorithm, developed for convective precipitation over the U.S. mainland, brief system outages, or an as yet unknown factor.

b) Binary interaction with Typhoon Flo (26W) — For most of Ed's lifetime it was in close proximity to Typhoon Flo. At their closest point of approach, Ed and Flo were separated by only 670 nm (1240 km) (Figure 3-25-4a and b); well within the 780 nm (1445 km) separation noted by Brand (1970) for cyclone binary interaction. The centroid-relative motion of Ed and Flo (Figure 3-25-4b) exhibited some of the features common to interacting tropical cyclones, see Lander and Holland (1993) (Figure 3-25-4c). For two days (300000Z September to 020000Z October), as both Ed and Flo moved steadily west-northwestward, they remained almost stationary with respect to the centroid-relative reference frame. At 021200Z, the two storms had begun a fairly steady cyclonic orbit and gradually closed to within 670 nm (1240 km) at 040000Z. Coincident with the start of the cyclonic orbit on the 2 October,

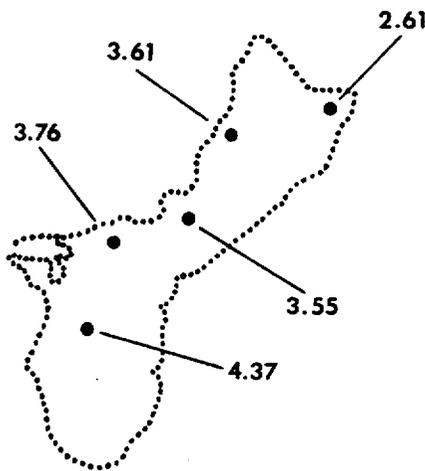
**a.**



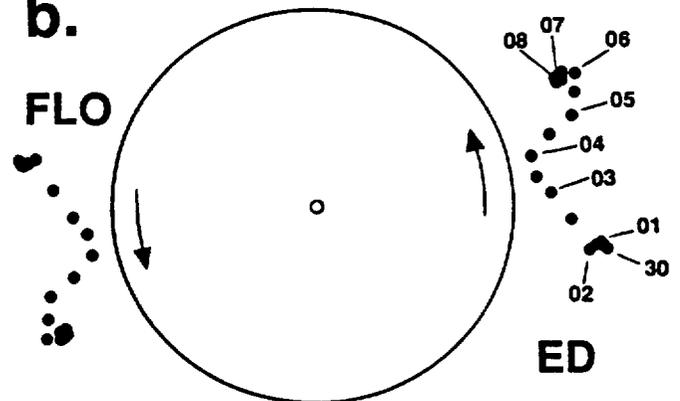
**a.**



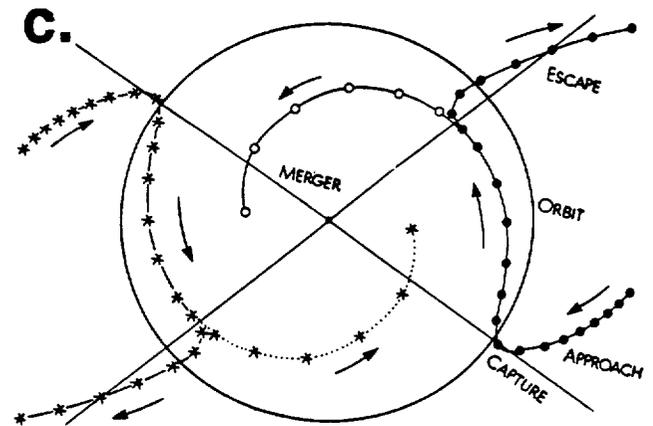
**b.**



**b.**



**c.**



**Figure 3-25-3** Total precipitation for Ed's passage over Guam: a) Storm total precipitation estimates from the NEXRAD for the period 282054Z September to 011504Z October. Shaded region =  $\geq 2$  inches (50 mm), black areas  $\geq 3$  inches (75 mm). Star locates the NEXRAD. (b) Storm total precipitation measurements from rain gauges for the same period.

**Figure 3-25-4** Binary interaction between Ed and Flo (26W): a) Tracks of Ed and Flo, b) Centroid-relative motion. Circle diameter = 600 nm (1110 km), dots = 12-hour time steps, and dates of 0000Z positions are indicated by 2-digit numbers. (c) Model of binary interaction between two tropical cyclones.

Ed turned a little more to the north and increased its speed of motion, while Flo slowed its forward speed and turned to follow an unusual west-southwesterly track. The cyclonic orbit ended abruptly at 060000Z as Flo recurved and followed Ed into the midlatitudes on an accelerating northeasterly track. After recurvature, Ed and Flo remained almost stationary in the centroid-relative reference frame.