2. G-IV Tail Doppler Radar Experiment

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Primary IFEX Goal: 1 - Collect observations that span the TC life cycle in a variety of environments for model initialization and evaluation.

Program significance: This experiment is a response to the requirement listed as Core Doppler Radar in Section 5.4.2.9 of the National Hurricane Operations Plan. The goal of that particular mission is to gather airborne-Doppler wind measurements that permit an accurate initialization of HWRF, and also provide three-dimensional wind analyses for forecasters. This experiment is similar to the P-3 Three-Dimensional Winds experiment, but employs the G-IV platform and tail Doppler radar.

There are four main goals: 1) to evaluate the G-IV as a platform for observing the cores of TCs, 2) to improve understanding of the factors leading to TC structure and intensity changes, 3) to provide a comprehensive data set for the initialization (including data assimilation) and validation of numerical hurricane simulations (in particular HWRF), and 4) to develop rapid real-time communication of these observations to NCEP.

The ultimate requirement for EMC is to obtain the three-dimensional wind field of Atlantic TCs from airborne Doppler data every 6 h to provide an initialization of HWRF through assimilation every 6 h. In 2015, the maximum possible rotation of missions is two per day or every 12 h. The G-IV platform is currently used by NHC for synoptic surveillance until approximately 36 h prior to TC landfall. In 2015 the flight modules described here are likely to be limited to cases within this landfall window or not of NHC operational interest. In anticipation of future operational use of the G-IV Doppler data, a preliminary flight pattern is introduced which attempts to satisfy the combined need for synoptic surveillance and optimal collection of Doppler data for assimilation. This flight pattern, as well as other proposed G-IV patterns, will be refined through experiments using the Hurricane Ensemble Data Assimilation System (HEDAS) and consultation with NHC.

Following the spring 2012 NOAA acceptance of the G-IV tail Doppler radar, the experiment will focus initially on documenting data coverage in TCs, in particular resolution of the outflow layer (via the central dense overcast). These observations will supplement those collected by the P-3 aircraft, and through HEDAS, their added value in TC initialization will be investigated. Flight patterns will also explore the viability of the G-IV as a substitute for the P-3 aircraft in terms of Doppler radar sampling of the TC core region. Coordinated flights with the P-3 aircraft will be required as part of this assessment.

Links to IFEX: The G-IV Tail Doppler Radar experiment supports the following NOAA IFEX goals:

Goal 1: Collect observations that span the TC lifecycle in a variety of environments
Goal 2: Develop and refine measurement technologies that provide improved real-time monitoring of TC intensity, structure, and environment
Goal 3: Improve understanding of the physical processes important in intensity change for a TC at all stages of its lifecycle

G-IV Three-Dimensional Doppler Winds: Several different options are possible: i) the square-spiral pattern (Figs. 2-1 and 2-2); ii) the rotating figure-4 pattern (Fig. 2-3); iii) the butterfly pattern that consists of 3 penetrations across the storm center at 60-degree angles with respect to each other (Fig. 2-4); iv) the single figure-4 (Fig. 2-5); and v) the surveillance/TDR combination pattern (Fig. 2-6). These patterns provide the maximum flexibility in planning, in which the need for dense date coverage must be balanced against the need to sample the entire vortex.

Square-spiral pattern: As the weak, developing, poorly organized circulations become larger, it will be necessary to spread out the pattern to cover a larger area at the expense of complete Doppler coverage. The pattern, as shown in Figs. 2-1 and 2-2, is designed to cover a box 300 nm x 300 nm with radial gaps in the coverage. As long as the circulation is still weak, but covers a larger area, this pattern will be considered; however, lack of symmetric coverage at all radii renders this a less viable option as the system organizes. Fig. 2-1 (2-2) shows the option of an outward (inward) spiral from (into) the center. Any orientation of the flight legs may be flown to permit the initial and final points to be closest to the base of operations.

Rotating figure-4 pattern: As the system intensity and/or organization increases, and a circulation center becomes clearly defined, a rotating figure-4 pattern may be preferred (Fig. 2-3). The advantage of this pattern over the square-spiral pattern is good definition of the wind field at all radii within the pattern. Any orientation of the flight legs may be flown to permit the initial and final points to be closest to the base of operations.

Butterfly pattern: This pattern (Fig. 2-4) should be flown in larger, well-organized TCs, generally in hurricanes. As the hurricane circulation becomes larger, it will be necessary to get the full radial coverage at the expense of full Doppler coverage. As an example, a butterfly pattern out to 100 nm could be flown in 3.3 h. Any orientation of the flight legs may be flown to permit the initial and final points to be closest to the base of operations.

Single figure-4 pattern: This pattern (Fig. 2-5) will be flown in very large circulations. It still provides wavenumber 0 and 1 coverage with airborne Doppler data, which should be sufficient in strong, organized systems. Radial coverage out to 240 and 300 nm (4 and 5 degrees) is possible in 5.4 and 6.8 h in pattern. Any orientation of the flight legs may be flown to permit the initial and final points to be closest to the base of operations.

Surveillance/TDR combination pattern: This pattern (Fig. 2-6) will be flown to test the ability of the G-IV platform to satisfy both NHC-tasked surveillance requirements (i.e., sampling the TC environment with GPS dropsondes) and the EMC-tasked requirement for tail Doppler radar sampling of the TC core region. The environmental sampling consists of a cyclonic circumnavigation of the TC at a fixed radius of 150 nm. This is followed by core region sampling using a rotating figure-4 pattern out to 75 nm. The duration of this pattern is approximately 6 h. Any orientation of the flight legs may be flown to permit the initial and final points to be closest to the base of operations.

G-IV Tail Doppler Radar Experiment Flight Planning Approach: Ideally, for initial experiments following the NOAA acceptance of the G-IV radar this would entail coordination with a P-3 aircraft conducting a Three-Dimensional Doppler Winds flight when the system is at depression, tropical storm, or hurricane strength. This initial coordination is necessary for 1) comparing and synthesizing storm structure derived from the two radar platforms and 2) the most thorough testing of HEDAS with this new data source. Subsequent flights may relax this requirement for P-3 coordination so as to test the Surveillance/TDR Combination Pattern (Fig. 2-6). It is not anticipated that the Combination Pattern will be flown during NHC tasking of the G-IV in 2015.

The likely scenarios in which this experiment would be carried out are as follows: 1) at the conclusion of NHC tasking for a landfalling TC, likely coordinated with the P-3 aircraft; 2) prior to NHC tasking for a TC of interest to EMC (priority is coordination with P-3 aircraft); 3) a recurving TC (priority is coordination with P-3 aircraft). Since coordination with the P-3 aircraft is an early requirement, this experiment would have to be weighed against other experiments (e.g., Rapid Intensification) which stagger the P-3 and G-IV flight times.

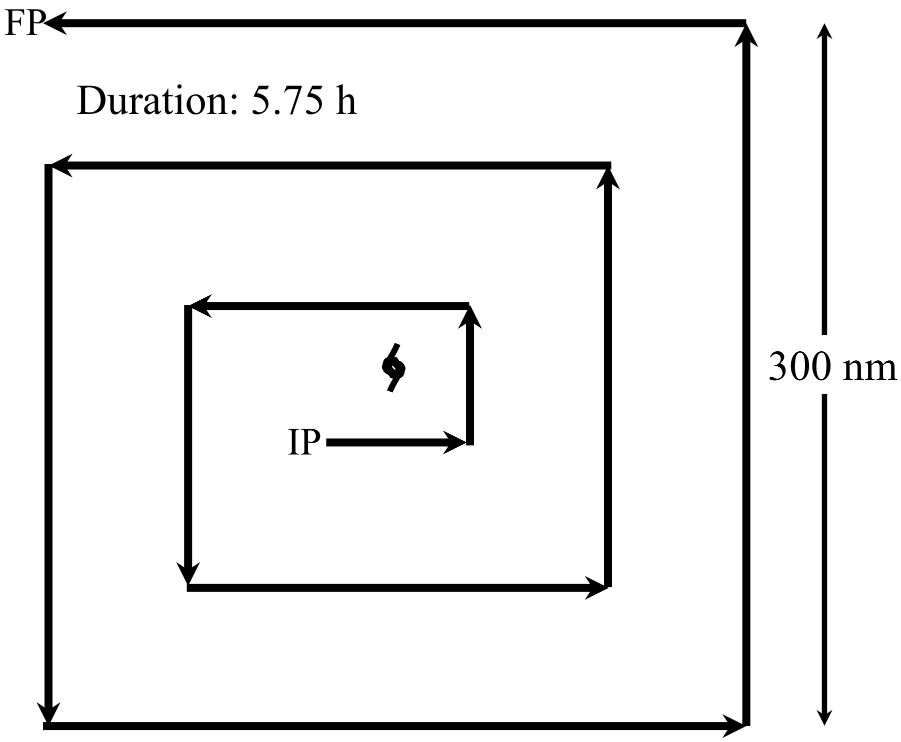

Figure 2-1: G-IV tail Doppler radar pattern – Square Spiral (outward)

Note 1. G-IV begins 30 nm to south and west of estimated circulation center (with proper rotation starting point can be SE, NE, or NW of center
Note 2. Fly 60 nm due east (due north, due west or due south, for IP SW, NE, and NW of center, respectively)--left turn--60 nm left turn--120 nm--left turn--120 nm--left turn--180 nm--left turn--180 nm--left turn--240 nm--left turn--240 nm--left turn--300 nm--left turn--300 nm--left turn--300 nm
Note 3. Duration: 2100 nm, or 4.75 hour + 1hour for deviations--covers 150 nm (2.5 deg) in each cardinal direction from center
Note 4. Aircraft should operate at its maximum cruising altitude of ~40-45 kft
Note 5. On all legs, deviate to avoid weather deemed to pose possible hazard
Note 6. As flight duration and ATC allow, attempt to sample as much of regions that require deviation
Note 7. Tail Doppler radar should be operated at a dual-PRF of 3/2, with the PRFs at 2000 and 3000 (effective Nyquist velocity of 48 m/s)
Note 8. If flying above 40,000 ft, pattern may be flown clockwise, if preferred.

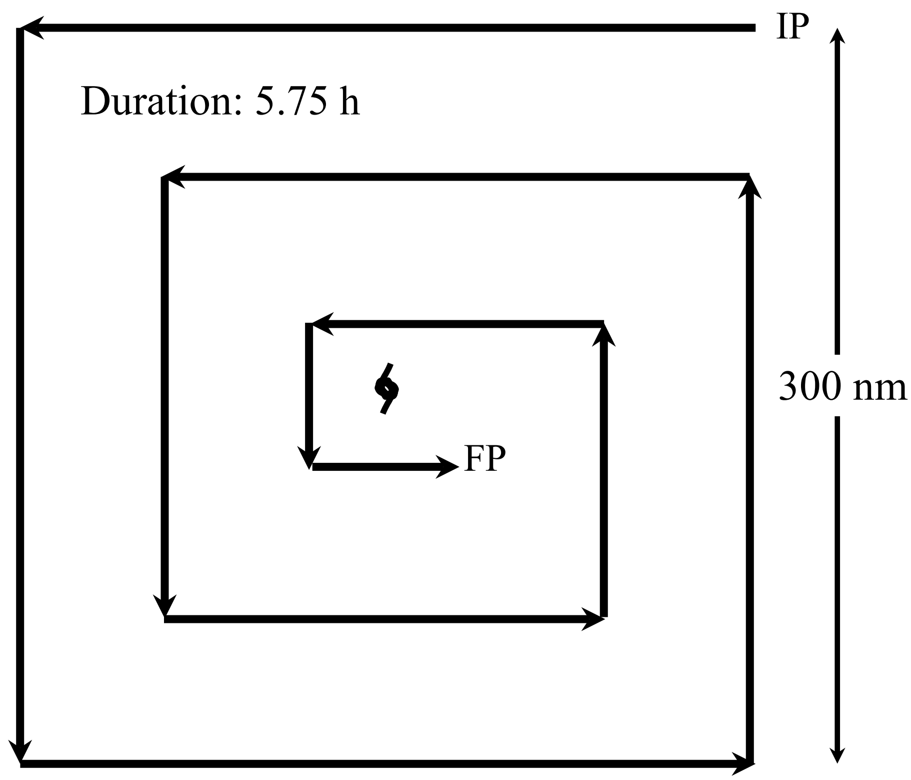

Figure 2-2: G-IV tail Doppler radar pattern – Square Spiral (inward)

Note 1. G-IV begins 150 nm to north and east of estimated circulation center (with proper rotation starting point can be NE, NW, SW, or SE of center)
Note 2. Fly 300 nm due west (due south, east, north, for IP NW, SW, or SE of center, respectively)--left turn--300 nm--left turn--300 nm--left turn--240 nm--left turn--240 nm--left turn--180 nm--left turn--180 nm--left turn--120 nm--left turn--120 nm--left turn--60 nm--left turn--60 nm
Note 3. Duration: 2100 nm, or 4.75 hour + 1 hour for deviations--covers 150 nm (2.5 deg) in each cardinal direction from center
Note 4. Aircraft should operate at its maximum cruising altitude of ~40-45 kftNote 5. On all legs, deviate to avoid weather deemed to pose possible hazard
Note 6. As flight duration and ATC allow, attempt to sample as much of regions that require deviation
Note 7. Tail Doppler radar should be operated at a dual-PRF of 3/2, with the PRFs at 2000 and 3000 (effective Nyquist velocity of 48 m/s)
Note 8. If flying above 40,000 ft, pattern may be flown clockwise, if preferred.

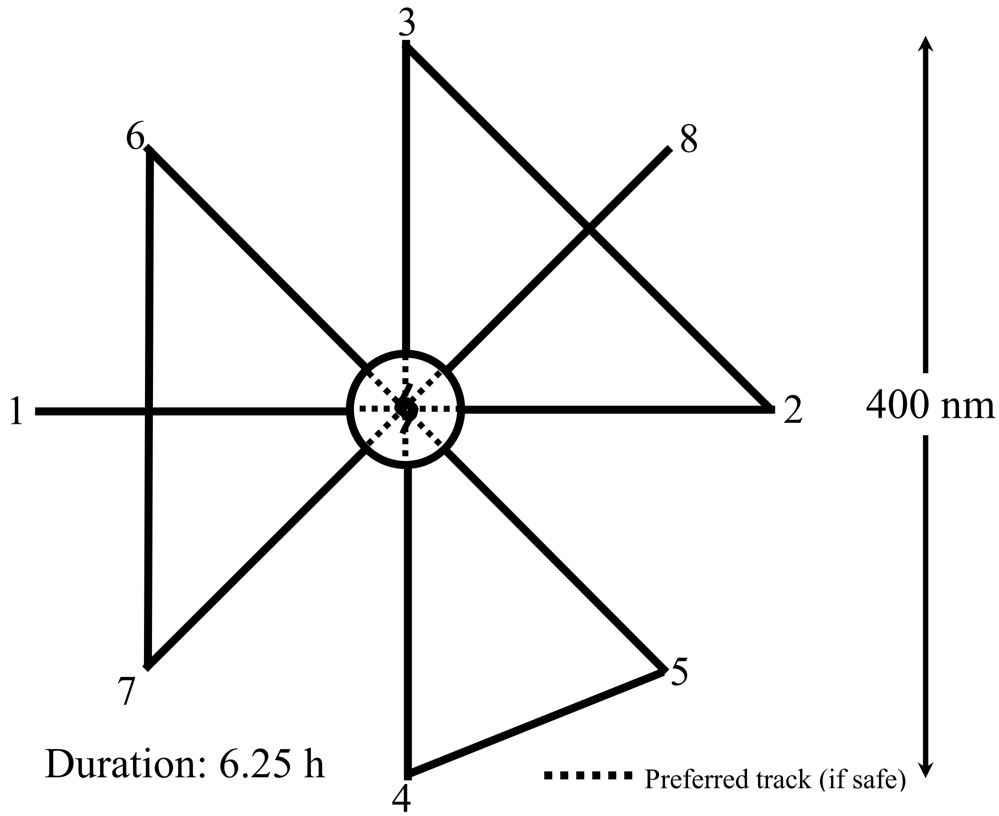

Figure 2-3: G-IV tail Doppler radar pattern – Rotating Figure-4

Note 1. IP is 200 nm from storm center
Note 2. Fly 1-2, deviating around eyewall if conditions require (eyewall assumed to extend 20 nm from center)--if deviation is required, fly to right of convection if possible. If conditions permit, fly through center of circulation
Note 3. Fly 2-3, deviating around convection if necessary
Note 4. Fly 3-4, as described in segment 1-2
Note 5. Fly 4-5, deviating around convection, if necessary
Note 6. Fly 5-6-7-8 in the same manner as 1-2-3-4
Note 7. Duration: 2317 nm, or 5.25 hours + 1 hour for deviations
Note 8. Aircraft should operate at its maximum cruising altitude of ~40-45 kft
Note 9. As flight duration and ATC allow, attempt to sample as much of regions that require deviations
Note 10. Tail Doppler radar should be operated at a dual-PRF of 3/2, with the PRFs at 2000 and 3000 (effective Nyquist velocity of 48 m/s)
Note 11. If flying above 40,000 ft, pattern may be flown clockwise, if preferred.

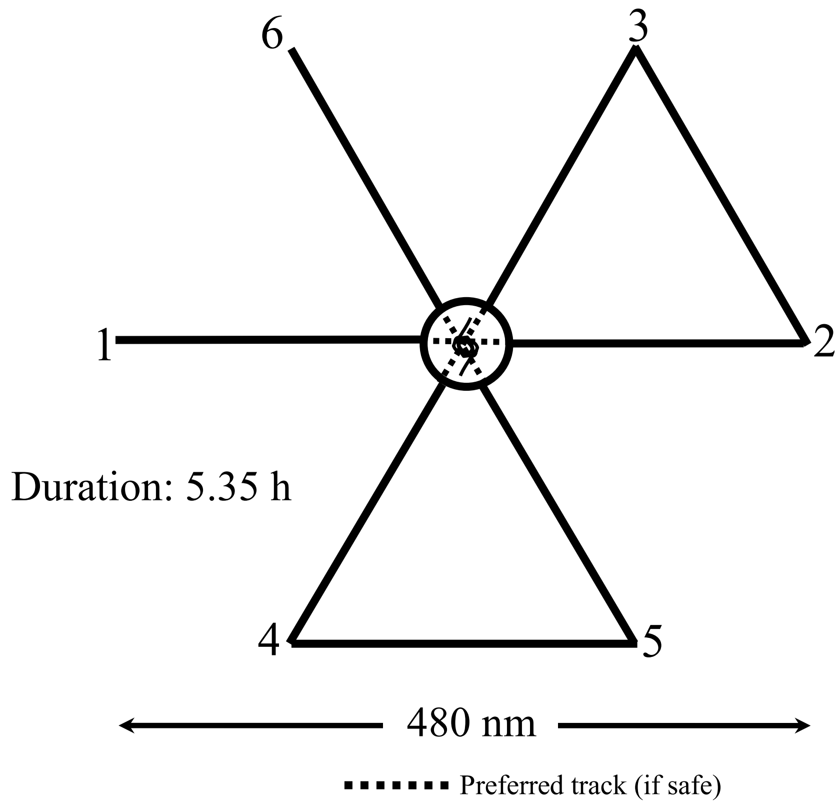

Figure 2-4: G-IV tail Doppler radar pattern – Butterfly

Note 1. IP is 240 nm from storm center at desired heading from storm center
Note 2. Fly 1-2, deviating around eyewall if conditions require (eyewall assumed to extend 20 nm from center in the figure)--if deviation is required, fly to right of convection if possible. If conditions permit, fly through center of circulation.
Note 3. Fly 2-3, deviating around convection if necessary
Note 4. Fly 3-4-5, as described in segment 1-2
Note 5. Fly 5-6, deviating around convection, if necessary
Note 6. Duration: 1920 nm, or 4.35 hours + 1 hour for deviations
Note 7. Aircraft should operate at its maximum cruising altitude of ~40-45 kft
Note 8. As flight duration and ATC allow, attempt to sample as much of regions missed by deviations
Note 9. Tail Doppler radar should be operated at a dual-PRF of 3/2, with the PRFs at 2000 and 3000 (effective Nyquist velocity of 48 m/s)
Note 10. If flying above 40,000 ft, pattern may be flown clockwise, if preferred.

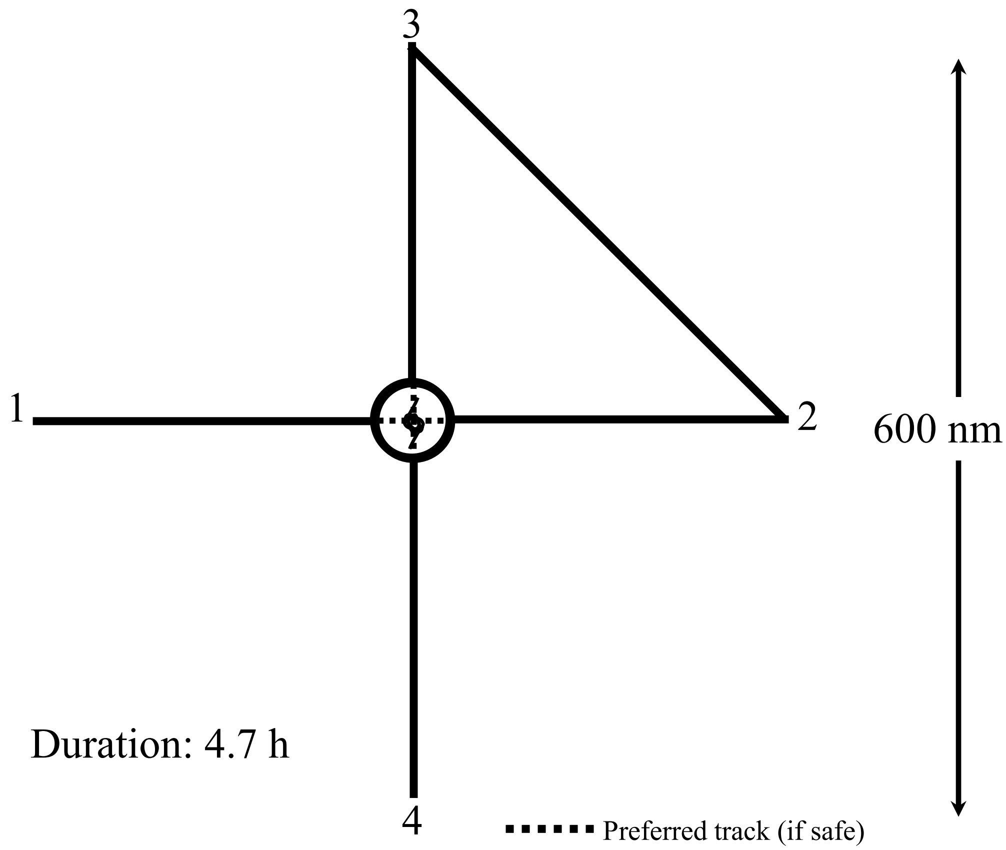

Figure 2-5: G-IV tail Doppler radar pattern – Single Figure-4

Note 1. IP is 300 nm from storm center
Note 2. Fly 1-2, deviating around eyewall if conditions require (eyewall assumed to extend 20 nm from center in this figure). If deviation is required, fly 1.5 circles around eyewall before continuing to point 2. Otherwise, if conditions permit, fly directly through circulation center.
Note 3. Fly 2-3, deviating around convection if necessary
Note 4. Fly 3-4, as described in segment 1-2; however, if full circle done in first pass, only half circle required
Note 5. Duration: 1624 nm, or 3.7 hours + 1 hour for deviations--pattern could be extended if time allows for even greater radial coverage
Note 6. Aircraft should operate at its maximum cruising altitude of ~40-45 kft
Note 7. As flight duration and ATC allow, attempt to sample as much of regions that require deviations
Note 8. Tail Doppler radar should be operated at a dual-PRF of 3/2, with the PRFs at 2000 and 3000 (effective Nyquist velocity of 48 m/s)
Note 9. If flying above 40,000 ft, pattern may be flown clockwise, if preferred.

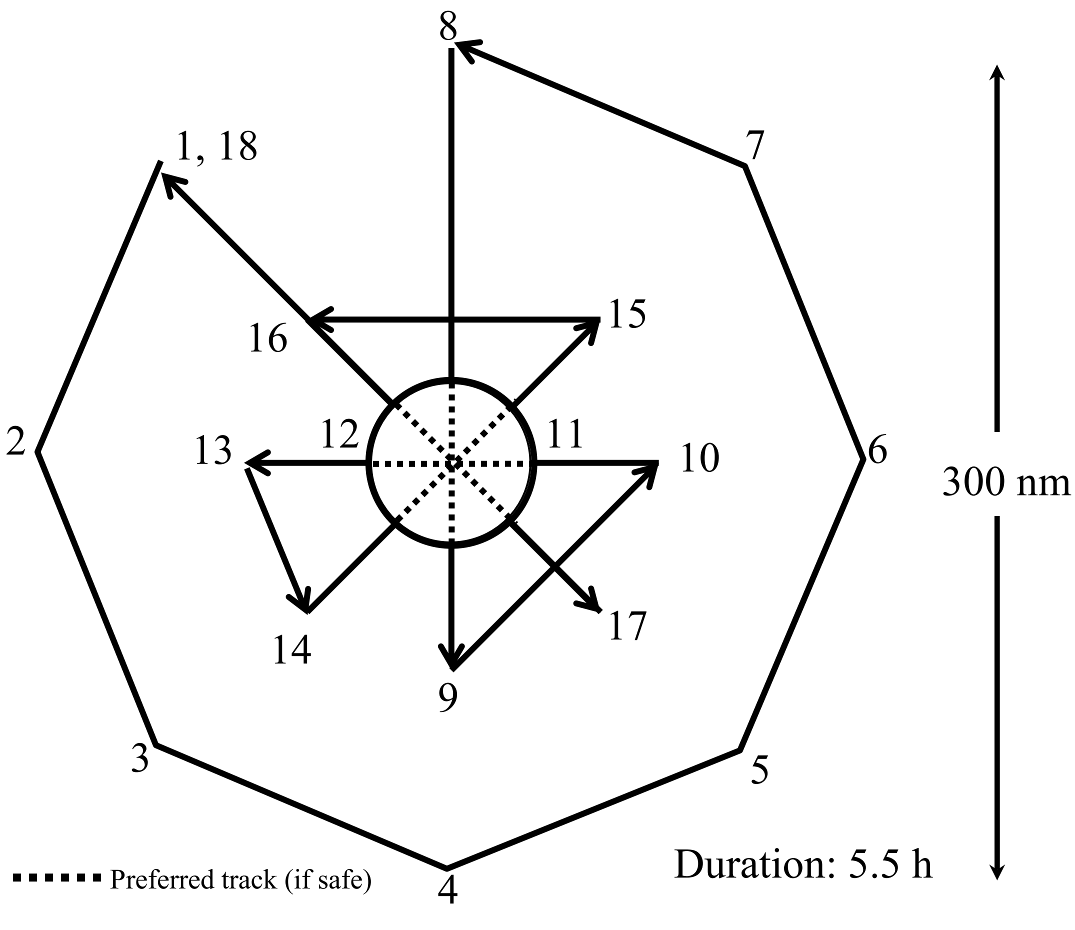

Figure 2-6: G-IV tail Doppler radar pattern – Surveillance/TDR Combination

Note 1. IP is 150 nm from storm center
Note 2. Fly 1-2-3-4-5-6-7-8-9-10-11-12-11-12-13-14-15-16-17-18, deviating around eyewall if conditions require (eyewall assumed to extend 30 nm from center)--if deviation is required, fly to right of convection if possible. If conditions permit, fly through center of circulation
Note 3. Dropsondes should be launched at all numbered points (except 11 and 12). If the aircraft is able to cross the center, a sonde should be dropped there. Extra sondes may be requested.
Note 4. On-station Duration: ~1933 nm, or about 4.5 hours + 1 hour for deviations
Note 5. Aircraft should operate at its maximum cruising altitude of ~40-45 kft
Note 6. As flight duration and ATC allow, attempt to sample as much of regions that require deviations
Note 7. Tail Doppler radar should be operated at a dual-PRF of 3/2, with the PRFs at 2000 and 3000 (effective Nyquist velocity of 48 m/s)
Note 8. If flying above 40,000 ft, pattern may be flown clockwise, if preferred.