2.3.8. Range and Bearing Resolution

2.3.8.1. Purpose

The purpose of this test is to determine how well the radar can resolve two targets closely spaced in azimuth and range, and to determine the effect these resolution limits have upon mission relatable intercepts and attacks.

2.3.8.2. General

Theoretical range and azimuth resolution are discussed in the radar theory section. The radar display can have a pronounced affect upon resolution. Resolution is important for an air-to-air radar because it allows the operator to determine the number of aircraft flying in formation or in the case of a doppler VS mode, closely spaced in azimuth alone. This function is known as "raid count". The raid count in turn affects the tactics used during an intercept and the number of fighters committed to each "cell" of incoming aircraft.

Range and bearing resolution measurements require external space positioning data. Space positioning data is required because precise time histories are needed for the location of three different aircraft simultaneously, allowing accurate determination of the difference in azimuth and range of two different radar targets. The dependency of the test procedure upon extensive space positioning data violates the basic assumptions for the development of these test procedures; however, the test is described here for completeness.

Most radars inherently have better range resolution than azimuth resolution. For this reason, during the azimuth resolution test, target placement is crucial. If either target gets closer in range than the other, it is possible for the targets to break out in range. The appearance is that the target broke out in azimuth when it, in fact, broke out in range. This makes the azimuth resolution appear to be better than it actually is. Space positioning ranges typically allow for close control of the test aircraft and targets. Close control can be used to ease the correct placement of the targets for the test.

2.3.8.3. Instrumentation

Data cards and an optional voice recorder are required for this test. Instrumentation is required to precisely track the test and two target airplanes and to record time correlated space positioning data on all three. Typically, the ground based tracker requires an electronic beacon to be installed on the test airplane and targets.

2.3.8.4. Data Required

The ground based tracker is required to provide a recording of the precise, time tagged, geographic location of the test airplane and both targets. Typically, the positions are recorded at greater than several times per second to an accuracy of less than 20 feet. The evaluator, within the test airplane, must record the precise time when the targets are broken out in azimuth and range for each radar mode tested.

2.3.8.5. Procedure

Immediately prior to the test, have the ground tracking station perform a precise time synchronization of the time source within the ground station and within the test airplane. Place the target airplanes 10 to 30 nm ahead of the test airplane on the same or a reciprocal heading and 1,000 feet above the test airplane. Have the targets join in a 50 feet trail or the minimum allowed considering the qualifications of the airplanes and crew for formation flying and the visibility/cloud layers. Establish radar contact in search mode, narrowing the search scan angle limits after initial detection and use a single bar scan pattern. On the test airplane's call, the trail target should reduce speed slightly to slowly open on the lead target, ensuring the lead target is still directly on the nose to maintain azimuth alignment between the test airplane and the targets. The evaluator must record the precise time when two distinct radar targets are first noticed. If visual contact is lost between the targets, the trail should climb 1,000 feet (without gaining airspeed) and the test discontinued. Repeat the test for all radar modes that affect the radar pulse width.

When breakout occurs and the data is taken, the test airplanes should maneuver to a side by side (abeam) position with approximately 500 feet of separation. The targets and test airplane should be heading towards each other for this portion of the test. The targets should be at the same altitude as long as visual contact is maintained. If visual contact is lost between the targets, one target should climb 1,000

feet and the test discontinued. The beginning range for the test should be at least as great as the range required to ensure breakout will not occur using the theoretical resolution limit discussed in the radar theory section. The following relationship applies:

$$R_{test\ begin}=(0.1nm)\tan(\theta)$$
$$R_{test\ begin}=\textit{range for the beginning of the test} \qquad (8)$$
$$\theta=\textit{test radar advertised antenna beamwidth}$$

The targets should continue inbound until the second target is broken out on the test radar display. The precise time at which two distinct radar targets are noticed should be recorded by the evaluator.

2.3.8.6. Data Analysis and Presentation

The space positioning data is typically provided in the form of precise latitude and longitude. The range to each target and the angle between the two targets can be derived from a knowledge of the test airplane and target airplane latitude and longitude at any given time using equation (9). The calculations must be performed for each target at the times of range and azimuth breakout. The difference between the target ranges at breakout during the range resolution tests is then the measured range resolution and the difference in azimuth between the two targets at breakout during the azimuth resolution tests is then the azimuth resolution.

$$\Delta_{lat}=|\textit{latitude of test airplane}-\textit{latitude of target airplane}|$$
$$\Delta_{long}=|\textit{longitude of test airplane}-\textit{longitude of target airplane}|$$
$$avg_{lat}=\left[\frac{(\textit{latitude of test airplane}+\textit{latitude of target airplane})}{2}\right]$$
$$R_{target}=\sqrt{[(\Delta_{lat})(6076)]^2+[(\Delta_{long})(\cos(avg_{lat}))(6076)]^2}$$
$$R_{target}=\textit{range ro either target as applicable}$$
$$R_{resolution}=|R_{target1}-R_{target2}|$$
$$R_{target1}=\textit{range to target 1}$$
$$R_{target2}=\textit{range to target 2}$$
$$\Delta_{lat1-2}=|\textit{latitude target 1}-\textit{latitude target 2}|$$
$$\Delta_{long1-2}=|\textit{longitude target 1}-\textit{longitude target 2}|$$
$$avg_{lat1-2}=\left[\frac{(\textit{latitude target 1}+\textit{latitude target 2})}{2}\right]$$
$$R_{target1-2}=\sqrt{[(\Delta_{lat1-2})(6076)]^2+[(\Delta_{long1-2})(\cos(avg_{lat1-2}))(6076)]^2}$$
$$\Delta_{res}=\arctan\left[\frac{R_{target1-2}}{\left(\frac{(R_{target1}+R_{target2})}{2}\right)}\right]$$
$$R_{target1-2}=\textit{range between target 1 and target 2}$$
$$\Delta_{res}=\textit{measured angular resolution of the radar}$$
$$\textit{all } \Delta_{lat} \textit{ and } \Delta_{long} \textit{ in minutes}$$
$$\textit{all } avg_{lat} \textit{ in degrees}$$

(9)

Relate the range and azimuth resolution to the expected tactics of the threat and from this assess the radar's ability to perform a raid count. Qualitatively assess the effect of the expected raid count capability upon intercept and attack tactics, particularly on the assignment of fighters to inbound cells and the optimization of attack tactics.

2.3.8.7. Data Cards

A sample data card is provided as card 12.

CARD NUMBER ___ TIME ____ PRIORITY L/M/H

AIR-TO-AIR RANGE AND BEARING RESOLUTION

[SYNCHRONIZE TIME TO THE GROUND STATION TIME SOURCE. POSITION THE TARGETS ON THE NOSE AT 10 TO 30 NM HEADING TOWARDS OR AWAY AND 1,000 FEET ABOVE THE TEST AIRPLANE. PLACE THE TEST RADAR IN SEARCH MODE, NARROWEST SCAN ANGLE PATTERN AND SINGLE BAR SCAN. THE TRAIL OPENS SLOWLY UNTIL THE TEST RADAR BREAKS OUT TWO TARGETS. RECORD DATA. REPEAT FOR ALL MODES AFFECTING PULSE WIDTH.]

MODE	TIME

[PLACE THE TARGETS IN A 500 FEET LINE ABREAST WHILE HEADING TO CLOSE. USE A __NM SEPARATION TO START. CONTINUE INBOUND UNTIL BREAKOUT OCCURS. RECORD TIME.]

TIME AT BREAKOUT _____

Card 12: Air-to-Air Range And Bearing Resolution Data Card