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Federal Aviation Agency

ADVISORY CIRCULAR

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AIR TRAFFIC CONTROL AND GENERAL OPERATIONS

EFFECTIVE: 8/15/67

SUBJECT: RADAR CAPABILITIES AND LIMITATIONS

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1. PURPOSE. This circular is to advise the aviation community of the inherent capabilities and limitations of radar systems and the effect of these factors on the service provided by air traffic control (ATC) facilities.

2. REFERENCES.

   a. Advisory Circular 90-19, Use of Radar for the Provision of Air Traffic Control Services, dated October 29, 1964.

   b. Airman's Information Manual, Part 1.

3. DEFINITIONS. The following is a list of basic terms which are used when discussing radar systems:

   a. Radar--Radio Detection and Ranging. A method whereby radio waves are transmitted into the air and are then received when they have been reflected by an object in the path of the beam. Range is determined by measuring the time it takes (at the speed of light) for the pulsating radio wave to go out to the object and then return to the receiving antenna. The direction of a detected object from a radar site is determined by the position of the rotating antenna when the reflected portion of the radio wave is received.

   b. Radar Beacon. This is sometimes called secondary radar. This system increases the capability and reliability of radar systems since it utilizes electronic components which activate transmitted radio waves from aircraft and are, therefore, not dependent on relatively weak reflected radio waves. The ground equipment (interrogator) sends out special radio pulses which trigger the airborne equipment (transponder). A series of coded radio pulses are sent back to the antenna. By varying the coded returns,

specific aircraft or all aircraft in a selected block of airspace may be readily identified. Another feature, which is called Mode C, is the transmission of aircraft altitude by beacon code to the controlling radar facility.

c. Blip or Radar Target. The illuminated spot or slash depicting a detected object which is displayed on the radar operator's display equipment at the range and azimuth (direction) from a detecting radar.

d. Radar Microwave Link. A system of receiver-transmitter sites which relay radar information over long distances. This system allows operators at a central control facility to see information detected by radar sites which are many miles away.

4. DISCUSSION.

a. Capabilities. The two main radar systems utilized by Federal Aviation Administration air traffic control are air route surveillance radar (ARSR) and airport surveillance radar (ASR). Both types combine primary radar and beacon radar for their displays. Other radars used to a lesser degree are precision approach radar, which may be utilized for issuing precise landing instructions from the controller, and airport surface detection equipment, which is used by tower operators for ground control during periods of poor visibility.

(1) Almost 90 ARSRs feed information to 28 Air Route Traffic Control Centers (ARTCCs) across the United States and its possessions. The approximately 200-mile detection range of the ARSR provides en route radar coverage to ARTCCs for the continental United States, except for portions of northern Minnesota, the Dakotas, and the southern tip of Texas.

(2) There are over 120 ASRs now in use to provide arrival and departure service at major terminals. Because of varied functions, ASRs differ from ARSRs by displaying a lesser range and by an increased antenna rotation rate which provides faster and more current information to the controller. Although surveillance radars do not measure the height of a target, the vertical beam width covers altitudes ranging from over 60,000 feet to about 2,000 feet depending on terrain features and the proximity of the target to the radar site.

(3) More reliable maintenance and improved equipment have reduced complete radar failures to a negligible factor. Most facilities actually have some components duplicated--one operating and another which immediately takes over when a malfunction occurs to the primary component.

(4) Radar has proven to be a substantial aid to safer and more efficient air traffic control even though our present systems are incapable of providing full coverage in all areas and at all altitudes. Certain limiting factors will be discussed below. In those instances when radar is not available to assist with aircraft control, basic nonradar procedures are implemented for providing separation from other controlled traffic.

b. Limitations. Limitations inherent to radar systems cause various problems for radar controllers which may or may not be eliminated or minimized by the development of corrective electronic fixes. It is very important for the aviation community to recognize the fact that there are limitations to radar service and that ATC controllers may not always be able to issue traffic advisories concerning aircraft which are not under ATC control and cannot be seen on radar.

(1) The characteristics of radio waves are such that they normally travel in a continuous straight line unless they are:

(a) "Bent" by abnormal atmospheric phenomena such as temperature inversions;

(b) Reflected or attenuated by dense objects such as heavy clouds, precipitation, ground obstacles, mountains, etc.; or

(c) Screened by high terrain features.

(2) The bending of radar pulses, often called anomalous propagation or ducting, may cause many extraneous blips to appear on the radar operator's display if the beam has been bent toward the ground or may decrease the detection range if the wave is bent upward. It is difficult to solve the effects of anomalous propagation, but using beacon radar and electronically eliminating stationary and slow moving targets by a method called moving target indicator (MTI) usually negate the problem.

(3) Radar energy that strikes dense objects will be reflected and displayed on the operator's scope thereby blocking out aircraft at the same range and greatly weakening or completely eliminating the display of targets at a greater range. Again, radar beacon

and MTI are very effectively used to combat ground clutter and weather phenomena, and a method of circularly polarizing the radar beam will eliminate some weather returns. A negative characteristic of MTI is that an aircraft flying a speed that coincides with the canceling signal of the MTI (tangential or "blind" speed) may not be displayed to the radar controller.

(4) Relatively low altitude aircraft will not be seen if they are screened by mountains or are below the radar beam due to earth curvature. The only solution to screening is the installation of strategically placed multiple radars which has been done in some areas.

(5) There are several other factors which affect radar control. The amount of reflective surface of an aircraft will determine the size of the radar return. Therefore, a small light airplane or a sleek jet fighter will be more difficult to see on radar than a large commercial jet or military bomber. Here again, the use of radar beacon is invaluable if the aircraft is equipped with an airborne transponder. Altitude information must be obtained by radio from the pilot since all present en route and airport surveillance radars are only two dimensional (range and azimuth). However, at several ATC facilities beacon Mode C is used to electronically display altitude information to the controller from appropriately equipped aircraft.

(6) The controllers' ability to advise a pilot flying on instruments or in visual conditions of his proximity to another aircraft will be limited if the unknown aircraft is not observed on radar, if no flight plan information is available, or if the volume of traffic and workload prevent his issuing traffic information. First priority is given to establishing vertical, lateral, or longitudinal separation between aircraft flying IFR under the control of ATC.

c. Summation. In summary, it is evident that radar is highly beneficial to the control and separation of IFR air traffic, but some aircraft may not be seen. This fact, together with the increasing amount of traffic that is flying while not radar identified and under control of ATC facilities, decreases the capability of a controller to cope with every contingency which may arise and occasionally precludes his capability to issue traffic advisory services. After separation between controlled traffic has been ensured, the

controller may then direct his attention to providing additional services such as radar advisories to visual flight rules aircraft. The pilot who requires these services will substantially assist the controller (and himself) by immediately advising the controller of the exact nature of his request, weather conditions, type of aircraft, route and type of flight plan, altitude, magnetic heading, and by understanding ATC radar and controller limitations.

Archie W. League, Director
Air Traffic Service