



IEEE Standard Radar Definitions

IEEE Aerospace and Electronic Systems Society

Sponsored by the
Radar Systems Panel

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IEEE Standard Radar Definitions

Sponsor

Radar Systems Panel
of the
IEEE Aerospace and Electronic Systems Society

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IEEE-SA Standards Board

Abstract: Definitions are provided for the purpose of promoting clarity and consistency in the use of radar terminology. The definitions represent the consensus of a panel of radar experts.

Keywords: radar, terminology

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Introduction

This introduction is not part of IEEE Std 686-2008, IEEE Standard Radar Definitions.

Originally, radar definitions were included in IEEE Std 172™-1971 [B6].^a In 1974, the Radar Systems Panel of the IEEE Aerospace and Electronic Systems Society set out to create a separate standard devoted to radar definitions. The result was the first edition of this standard, IEEE Std 686-1977. In order to avoid overlap and conflict with the radar definitions existing in IEEE Std 172-1971, the IEEE Standards Board allowed only new terms, not already in that standard, to be included in IEEE Std 686-1977.

The second edition, IEEE Std 686-1982, included terms formerly found in IEEE Std 172-1971, with the exception of a few terms that are common to both fields, and new and updated terms. IEEE Std 686-1982 updated, added, and/or deleted standard radar definitions. The third edition, IEEE Std 686-1990, and the fourth edition, IEEE Std 686-1997, added and/or deleted standard radar definitions.

IEEE Std 686-2008 adds new terms, revises others, and deletes a number of obsolete terms that no longer appear in radar literature or usage. As radar technology and literature evolve, new terms will appear; further updating at approximately five-year intervals is planned.

The work of preparing the drafts of this standard, integrating all comments, resolving differences, and coordinating this standard with other standards was accomplished by the Working Group for the Radar Systems Panel of the IEEE Aerospace and Electronic Systems Society. In particular, radar definitions common to ultrawideband radar were coordinated with the UWB Radar Committee for IEEE Std 1672.

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^a The numbers in brackets correspond to those of the bibliography in Annex A.

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1. Overview

1.1 Scope

This standard is devoted to providing radar definitions. The standard includes terms formerly found in IEEE Std 172™-1971 [B6],¹ with the exception of a few terms that are common in both fields, and new and updated terms. IEEE Std 172-1983 [B7] was withdrawn in 1983. As radar technology and literature evolve, new terms will be added and obsolete terms deleted.

1.2 Purpose

This standard is published for the purpose of promoting clarity and consistency in the use of radar terminology. The definitions represent the consensus of a panel of radar experts. The purpose of the revision is to add new terms, revise others, and delete a number of obsolete terms that no longer appear in radar literature or usage.

¹ The numbers in brackets correspond to those of the bibliography in Annex A.

2. Radar definitions (and acronyms)

For the purposes of this document, the following terms and definitions apply. *The Authoritative Dictionary of IEEE Standards Terms* [B3] should be referenced for terms not defined in this clause.

acquisition: The process of establishing a stable track on a target that is detected by a radar during search or designated in one or more coordinates from another source. When designated, a search of a limited given volume of coordinate space is usually required because of errors or incompleteness of the designation.

acquisition probability: The probability of establishing track on a designated target or a target detected in search. *See also:* **tracking**.

active electronically scanned array (AESA) radar: A radar that uses an antenna with distributed transmit and receive elements co-located with the antenna, each of which may be individually controlled in amplitude, time delay, and/or phase providing very rapid electronic beam scanning.

aided tracking: A tracking technique in which the manual correction of the tracking error corrects the rate of motion of the tracking mechanism.

AI radar: *See:* **airborne-intercept radar**.

airborne early warning (AEW) radar: Describing an early-warning or air-surveillance radar carried by an airborne or spaceborne vehicle. *See also:* **early-warning radar**.

NOTE—The abbreviations capitalized in this standard are in accordance with prevailing radar usage. Lowercase abbreviations are an acceptable alternative (and are preferred by some authors and editors) provided they are used in a consistent manner.²

airborne-intercept (AI) radar: A fire-control radar for use in interceptor aircraft.

airborne moving-target indication (AMTI): *See:* **airborne MTI**.

airborne moving-target indication (AMTI) radar: An MTI radar flown in an aircraft or other moving platform with corrections applied for the effects of platform motion, which include the changing clutter Doppler frequency and the spread of the clutter Doppler spectrum *See also:* **displaced phase center antenna**; **space-time adaptive processing**; **time-averaged-clutter coherent airborne radar**.

airport surface detection equipment (ASDE): A high-resolution radar usually located on the airport control tower or other high point and used for observation of the positions of aircraft and other vehicles on the surface of an airport.

airport-surveillance radar (ASR): A medium-range (e.g., 100 km) surveillance radar used to control aircraft in the vicinity of an airport.

air-route-surveillance radar (ARSR): A long-range (e.g., 350 km) surveillance radar used to control aircraft on airways beyond the coverage of airport-surveillance radar (ASR).

air-surveillance radar: A surveillance radar whose function is to detect and track aircraft over a volume of space.

² Notes in text, tables, and figures of a standard are given for information only and do not contain requirements needed to implement the standard.

alert-confirm detection: A technique in which initial detection is followed quickly with a confirm dwell waveform optimized to the range, angle, and sometimes radial velocity of the alert detection. *See also:* **two-step sequential detection**.

ambiguity function: The squared magnitude $|\chi(\tau, f_d)|^2$ of the function that describes the response of a radar receiver to point targets displaced in range delay (τ) and Doppler frequency (f_d) from a reference position, where $|\chi(0,0)|$ is normalized to unity. Mathematically,

$$\chi(\tau, f_d) = \int u(t) u^*(t + \tau) \exp(2\pi j f_d t) dt$$

where

$u(t)$	is the transmitted waveform, suitably normalized
$u^*(t)$	is the complex conjugate of $u(t)$
positive τ	indicates a target beyond the reference delay
positive f_d	indicates an approaching target

The ambiguity function is used to examine the suitability of radar waveforms for achieving accuracy, resolution, freedom from ambiguities, and reduction of unwanted clutter.

NOTE—See also IEEE Std 1672™-2006 [B5].

amplitude-comparison monopulse: A form of monopulse in which the angular deviation of the target from the antenna axis is measured as the amplitude ratio of the target as received by two antenna patterns. The patterns may be a pair of beams displaced on opposite sides of the antenna axis, or a difference-channel beam having odd symmetry about the axis and a sum beam having even symmetry. In the latter case the ratio may have positive and negative values (0° or 180° phase shift, or in some cases $+90^\circ$ and -90°). Distinguished from phase-comparison monopulse, in which the relative phase of the two patterns carries the information on target displacement. *See also:* **phase-comparison monopulse**.

amplitude fluctuations: *See:* **target fluctuation**.

amplitude noise: Used variously to describe target fluctuation and scintillation error. Use of one of these specific terms is recommended to avoid ambiguity.

angel (or angel echo): A radar echo caused by birds, insects, and atmospheric clear-air turbulence not usually visible to the eye. Often a term applied to any unknown radar echo that does not appear to be related to conventional targets.

angle noise: The noise-like variation in the apparent angle of arrival of a signal received from a target, caused by changes in phase and amplitude of multiple, unresolved target-scattering sources. Includes both glint and scintillation errors. *See also:* **glint; scintillation error**.

angular resolution: The ability to distinguish between two targets solely by the observation of their angle, usually expressed in terms of the minimum angle separation by which two targets at a given range can be distinguished. The required separation should be specified for targets of given relative power level at the receiver. Equal powers are often assumed, but where resolution of targets of different powers is important it may be necessary to specify the separation at two or more power ratios. The concept of angular resolution should not be confused with angular measurement accuracy, which for a single target is a function of antenna beamwidth and signal-to-noise ratio.

anticlutter circuits: Circuits that attenuate undesired reflections from the natural environment (clutter) to permit detection of targets otherwise obscured by such reflections. *See also:* **clutter**.

antenna: Subsystem for efficient coupling of electromagnetic radiation into or from the propagation medium.

antenna-pattern loss: *See:* **beamshape loss.**

antisubmarine warfare (ASW) radar: A radar used in antisubmarine warfare. It includes radars for the detection of submarines and submarine effects as well as radars on ships or aircraft employed in ASW operations to obtain situational awareness of the surface ships and aircraft in the vicinity of ASW operations.

antisurface vessel (ASV) radar: A radar used in airborne maritime surveillance of shipping. *See also:* **antisubmarine warfare radar.**

area moving-target indication (MTI): A method of MTI based upon amplitude changes in corresponding resolution cells for radar returns obtained at different times.

array antenna: Antenna made up of individual transmitting and receiving elements where beam forming and steering is achieved by control of time or phase delay between elements. *See also:* **phased array.**

ARSR: *See:* **air-route surveillance radar.**

ASDE: *See:* **airport surface detection equipment.**

ASR: *See:* **airport-surveillance radar.**

ATC: Acronym for air traffic control.

ATR: *See:* **Automatic Target Recognition.**

auroral clutter: Clutter from the aurora borealis or aurora australis. Most frequently observed with HF over-the-horizon radars and VHF radars.

automatic detection and tracking (ADT): In a surveillance radar, the computer-based ADT of targets based on target locations obtained from each look. *See also:* **track-while-scan.**

Automatic Target Recognition (ATR): Radar signal and image processing techniques associated with automatic discrimination and identification of targets as opposed to detection processing (including the exploitation of target detection reports or track profiles). However, ATR includes detection processing as an essential or critical first component in the radar signal and image processing chain.

automatic tracking: Tracking with the use of electronic circuitry rather than a human operator in which a system employs some feedback mechanism, (e.g., a servo or computer) to follow automatically some characteristic of a signal or target, such as range, angle, Doppler frequency, or phase. *See also:* **tracking, tracking radar.**

automatic video noise leveling: A constant-false-alarm rate (CFAR) technique in which the receiver gain is readjusted to maintain a constant video noise level. The noise level is sampled at the receiver output at the end of each range sweep, prior to the next transmission. The resulting receiver gain is fixed throughout the next sweep. Under some jamming conditions, a fixed video noise can be maintained at the display.

NOTE—This term is deprecated.

azimuth: The angle between a horizontal reference direction (usually north) and the horizontal projection of the direction of interest, measured clockwise.

azimuth markers: *See:* **azimuth marks.**

azimuth marks: Calibration marks used on a display for azimuth. *Syn:* **azimuth markers.**

azimuth-stabilized plan-position indicator (PPI): A PPI on which the reference direction remains fixed with respect to the indicator, regardless of the vehicle orientation.

background return: *See:* **clutter.**

NOTE—No longer in common use.

backscatter: Energy reflected or scattered in a direction opposite to that of the incident wave.

backscatter coefficient: A normalized measure of radar return from a distributed scatterer. For area targets, such as ground or sea clutter, it is defined as the average *monostatic* radar cross section (RCS) per unit surface area. The backscatter coefficient for area targets, often expressed in decibels and denoted by σ^0 , is dimensionless but is sometimes written in units of m^2/m^2 for clarity. For volume scatter, such as that from rain, chaff, or deep snow cover, it is defined as the average monostatic RCS per unit volume and is expressed in units of m^2/m^3 or m^{-1} . The volume backscatter coefficient is often expressed in decibels and denoted by the symbol η or η_v . The backscatter coefficient is sometimes known as *normalized radar reflectivity*.

backscatter cross section: *See:* **radar cross section.**

bandwidth, root-mean-square: The root-mean-square (rms) deviation of the power spectrum of the received signal relative to zero frequency or the spectral center, in units of radians per second. This bandwidth β is defined as the square root of:

$$\beta^2 = \frac{\int_{-\infty}^{\infty} [2\pi(f - f_0)]^2 |S(f)|^2 df}{\int_{-\infty}^{\infty} |S(f)|^2 df}.$$

where

f	is the signal frequency
$S(f)$	is the Fourier transform of the signal
$s(t - \tau_0)$	is the center frequency of the spectrum, with true time delay τ_0 and f_0

β^2 is the normalized second moment of the spectrum $|S(f)|^2$ about the mean, and β is sometimes called *effective bandwidth*.

Barker code: A binary phase code used for pulse compression, in which a long pulse is divided into n subpulses with the phase of each subpulse being 0 or π radians. Barker coded pulses have the property that after matched filter processing there are $(n - 1)/2$ sidelobes, or $n/2$ for n even, on each side of the main response, each at a peak voltage level $1/n$ relative to the main response. Barker codes exist with $n = 2, 3, 4, 5, 7, 9,$ and 13 . *See also:* **coded pulse.**

beacon: *See:* **radar beacon.**

beacon equation: An equation that gives the maximum detection range of a transponder or secondary radar as a function of system parameters for a given set of conditions. It is the one-way counterpart of the two-way radar equation.

beam: The formation of radiation into a constrained volume using an antenna. *See also:* **antenna**.

beam broadening: The increase in the antenna beamwidth, often as a result of scanning the beam of a phased array off the broadside direction.

beamshape loss: A loss factor included in the radar equation to account for the target not always being at the peak of the radar beam. For scanning search radars this loss accounts for the use of the peak antenna gain in the radar equation instead of the effective gain that results when the received train of pulses is modulated by the two-way pattern of a scanning antenna. For phased-array search radars, this loss accounts for using the peak gain instead of the effective gain that results from the variation of the antenna gain over the search pattern. *Syn:* **antenna-pattern loss**.

bias error: A systematic error, whether due to equipment or propagation conditions. A nonzero mean component of a random error.

bipolar video: A radar video signal whose amplitude can have both positive and negative values; derived from a synchronous phase detection process. Coherent detection produces one type of bipolar video. *See also:* **coherent signal processing**.

bistatic denial: An electronic counter-countermeasure (ECCM) method designed to deny a coherent reference to a noncooperative bistatic radar receiver, thus degrading detection performance of the bistatic radar without degrading the performance of the host radar.

bistatic radar: A radar using antennas for transmission and reception at sufficiently different locations that the angles or ranges to the target are significantly different.

bistatic-scatter cross section: *See:* **radar cross section**.

blind phase: In moving-target indication (MTI) radars, when the echo of interest is in quadrature to the reference signal. It occurs in systems that detect only the in-phase (or quadrature phase) signal component. *See also:* **moving-target indication**.

blind range: A range corresponding to the time delay of an integral multiple of the interpulse period plus a time less than or equal to the transmitted pulse length. A radar usually cannot detect targets at a blind range because of interference by a subsequent transmitted pulse. *See also:* **eclipsing**.

blind speed [radar using moving-target indication (MTI)]: Radial velocity of a target with respect to the radar for which the MTI response is approximately zero. In a coherent MTI system using a uniform repetition rate, a blind speed is a radial velocity at which the target changes its distance by one-half wavelength, or a multiple thereof, during each pulse-repetition interval (PRI).

blip: A deflection or a spot of contrasting luminescence on a radar display caused by the presence of a target.

blip-scan ratio: The fraction of scans for which a blip is observed at a given range. *Syn:* **single-scan probability of detection**.

blooming: An increase in the blip size on the display as a result of an increase in signal intensity or duration.