

IEEE Standard Radar Definitions

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IEEE Standard Radar Definitions

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Abstract: IEEE Std 686-1990, *IEEE Standard Radar Definitions*, is a glossary of standard radar definitions. The definitions represent the consensus of opinion of a panel of leading experts in radar technology and should serve as a guide to standardization of meanings.

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Foreword

(This Foreword is not a part of IEEE Std 686-1990, IEEE Standard Radar Definitions.)

This standard is published for the purpose of promoting clarity and consistency in the use of radar terminology. The definitions represent the consensus (reached after several rounds of review, comment, and revision) of a panel of radar experts, including authors of several books on radar. It is intended that these definitions shall serve as a guide to standardization of meanings.

Originally, radar definitions were included in IEEE Std 172-1971, IEEE Standard Definitions of Navigation Aid Terms. The Radar Systems Panel of the IEEE Aerospace and Electronic Systems Society undertook, beginning in 1974, to create a separate standard devoted to radar definitions. The result was the first edition of this standard, IEEE Std 686-1977, IEEE Standard Radar Definitions. In order to avoid overlap and conflict with the radar definitions then existing in IEEE Std 172-1971, the IEEE Standards Board allowed only new radar terms, not already in that standard, to be included in IEEE Std 686-1977.

The second edition, IEEE Std 686-1977, included terms formerly found in IEEE Std 172-1971, with the exception of a few terms that are common to both fields, and new or updated terms. IEEE Std 686-1990 updates, adds, and/or deletes standard radar definitions.

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*All members of the Radar Systems Panel Balloting Committee are from the United States unless otherwise noted.

The entire membership of the Radar Systems Panel participated in reviewing successive drafts and recommending revisions, additions, and deletions. The work of preparing the drafts, integrating all the comments, resolving differences, and coordinating with other IEEE Standards was accomplished by the Terminology Committee of the IEEE Aerospace and Electronic Systems Society, which had the following membership at the time this standard was approved:

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*Frederick C. Williams was the initial chairman of the Terminology Committee until his death in 1986.

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IEEE Standard Radar Definitions

acquisition. The process of establishing a stable track on a target that is designated in one or more coordinates. 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 a stable track on a designated target.

A-display. A type of radar display format. *See: display.*

AEW. Acronym for airborne early warning; describing an early-warning radar carried by an airborne or spaceborne vehicle. *See: early-warning radar.*

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

AI radar. Acronym of airborne-intercept radar.

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

airport surface detection equipment (ASDE).¹ A ground-based radar for observation of the positions of aircraft and other vehicles on the surface of an airport.

airport-surveillance radar (ASR). A medium-range (for example, 60 nautical miles) surveillance radar used to control aircraft in the vicinity of an airport.

air-route-surveillance radar (ARSR). A long-range (for example, 200 nautical miles) surveillance radar used to control aircraft on

airways beyond the coverage of airport-surveillance radar (ASR).

ambiguity function. The squared magnitude $|\chi(\tau, f_d)|^2$ of the function that describes the response of a radar receiver to 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 envelope waveform, suitably normalized, positive τ indicates a target beyond the reference delay, and positive f_d indicates an incoming target. Used to examine the suitability of radar waveforms for achieving accuracy, resolution, freedom from ambiguities, and reduction of unwanted clutter.

amplitude-comparison monopulse. A form of monopulse employing receiving beams with different amplitude-versus-angle patterns. If the beams have a common phase center, the monopulse is pure amplitude-comparison; otherwise it is a combination of amplitude-comparison and phase-comparison. *See also: monopulse and phase-comparison monopulse.*

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

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

angel (or angel echo). A radar echo caused by meteorological conditions, such as clouds, atmospheric inhomogeneities, lightning, or by insects or birds. Detection of desired targets, such as aircraft, may be degraded when the angels are seen over large areas.

angle noise. The noise-like variation in the apparent angle of arrival of a signal received

¹The 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.

from a target, caused by changes in phase and amplitude of target-scattering sources and including angular components of both glint and scintillation error.

angular resolution. The minimum angular separation at which two equal targets at the same range can be distinguished from each other.

anticlutter circuits. Circuits that attenuate undesired reflections to permit detection of targets otherwise obscured by such reflections.

anti-transmit-receive (ATR) switch. A radio-frequency switch that automatically decouples the transmitter from the antenna during the receiving period; it is employed when a common transmitting and receiving antenna is used.

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

ARSR. Acronym for air-route surveillance radar.

A-scope. A cathode-ray oscilloscope arranged to present an A-display.

ASDE. Acronym for airport surface detection equipment.

ASR. Acronym for airport-surveillance radar.

ASW. Acronym for antisubmarine warfare, applied to radars whose function is to detect submarines, particularly those which are exposing only a small portion of their structure.

ATC. Acronym for air traffic control.

ATR switch. Acronym for anti-transmit-receive switch.

automatic threshold variation. A constant-false-alarm-rate (CFAR) technique in which the detection decision threshold is varied continuously in proportion to the incoming IF and video noise level.

automatic tracking. Tracking in which a system employs some feedback mechanism, for example 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.

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

azimuth marks (or markers). Calibration marks for azimuth.

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

background return. Same as clutter.

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

backscatter coefficient. A normalized measure of radar return from a distributed scatterer; applied to clutter and to targets of imaging radars and scatterometers. For area targets, such as ground or sea clutter, it is defined as the average monostatic radar cross section per unit surface area. It 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 radar cross section per unit volume; the units are m^2/m^3 or m^{-1} .

backscattering cross section. *See: radar cross section (RCS).*

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

NOTE: β_2 is the normalized second moment of the spectrum $|S(f)|^2$ about the mean.

B-display. A type of radar display format. *See: display.*

beacon. *See: radar beacon.*

beacon equation. An equation that gives the maximum detection range or signal-to-noise ratio (SNR) 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.

beamshape loss. A loss factor included in the radar equation to account 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. *Syn: antenna-pattern loss.*

bias error. A systematic error, whether due to equipment or propagation conditions. A non-zero mean value 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.

bistatic cross section. *See: radar cross section (RCS).*

bistatic radar. A radar using antennas at different locations for transmission and reception.

blind phase. In MTI radars, when the echo of interest is in quadrature to the reference signal. It occurs in systems that detect only the in-phase signal component.

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 subsequent transmitted pulses.

blind speed (radar using 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.

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.

NOTE: Corresponds to probability of detection when observer's integration time is less than scan period.

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

boresighting. The process of aligning the electrical and mechanical axes of a directional antenna system, usually by an optical procedure.

box-car detector. (Obsolete) In radar, a detector whose output is held at the amplitude of the last sample until the next sample arrives. Functionally the same as a sample and hold.

B-scope. A cathode-ray oscilloscope arranged to present a B-display.

calibration marks (or markers). Indications superimposed on a display to provide a numerical scale of the parameters displayed.

canceled video. In MTI, the video output remaining after the cancellation process.

canceler. That portion of the system in which unwanted signals, such as clutter, fixed targets, and other interference, are suppressed by a process of linear subtraction.

cancellation ratio. In MTI, the ratio of canceler voltage amplification for fixed-target echoes received with a fixed antenna, to the gain for a single pulse passing through the unprocessed channel of the canceler.

capture effect. The tendency of a receiver to suppress the weaker of two time-coincident signals within its passband.

carrier-controlled approach (CCA) system. An aircraft carrier radar system providing information by which aircraft approaches may be directed via radio communication.

C-band. A radar-frequency band between 4 GHz and 8 GHz, usually in the International Telecommunications Union (ITU) assigned band 5.2 GHz to 5.9 GHz.

C-display. A type of radar display format. *See: display.*

CFAR. Acronym for constant-false-alarm rate.

chaff. Strips of lightweight metal or metalized material that are dispensed in large numbers (bundles) into surveillance or observation volume of a radar to reflect impinging signals and simulate a true target. Each bundle may contain thousands of individual reflectors whose lengths are related to the wavelength of the radar. Chaff for use at HF and VHF frequencies is sometimes called "rope." (In WWII, chaff was called "window" in Great Britain and "Dueppel" in Germany.)

chirp. A technique for pulse compression that uses frequency modulation (usually linear) during the pulse.

clutter. Unwanted echoes, typically from the ground, sea, rain or other precipitation, chaff, birds, insects, and aurora.

clutter attenuation. In moving-target indication, the ratio of clutter power at the canceler input to clutter residue power at the output,

normalized to the attenuation for a single pulse passing through the unprocessed channel of the canceler. *Syn: clutter cancellation or suppression. See: MTI improvement factor.*

clutter filter. A filter or group of filters included in a radar for the purpose of rejecting clutter returns and passing target returns at other Doppler frequencies. MTI and pulsed-Doppler processors are examples.

clutter improvement factor. Same as MTI improvement factor.

clutter-referenced MTI. A type of noncoherent MTI that uses clutter as a reference. *See: non-coherent MTI.*

clutter reflectivity. The backscatter coefficient of clutter. *See: backscatter coefficient.*

clutter residue. The clutter power remaining at the output of an MTI system; it is the sum of several (generally uncorrelated) components resulting from radar instabilities, antenna scanning, relative motion of the radar with respect to the sources of clutter, and fluctuations of the clutter reflectivity. *See also: canceled video.*

clutter visibility factor. The predetection signal-to-clutter ratio that provides stated probabilities of detection and false alarm on a display; in moving-target indicator systems, it is the ratio after cancellation or Doppler filtering.

coast. A radar memory feature that causes the range or angle tracking systems to continue to move in the same direction and at the same rate that an original target was moving. It is used to prevent lock-on to a stronger target near the target being tracked.

coded pulse. A pulse with internal (intrapulse) amplitude, frequency, or phase modulation, used for identification or for pulse compression.

coherent integration. Integration of RF, IF, or bipolar envelope signals in which phase or polarity is preserved, sometimes called "pre-detection integration." *See: integration.*