IEEE Standard Radar Definitions

IEEE Aerospace and Electronic Systems Society

Sponsored by the
Radar Systems Panel

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Radar Systems Panel
of the
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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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IEEE Standard Radar Definitions

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 S*ee 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° 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:

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

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.

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

box-car detector: 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.*

NOTE—No longer in common use.

broadside: For a planar or linear array, the direction normal to the array surface. Sometimes called the *on-axis direction.*

burnthrough: The process of increasing the radar signal to allow detection in the presence of jamming, for example by increasing pulse energy or decreasing range. *See*: **self-screening range**.

burnthrough range: The range at which a target can be detected in the presence of jamming. *See*: **burnthrough; self-screening range**.

burst: *See*: **pulse burst**.

calibration markers: *See:* **calibration marks**.

calibration marks: Indications superimposed on a display to provide a numerical scale of the parameters displayed.

canceled video: In moving-target indication (MTI), the video output remaining after the cancellation process. *See also:* **clutter residue; moving-target indication**.

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: (A) In moving-target indication (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. This measure of MTI performance, in which high performance is represented by a low numerical value, has been largely replaced by the MTI improvement factor. *See also:* **moving-target indication**. **(B)** In interference-reduction techniques other than MTI: The cancellation ratio is the ratio of interference output power in the absence of the technique to that when the technique is applied, when the system gains for the two cases are adjusted to provide equal noise outputs. High performance is indicated by a high numerical value, generally expressed in decibels to avoid ambiguity between power and voltage ratios.

capture effect: The effect in which a receiver suppresses the weaker of two time-coincident signals within its passband. In the case of the simultaneous strong and weak targets, this suppression is undesirable.

carrier-controlled approach (CCA) system: An aircraft carrier radar system providing information which facilitates direction of aircraft via radio communication.

C-band: A radar-frequency band between 4 GHz and 8 GHz, usually in the International Telecommunications Union (ITU) allocated band 5.250 GHz to 5.925 GHz.

NOTE—See IEEE Std 521™-2002 [B8].

CFAR: *See*: **constant-false-alarm rate**.

chaff: Strips of lightweight metal or metalized material that are dispensed in large numbers (bundles) so as to simulate a true target, or, more usually, to create a large clutter signal that masks the detection of wanted

targets. Note that (1) each bundle may contain thousands of individual reflectors whose lengths are related to the wavelength of the radar; (2) chaff for use at HF and VHF frequencies is sometimes called *rope*; (3) in WWII, chaff was called *window* in Great Britain and *Dueppel* in Germany.

chirp: A form of pulse compression that uses frequency modulation (usually linear) during the pulse.

circulator: Device that can be used to provide isolation between transmitter and receiver.

clutter: Unwanted echoes, typically from the ground, sea, rain or other precipitation, chaff, birds, insects, meteors, and aurora. *Syn:* **background return**.

clutter attenuation (CA): In moving-target indication (MTI) or Doppler radar, the ratio of (1) the clutter power at the input to the clutter processor (but after beamforming), to (2) the clutter power at the output. In MTI, a single value of CA will be obtained, while in Doppler radar the value will generally vary over the different Doppler filters. *See also***: MTI improvement factor**.

clutter detectability factor: The predetection signal-to-clutter ratio that provides stated probability of detection for a given false-alarm probability in an automatic detection circuit. In moving-target indication (MTI) systems, it is the ratio after cancellation or Doppler filtering.

clutter fence: A barrier surrounding a ground-based radar to serve as an artificial horizon and suppress ground clutter.

clutter filter: A filter or group of filters (filter bank) included in a radar for the purpose of rejecting clutter returns and passing target returns at Doppler frequencies different from the Doppler frequencies of clutter. Moving-target indication (MTI) and pulsed-Doppler processors are examples.

clutter improvement factor: *See:* **moving-target indication improvement factor**.

clutter map: Computer-stored values of radar-measured clutter for each range-azimuth or range-azimuth-elevation resolution cell or local region, used to set thresholds for each cell in a constant-false-alarm rate (CFAR) detection system or to adjust other processing parameters. May also include elevation and Doppler dimensions.

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

clutter residue: The uncanceled clutter power remaining at the output of an moving-target indication (MTI) or Doppler signal processor. *See also:* **canceled video**.

clutter visibility factor: The predetection signal-to-clutter ratio that provides stated probability of detection for a given false-alarm probability on a display. In moving-target indication (MTI) 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 invoked manually or automatically when the tracked target approaches a stronger echo (target or clutter) to prevent capture of the track by that echo or to maintain track over brief periods of signal loss.

coded pulse. A *pulse compression* waveform in which a long pulse is divided into many subpulses, with the phase of each subpulse assuming a discrete value (often 0 or π radians) chosen in a deterministic manner (as in Barker codes, which result in all time sidelobes being equal) or chosen in a pseudorandom manner (such as with linear recursive or maximal-length sequences). *See also*: **Barker code**.

coherent integration: Integration of radio frequency (RF), intermediate frequency (IF), or bipolar envelope signals over an interval in which phase or polarity is preserved. *See also:* **integration (of radar signals)**.

coherent moving-target indication (MTI): The usual form of MTI in which a moving target is separated from large clutter echoes as a result of a pulse-to-pulse change in echo phase relative to the phase of a coherent reference oscillator. *See:* **moving-target indication**.

coherent processing interval (CPI): The time during which the radar signal is received and processed coherently. Such processing is usually for Doppler filtering.

coherent signal processing: Integration, filtering, or detection of an echo signal using the amplitude of the received signal and its phase referred to that of a reference oscillator or to the transmitted signal.

coherent video: Bipolar video obtained from a synchronous (coherent) detector.

coho: A term derived from coherent oscillator, designating an oscillator used in a coherent radar to provide a reference phase by which changes in the phase of successively received pulses may be recognized. In practice, a coho usually operates at the receiver intermediate frequency.

collapsing loss: The increase in required input signal-to-noise ratio to maintain given probability of detection for a given false-alarm probability when resolution cells or samples containing only noise are integrated along with those containing signal and noise. This type of loss occurs, for example, when radar returns containing range, azimuth, and elevation information are constrained to a two-dimensional (2-D) display.

collapsing ratio: The ratio

$$(m + n)/n$$

where

m is the number of noise-only samples
n is the number of signal-plus-noise samples

combination monopulse: A form of monopulse employing amplitude comparison in one angular coordinate plane and phase comparison in the orthogonal coordinate plane.

complex target: A target composed of more than one scatterer within a single radar resolution cell. A target may be both complex and distributed. *See also:* **distributed target**.

conformal array: An array antenna that is shaped to fit the surface of its host platform, such as an aircraft or missile.

conical scanning: A form of angular tracking in which the antenna beam is offset from the tracking axis of the antenna. Rotation of the beam about the axis generates a cone whose vertex angle is of the order of the beamwidth. Such scanning may be either rotating or nutating, according to whether the direction of polarization rotates or remains unchanged. The variation of signal amplitude as the beam scans provides information on the amount and direction of displacement of the target from the axis of rotation.

conical-scan-on-receive-only (COSRO): A method in which only the receiving beam is conically scanned for angle tracking.

conopulse: A tracking radar that uses two simultaneous squinted beams that are rotated around the antenna boresight to produce, on a time-shared basis, monopulse angle-error signals in two orthogonal coordinates

(such as azimuth and elevation). Note that (1) only two receivers are required rather than three as in the usual monopulse tracker; (2) also called *konopulse* and *scan with compensation.*

constant-false-alarm rate (CFAR) receiver: A radar receiver that maintains the output false-alarm rate constant in spite of the varying nature of the receiver noise level, echoes from the clutter environment, or from electronic countermeasures (ECM). CFAR is usually achieved by establishing a threshold level which varies according to the local noise and/or clutter environment measured in the near vicinity of the target echo.

continuous wave (CW) Doppler radar: A radar that transmits a CW signal and discriminates desired targets from other targets or clutter on the basis of the Doppler shift due to radial motion. *See also:* **CW radar; Doppler radar.**.

continuous wave (CW) radar: A radar that transmits a CW signal. *See also:* **continuous wave Doppler radar**.

corner reflector: Two (dihedral) or three (trihedral) orthogonal conducting surfaces, designed to return an incident electromagnetic wave toward its source. It is often used to provide a conspicuous radar target as a safety measure for a small sailboat, or to enhance the detectability of a radar target on which it is mounted or to calibrate a radar.

corporate feed: A feed structure for a phased array that has a signal path that divides repeatedly and provides equal path lengths from the source to each array element.

cosecant-squared pattern: A vertical-plane antenna pattern in which the transmitting and receiving power gains vary as the square of the cosecant of the elevation angle. The unique property of this pattern is that it results in the received echo signal being independent of range if

a) the target is of constant radar cross section,

b) moves at constant altitude,

c) the earth's surface can be considered flat.

See also: **modified cosecant-squared antenna pattern.**

Costas code: A frequency-hopping pulse compression waveform in which a long pulse is divided into *n* subpulses with the frequency of each subpulse chosen from *n* contiguous frequencies in a manner first suggested by John P. Costas.

NOTE—See Costas [B2].

crosseye jammer: A technique in which a jamming signal is radiated by two elements (or subarrays) fed in antiphase, giving a null on boresight and lobes of opposite phase either side of the null, to confuse a tracking radar.

crossover loss: For a tracker that uses an offset beam, such as a conical scan tracker, the reduction in signal-to-noise ratio for a target on the tracking axis relative to that for a target on the peak two-way antenna gain of the beam. The crossover loss factor is the ratio of the signal-to-noise ratio for a target on the peak two-way antenna gain to that for a target on the tracking axis. *See also*: **conical scanning.**

cross polarization electronic countermeasures (ECM): An ECM technique that transmits with a polarization orthogonal to the principal polarization of the victim radar. Since cross polarized antenna patterns are often much different from the normal, copolarized patterns, tracking might be disrupted. *See also*: **electronic countermeasures.**

cross section: Often used as a shortened form of radar cross section (RCS). To be avoided when there is a possibility of confusion with geometric cross section.

cumulative detection probability: The probability that a target is detected on at least one of *n* successive scans or detection opportunities of a surveillance radar.

CW Doppler radar: *See:* **continuous wave Doppler radar.**

CW radar: *See:* **continuous wave radar.**

decoy: A device (physical or electronic) deployed such that it is detected rather than or in addition to the intended target, the intent being to prevent identification of the true target.

defensive aids suite (DAS): A suite of techniques used to detect incoming threats and deploy countermeasures (electronic and physical) and/or take evasive maneuvers.

defruiter: Equipment that deletes random asynchronous unintentional returns in a beacon system. Commonly used in secondary surveillance radars. *See*: **fruit.**

depth of focus: In synthetic-aperture radar (SAR), the range interval over which the cross-range resolution is maintained without introducing or changing the focusing correction in signal processing.

designation: Selection of a particular target and transmission of its approximate coordinates from some external source to a radar. Usually to initiate tracking.

detectability factor: In pulsed radar, the ratio of single-pulse signal energy to noise plus interference power per unit bandwidth that provides stated probability of detection for a given false-alarm probability, measured in the intermediate-frequency (IF) amplifier bandwidth and using an IF filter matched to the single pulse and followed by optimum video integration.

detection: The process of determining the presence of a target.

detection probability: The probability that a signal, when actually present at the input to the receiver, will be correctly declared a target signal based on observation of the receiver output. *See also:* **false-alarm probability:**

Dicke fix: An electronic counter-countermeasures (ECCM) technique designed to counter impulsive jamming and some types of swept-frequency jamming. The usual configuration is a broadband intermediate-frequency (IF) amplifier followed by a limiter and then an IF amplifier of optimum bandwidth for the radar signal.

difference channel (monopulse radar): A receiving channel in which the response, as a function of a given radar coordinate, approximates the first derivative of the response of the main (sum) channel, to indicate the displacement of the target from the center of the main channel. The term was originally applied to monopulse radar, in which the difference between two offset beams or antenna phase centers was used to generate an error signal for tracking. In more modern radars the difference channel in angle can be generated by a feed network producing an aperture illumination function with odd symmetry. Similar channels in range and Doppler coordinates can be generated by suitable gates and filters.

difference pattern: The curve of antenna gain versus angle for the difference channel of a monopulse antenna. *See also*: **difference channel.**

difference slope: In a monopulse radar, the slope of the difference-pattern voltage (normalized with respect to the sum-pattern voltage) as a function of target angle from the tracking axis. The slope is usually specified at the point on the curve where the difference-pattern voltage is zero, which corresponds to the

tracking axis. In range and Doppler coordinates, it is the corresponding slope of the difference channel voltage normalized to that of the sum channel.

diffuse multipath: Propagation between radar and target for which one path is direct and the other(s) involve scattering from a rough surface or an atmospheric volume.

digital RF memory (DRFM): A digital memory that may be used as part of an electronic countermeasures (ECM) system, allowing a received radar signal to be captured, stored, and reradiated at arbitrary times, to generate false targets in a victim radar.

discrimination: Separation or identification of the differences between similar (but not identical) signals.

discriminator: A circuit in which the output is dependent upon how an input signal differs in some aspect from a standard or from another signal.

dish: A colloquial term for the reflecting surface of a paraboloidal-reflector antenna.

displaced phase center antenna (DPCA): An antenna and signal processing method used in airborne moving-target indication (AMTI) radar to compensate for the spread of the clutter Doppler spectrum caused by platform motion. An example of a popular DPCA method is to employ two squinted antenna beams, take their sum and their difference on each of two successive pulses, and combine them in such a manner that the radar antenna appears to be stationary from pulse to pulse (a stationary antenna does not cause widening of the clutter spectrum). *See also:* **airborne MTI radar; space-time adaptive processing.**

distributed target: A target composed of a number of scatterers, where the target extent in any dimension is greater than the radar resolution in that dimension. *See also:* **complex target.**

diversity gain: The reduction in predetection signal-to-interference energy ratio required to achieve a given level of performance, relative to that of a nondiversity radar, resulting from the use of diversity in frequency, polarization, space, or other characteristics.

Doppler beam sharpening (DBS): A form of squint-mode synthetic-aperture radar (SAR) employed in a sector-scanning air-to-ground radar. It usually has less resolution than a conventional SAR, since it employs a shorter processing (integration) time and varies this time as a function of beam squint angle so as to keep the resolution constant. Often displayed in near-real time on a plan-position indicator (PPI).

Doppler filter: A filter used in continuous wave (CW) radar, Moving-target indication (MTI), pulsed-Doppler radars, or a discrete Fourier transform (DFT) for the purpose of separating moving-target echo signals from stationary clutter echo signals; or to separate one moving target from another moving target due to a different Doppler frequency shift.

Doppler radar: A radar that utilizes the Doppler effect to determine the radial component of relative radar-target velocity or to select targets having particular radial velocities.

doubly spread targets: Target returns distributed in two dimension of the radar such as range and Doppler or range and cross range. This is typically expected in weather radar or in high-resolution radar for synthetic-aperture radar (SAR) or inverse SAR (ISAR). *See also*: **singly spread targets**.

DPCA: *See*: **displaced phase center antenna.**

ducting: Confinement of near-horizontally directed electromagnetic waves to a restricted horizontal layer in the atmosphere, resulting from a sufficiently steep negative vertical gradient of the atmospheric refractive index in a limited altitude region. The region of steep gradient is not necessarily identical to the dimensions of the duct. *Syn:* **superrefraction; trapping.**

duplexer: A device which allows a single antenna to be used on a time-shared basis for both transmitting and receiving.

duty cycle: The ratio of the active or ON time within a specified period to the duration of the specified period. For a pulsed radar, the ratio of transmitted pulse width to pulse-repetition interval. Duty cycle is also the ratio of the average RF power to the peak RF power over the specified period or duration.

duty factor: *See*: **duty cycle.**

dwell: A data acquisition interval during which the data is usually processed together for detection or measurement. The radar's parameters may be unchanged during the dwell, but often parameters such as the radar frequency, target range, and aspect angle change.

early-warning radar: Radar employed to search for distant enemy aircraft or missiles.

ECCM: *See*: **electronic counter-countermeasures.**

echo: The portion of energy of the radar signal that is reflected to a receiver.

echo box: A high-Q resonant cavity that stores part of the transmitted pulse power and feeds the resulting exponentially decaying power into the receiver after completion of the pulse transmission.

eclipsing: The loss of information on radar echoes at ranges when the receiver is blanked because of the occurrence of a transmitter pulse. Numerous such blankings can occur in pulse-Doppler radars having medium or high pulse-repetition frequencies. *See*: **blind range.**

ECM : *See*: **electronic countermeasures.**

effective echoing area: *See:* **radar cross section.**

effective radiated power (ERP): The radar power radiated in a specified direction. This is the power generated times the antenna gain in the specified direction, reduced by microwave and antenna losses. Often specified for a radar jammer in the direction of the intended jammed radar.

electromagnetic interference (EMI): Typically from external electronic devices or equipment operating and radiating in proximity to a radar receiver.

electromagnetic pulse (EMP): Typically associated with electronic countermeasures (ECM) in radar systems.

electronic counter-countermeasures (ECCM): Any electronic technique designed to make a radar less vulnerable to electronic countermeasures (ECM). *See also*: **electronic protection measures.**

electronic countermeasures (ECM): Any electronic technique designed to deny detection or accurate information to a radar. Screening with noise, confusion with false targets, and deception by affecting tracking circuits are typical ECM.

electronic scan: The process of pointing the radar beam by electronically adjusting the phases or time delays of the signals radiated by elements or portions of an array antenna.

electronic protection measures (EPM): *See*: **electronic counter-countermeasures (ECCM).**

electronic-warfare support measures (ESM): Actions taken to search for, intercept, locate in angle, record, and analyze radiated electromagnetic energy for the purpose of exploiting such radiations in support of military operations.

element: In a phased array, a portion of the array antenna that is controlled by a single phase shifter. *See also*: **phased array, subarray.**

elevation angle: In radar, the angle between the line-of-sight in the direction of interest and a horizontal reference plane, measured upwards.

energy ratio: The ratio of signal energy to noise power spectral density in the receiver, at a point where the noise factor has been established and prior to filtering, which would exclude components of the input signal. Also equals the maximum output signal-to-noise power ratio for a matched-filter system.

escort jamming: An electronic countermeasure (ECM) tactic wherein a jamming platform accompanies friendly vehicles; the radiation of noise or pulsed energy by the jammer in the frequency bands of hostile electronic systems to protect the friendly vehicles from hostile systems.

ESM: *See:* **electronic-warfare support measures.**

EW: Acronym for early warning; electronic warfare.

exponential reference atmosphere: A mathematical model of atmospheric refraction in which the refractivity is approximated by an exponential function of height:

$$N = N_s \exp(-c_e h)$$

where

N	is refractivity = $(n - 1) \times 10^6$
n	is atmospheric refractive index
N_s	is value of N at the surface
h	is height in km above the surface

NOTE—In Bean and Thayer [B1] the exponential coefficient c_e is given by:

$$c_e = -\ln\left[1 - \frac{7.32}{N_s}\exp\left(0.005577 N_s\right)\right]$$

The average value of N_s in the U.S. is 313, and the value for a "4/3 earth radius" is 301.

false alarm: An erroneous radar target detection decision caused by noise or other interfering signals exceeding the detection threshold.

false-alarm probability: The probability that noise or other interfering signals will erroneously cause a target detection decision. *See also:* **detection probability**.

false-alarm time: The average time between false alarms; that is, the average time between crossings of the target decision threshold by signals not representing targets.

NOTE—In the early work of Marcum [B9], false-alarm time is defined as the time in which the probability of one or more false alarms is one-half, but Marcum's definition is no longer commonly used.

fast-time-constant (FTC) circuit: A circuit with short time-constant (such as a differentiator or high-pass filter) used to emphasize signals of short duration and reduce the receiver response to signals from extended clutter, long-pulse jamming, or noise. It is a form of pulse width discriminator (PWD).

fence: (A) A line or network of early-warning radars. **(B)** The locus of the positions of a surveillance radar beam that describes the search area covered by space-based radar. *See also*: **clutter fence**.

field-of-view (FOV): The angular sector that may be viewed by a radar antenna.

filter bank (Doppler processing): A contiguous set of filters covering the Doppler frequency range of interest, used to separate moving targets. Commonly used in continuous wave (CW) and pulsed-Doppler radars and in the moving-target detector (MTD) for detecting moving targets in clutter.

filter mismatch loss: The loss in output signal-to-noise ratio of a filter relative to the signal-to-noise ratio from a matched filter. Filter mismatch loss is caused by using a filter whose response is not matched to the transmitted signal.

fire-control radar: A radar whose prime function is to provide information for the manual or automatic control of artillery or other weapons.

fluctuating target: A radar target whose echo amplitude varies as a function of time. *See also:* **target fluctuation**.

fluctuation: *See:* **target fluctuation**.

fluctuation loss: The change in radar delectability or measurement accuracy for a target of given average echo return power due to target fluctuation. It may be measured as the change in required average echo return power of a fluctuating target as compared to a target of constant echo return, to achieve the same detection probability or measurement accuracy. In detection, the fluctuation loss may be less than unity, represented by a negative dB value.

FM-CW radar: *See*: **frequency-modulated continuous wave radar**.

Foliage Penetration (FOPEN): The ability of a radar [usually an airborne synthetic-aperture radar (SAR)] to detect targets hidden under forest canopies. Such a radar will usually use relatively low frequencies (HF, VHF, or UHF) for which the attenuation of foliage is lower than at microwave frequencies.

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

fractional bandwidth: The fractional bandwidth of a device or a signal is

$$B_F = \frac{f_h - f_l}{\frac{1}{2}(f_h + f_l)} = \frac{B}{f_C}$$

where f_h and f_l are the highest and lowest frequencies beyond which the signal is at least 10 dB below the peak level, the bandwidth B is $f_h - f_l$, and the center frequency f_C is $(f_l + f_h)/2$.

NOTE—See IEEE Std 1672-2006 [B5].

frequency-agile radar: A pulse radar in which the transmitter carrier frequency is changed between pulses or between groups of pulses, usually by an amount comparable to or greater than the pulse bandwidth.

frequency diversity radar: A radar that operates at more than one frequency, using either parallel channels or sequential groups of pulses. Parallel channels may have complete duplicate transmitters and receivers, or may divide the transmitted pulse into subpulses at different frequencies, to which parallel receiver channels are tuned.

frequency-modulated continuous wave (FM-CW) radar: A radar transmitting a continuous carrier modulated by a periodic function such as a sinusoid or sawtooth wave to provide range data.

frequency-modulated (FM) ranging: A technique in which a continuous carrier is frequency modulated by a sinusoidal or triangular waveform, permitting the echo time delay to be measured as the phase shift of the sinusoid or the difference between transmitted and received frequencies.

frequency resolution: The ability of a receiver or signal processing system to detect or measure separately two or more signals that differ only in frequency. The classic measure of frequency resolution is the minimum frequency separation of two otherwise identical signals that permits the given system to distinguish that two frequencies are present and to extract the desired information from each of them. When the separation is done by means of a tunable bandpass filter system, the resolution is often specified as the width of the frequency-response lobe measured at a specific value (such as three decibels) below the peak response. *See also:* **angular resolution.**

frequency-scanned array: An antenna that generates phase differences in adjacent elements that are connected by lengths of signal path by changing the signal frequency.

fruit: "False Replies Unsynchronized In Time" or "False Replies Unsynchronized to Interrogator Transmission"; asynchronous interference on the display of a secondary surveillance radar**.**

FTC: *See:* **fast-time-constant circuit**.

full field-of-view (FFOV): A large FOV, typically ± 60º, produced by a phased array that has closely spaced radiating elements to avoid grating lobes.

fusion: The development of improved detection, tracking, and identification of targets through a combination of data from a number of sources. Sources can be similar (e.g., radars) or disparate (e.g., radars and optical systems).

gate: (A) An interval of time during which some portion of a circuit or display is allowed to be operative. **(B)** The circuit that provides gating.

gating: The application of enabling or inhibiting pulses during part of a cycle of equipment operation.

GCA: *See*: **ground-controlled approach radar**.

GCI: *See*: **ground-controlled intercept radar**.

GDOP: *See*: **geometric dilution of precision**.

geometric dilution of precision (GDOP): An increase in measurement errors in certain regions of coverage of a measurement system that combines several surface-of-position measurements, such as range only, angle only, or range difference (hyperbolic), to locate the object of interest. When two lines of position cross at a small acute angle, the measurement accuracy is reduced along the axis of the acute angle.

ghost target: An apparent target in a radar that does not correspond in position or frequency or both to any real target, but which results from distortion or misinterpretation by the radar circuitry of other real target signals that are present. It may result from range-Doppler ambiguities in the radar waveform used, from intermodulation distortion due to circuit amplitude nonlinearities, or from combining data from two antenna systems or waveforms.

glint: The inherent component of error in measurement of position and/or Doppler frequency of a complex target due to interference of the reflections from different elements of the target. Note that glint may have peak values beyond the target extent in the measured coordinate. *Contrast:* **scintillation error**.

GMTI: *See:* **ground moving-target indication.**

grass: A descriptive colloquialism referring to the appearance of noise on certain displays, such as an A-display. *See also*: **radar display**.

grating lobe: Radiation from a phased array in a specific undesired direction as a result of large element spacing and large scan angles.

ground clutter: Clutter resulting from the ground or objects on the ground. *Syn:* **ground return**.

ground-controlled approach (GCA) radar: A ground radar system providing information by which aircraft approaches to landing may be directed via radio communications. The system often consists of a precision-approach radar (PAR) and an airport-surveillance radar (ASR).

ground-controlled intercept (GCI) radar: A military radar system by which a controller on the ground may direct an aircraft to make an interception of another aircraft.

ground moving-target indication (GMTI): The application of **MTI** techniques to the detection of ground moving targets from an airborne radar, often using techniques such as displaced phase center antenna (DPCA) or space-time adaptive processing (STAP) to compensate for the effects of the moving radar platform. *See*: **moving-target indication (MTI)**.

ground range: Distance along the ground between the points directly beneath the radar and the target.

ground return: *Syn:* **ground clutter**.

guard channel: One or more auxiliary parallel processing channels to control the main processing channel in order to reject interference that is partly in, but not centered on, the main channel. Guard channels may be displaced in time (range), Doppler frequency, carrier frequency, or angle. Sometimes called *guard gates, guard bands,* or *sidelobe blanking* (not cancellation). Guard channel is used against range gate stealers, velocity gate stealers, sidelobe jamming (SLJ), and to enhance apparent angle resolution in identification friend or foe (IFF). May use auxiliary displays. *See also:* **sidelobe blanker**.

height-finding radar: A radar whose function is to measure the range and elevation angle to a target, thus permitting computation of altitude or height. Such a radar usually accompanies a surveillance radar that determines other target parameters. *See also:* **nodding beam height finder**; **three-dimensional radar**.

high-pulse-repetition-frequency (HPRF) waveform: A waveform whose pulse-repetition frequency (PRF) is high enough to have no Doppler ambiguities for a given maximum-speed target. *See also:* **low-pulse-repetition-frequency waveform; medium-pulse-repetition-frequency waveform**.

hit: A target echo from one single pulse.

IAGC: *See*: **instantaneous automatic gain control.**

identification (of a target): The knowledge that a particular radar return signal is from a specific target. This knowledge may be obtained by determining size, shape, timing, position, maneuvers, rate of change of any of these parameters, signal modulation characteristics, or by means of coded responses through secondary radar. Distinguished from *target classification,* in which only the type of target is determined (and which is often the intended meaning), and from *target recognition,* a more general term that encompasses identification and classification.

identification friend or foe (IFF): A cooperative target identification system to distinguish friendly targets from hostile ones, in which an interrogator transmits a coded signal that asks for a reply from a transponder carried by the target. *See also*: **secondary surveillance radar**.

illuminator: That part of a semiactive guidance missile weapon system that radiates electromagnetic waves in the direction of a designated target so that echo signals reflected from the illuminated target can be used by another sensor (the missile seeker) for purposes of homing.

imaging radar: A high-resolution radar whose output is a representation of the radar cross section (RCS) within the resolution cell (backscatter coefficient) from the object or scene resolved in two or three spatial dimensions. The radar may use real aperture [such as a sidelooking airborne radar (SLAR)], synthetic-aperture radar (SAR), inverse synthetic-aperture radar (ISAR), interferometric SAR, or tomographic techniques.

NOTE—See IEEE Std 1672-2006 [B5].

impulse radar: A radar whose transmitted pulse consists of one or a few cycles of carrier, usually generated by application of a short video pulse to a wideband RF amplifier (e.g., a TWT) or directly to a wideband antenna (e.g., a dipole).

in-phase video: One of a pair of coherent, bipolar video signals derived from the RF or IF signal by a pair of synchronous detectors with a 90° phase difference between the coherent oscillator (coho) reference inputs used for each. The in-phase component is often identified as *I* and the other of the pair as quadrature video, or *Q*. *See also:* **quadrature video**.

instantaneous automatic gain control (IAGC): (A) That part of a receiver system that automatically adjusts the gain of an amplifier within the time duration of each pulse so that a substantially constant output pulse peak amplitude is obtained when the input pulse peak amplitudes are varying, the adjustment being sufficiently fast to operate during the time a pulse is passing through the amplifier. **(B)** A quick-acting automatic gain control that responds to variations of mean clutter or jamming level over different range or angular regions, avoiding receiver saturation.

integration (of radar signals). The combination by addition (or the logical equivalent) of echo pulses or signal samples obtained by a radar as it illuminates a target so as to utilize the energy from more than one radar pulse or a longer radar dwell.

integration loss: The loss incurred by integrating a signal compared with perfect coherent integration.

intended polarization: The polarization of the radio wave for which the antenna system is designed.

intensity modulation: A process used in certain displays whereby the luminance of the signal indication is a function of the received signal strength.

interclutter visibility: The ability of a radar to detect moving targets that occur in resolution cells having low clutter between patches of strong clutter; usually applied to moving-target indication (MTI) or pulsed-Doppler radars. The higher the radar range and/or angle resolution, the better the interclutter visibility.

interferometer. An antenna and receiving system that determines the angle of arrival of a wave by phase comparison of the signals received at widely separated antennas. In radar, the angle measurement made by an interferometer is generally ambiguous, and means must be used to resolve the ambiguities.

interferometric synthetic-aperture radar (SAR): A configuration of SAR in which the phase difference is measured between corresponding resolution cells of images obtained from two antennas, separated either across-track or along track. In the case of across-track interferometry, the phase difference allows the height of the target in that resolution cell to be determined, giving a three-dimensional (3-D) version of the

image, and hence providing topographic maps or (at very high resolution) information on target shape. In the case of along-track interferometry, the phase difference allows the velocity of a moving target to be determined. *See also*: **airborne MTI radar; displaced phase center antenna; space-time adaptive processing.**

interrogation: In a transponder system, the signal or combination of signals intended to trigger a response.

interrogator: The transmitter of a secondary radar system.

interrogator-transponder. A combined interrogator and transponder.

inverse-synthetic-aperture radar (ISAR): An imaging radar in which cross-range resolution (angular resolution) of a target (such as a ship, aircraft, or other reflecting object) is obtained by a synthetic aperture formed by the rotation or translation of the target, as opposed to motion of the radar. Cross-range resolution of target whose exact angular motion is unknown (e.g. noncooperative targets such as ships at sea) is often achieved by resolving in the Doppler domain the different Doppler frequencies produced by echoes from the individual parts of the object. *See also*: **synthetic-aperture radar.**

ISAR: *See*: **inverse synthetic-aperture radar**.

jaffing: An electronic countermeasures (ECM) technique in which jamming by reflection from a chaff cloud is employed in order to exploit multipath effects, the result of which is to produce a distributed source of interfering energy at the radar receiver.

jamming: A form of electronic countermeasure (ECM) in which interfering signals are transmitted at frequencies in the receiving band of a radar for the purpose of obscuring the radar signal (as in *noise jamming*) or causing confusion in interpreting the radar signal (as in *repeater jamming*).

jam strobe: Indication of jammer azimuth bearing, one form being a marker on the radar plan-position indicator (PPI) display. It can also show the jammer signal strength and severity of main and sidelobe jamming (SLJ).

jet-engine modulation (JEM): Amplitude and/or frequency modulation of the radar echo from a jet-powered aircraft by motion of the compressor or turbine blades. These modulations may cause errors in measuring the Doppler frequency of the target, but they also provide information useful in noncooperative target recognition.

JDL STAP: *See*: **joint domain localized space-time adaptive processing.**

jitter: (A) Small, rapid variations in the size, shape, or position of observable information, frequently caused by mechanical and electronic switching systems or faulty components. It also refers to zero-mean random errors in successive target position measurements due to target echo characteristics, propagation, or receiver thermal noise. **(B)** Intentional variation of a radar parameter, for example, pulse interval.

joint domain localized space-time adaptive processing (JDL STAP): An architecture for multi-channel multi-pulse space-time adaptive processing (STAP) in which a transformation to the angle-Doppler domain is applied to the radar data prior to adaptive filtering, thus effectively decoupling space and time degrees of freedom from the number of channels in space and the number of pulses. The number of beams and Doppler resolution cells to be adaptively combined can be selected without regard to the number of channels in the phased array or the number of pulses in the coherent processing interval. One significant consequence of this approach is that significantly reduced degrees of freedom associated with selecting relatively few beams and Doppler resolution cells reduces the size of the sample covariance matrix and thus the number of independent and identically distributed training data required.

K_a-band: A radar-frequency band between 27 GHz and 40 GHz, usually in the International Telecommunication Union (ITU) allocated band 33.4 GHz to 36 GHz.

NOTE—See IEEE Std 521-2002 [B8].

K-band: A radar frequency band between 18 GHz and 27 GHz, usually in the International Telecommunication Union (ITU) allocated band 24.05 GHz to 24.25 GHz.

NOTE—See IEEE Std 521-2002 [B8].

keep-alive circuit: In a transmit-receive switch, a circuit for producing residual ionization for the purpose of reducing the initiation (breakdown) time of the main discharge .

K_u-band: A radar-frequency band between 12 GHz and 18 GHz, usually in one of the International Telecommunication Union (ITU) allocated bands 13.4 GHz to 14.4 GHz or 15.7 GHz to 17.7 GHz.

NOTE—See IEEE Std 521-2002 [B8].

LADAR: *See*: **laser radar.** *See also*: **LIDAR**.

laser radar: A radar whose carrier frequency is produced by a laser, usually in the infrared or visible light region. *See also*: **LADAR; LIDAR**.

L-band: A radar-frequency band between 1 GHz and 2 GHz, usually in the International Telecommunication union (ITU) allocated band 1.215 GHz to 1.4 GHz.

NOTE—See IEEE Std 521-2002 [B8].

leading-edge tracking: A radar range tracking technique in which the range error signal is based on the range delay of the leading edge of the received echo. This provides the ability to reject delayed interference, chaff, and more distant sources.

LIDAR: Acronym for laser radar: light detection and ranging.

limited field-of-view (LFOV): An FOV significantly smaller than ± 60º that is produced by a phased array with widely spaced radiating elements.

linear array: An antenna that uses radiating elements arranged in a straight line. This configuration supports scanning in one dimension when required.

lin-log receiver: A receiver having a linear amplitude response for small amplitude signals and a logarithmic response for large amplitude signals. A practical method for implementing a logarithmic receiver.

lobe switching: A means of direction finding in which a directive radiation pattern is periodically shifted in position so as to produce a variation of the signal at the target. The signal variation provides information on the amount and direction of displacement of the target from the pattern mean position. *Syn:* **sequential lobing.**

logarithmic receiver: A receiver whose output is proportional to the log of the input. Often used to prevent receiver saturation by large signals. Sometimes called *log receiver* or *logarithmic detector*. *See also*: **lin-log receiver; log-fast-time-constant receiver.**

log-fast-time-constant (FTC) receiver: A receiver whose video amplifier has a logarithmic input-output characteristic and which is followed by a high-pass filter, or FTC. Its purpose is to suppress distributed

clutter or to help achieve a constant-false-alarm rate (CFAR) for clutter whose statistics can be described by a Rayleigh distribution.

look: A colloquial expression for a single attempt at detection of a target.

low probability of intercept (LPI) radar: A radar using a coded waveform with low peak transmit power, so as to minimize the likelihood of interception by a hostile ESM system.

low-pulse-repetition-frequency (**LPRF) waveform**. A pulsed-radar waveform whose pulse-repetition frequency is such that targets of interest are unambiguously resolved with respect to range. *See also:* **high-pulse-repetition-frequency waveform; medium-pulse-repetition-frequency waveform**.

mainlobe jammer (MLJ): A radar jammer whose signal enters the radar through the antenna main beam.

matched filter: A filter that maximizes the output ratio of peak signal power to mean noise power. For white noise, it has a frequency response function that is the complex conjugate of the transmitted spectrum. Its impulse response is the time inverse of the transmitted waveform.

MDS: *See*: **minimum detectable signal**.

MDV: *See*: **minimum detectable velocity**.

medium-pulse-repetition-frequency (**MPRF) waveform**. A pulsed-radar waveform whose pulse-repetition frequency is such that targets of interest are ambiguous with respect to both range and Doppler shift. *See also:* **high-pulse-repetition-frequency waveform; low-pulse-repetition-frequency waveform.**

microwave plumbing: *See:* **plumbing**

millimeter-wave radar: A radar whose carrier frequency is from 30 GHz to 300 GHz (wavelength is 1 mm to 10 mm). This frequency range includes V, W, and part of Ka bands. The millimeter-wave bands allocated by the International Telecommunication Union (ITU) between 110 GHz and 300 GHz are 126 GHz to 142 GHz, 144 GHz to 149 GHz, 231 GHz to 235 GHz, and 238 GHz to 248 GHz.

NOTE—See IEEE Std 521-2002 [B8].

minimum detectable signal (MDS): The minimum signal level that gives reliable detection in the presence of white Gaussian noise. It must be described in terms of a probability of detection and a probability of false alarm, due to its statistical nature.

minimum detectable velocity (MDV): In a Doppler processing radar for detection of moving targets, the minimum target velocity that can be detected. *See*: **moving-target indication (MTI).**

minimum discernible signal: The minimum detectable signal (MDS) for a system using an operator and display or aural device for detection.

modified cosecant-squared antenna pattern: A cosecant-squared antenna pattern modified to obtain increased antenna gain at the higher elevation angles so as to provide larger echo signals from targets at high altitude and short range, which would normally be too weak to be detected when sensitivity time control (STC) is used along with the conventional cosecant-squared antenna pattern. Sometimes called a *thumb pattern.* Commonly used in two-dimensional (2-D) air-traffic control radars.

monopulse: A radar technique in which information concerning the angular location of a target is obtained by comparison of signals received in two or more simultaneous antenna beams. Note that (1) the simultaneity of the beams makes it possible to obtain a two-dimensional (2-D) angle estimate from a single pulse (hence the term *monopulse*), although multiple pulses are usually employed to improve the accuracy

of the estimate or to provide Doppler resolution; (2) the simultaneous lobe technique used in continuous wave (CW) radars is also referred to as *monopulse,* although pulses are not used.

monostatic radar: A radar system that transmits and receives through either a common antenna or through collocated antennas.

moving-target detector (MTD): A low-pulse-repetition-frequency (LPRF) pulsed-Doppler system usually characterized by employing a filter bank, adaptive thresholds, clutter map, and more than one coherent processing interval at different pulse-repetition frequencies (PRFs).

NOTE—See IEEE Std 1672-2006 [B5].

moving-target indication (MTI): A technique that enhances the detection and display of moving radar targets by suppressing fixed targets. Doppler processing is one method of implementation.

moving-target indication (MTI) improvement factor: The signal-to-clutter power ratio at the output of the clutter filter divided by the signal-to-clutter power ratio at the input of the clutter filter, averaged uniformly over all target radial velocities of interest. *Syn:* **clutter improvement factor.**

MTI: *See*: **moving-target indication**.

multifunction phased-array radar (MFR): A phased-array radar able to perform multiple tasks such as surveillance, tracking of multiple targets, and weapon designation.

multilateration: The location of an object by means of two or more range measurements from different reference points. It is a useful technique with radar because of the inherent accuracy of radar range measurement. The use of three reference points to obtain target location is known as *trilateration.*

multipath: The propagation of a wave from one point to another by more than one path. When multipath occurs in radar, it usually consists of a direct path and one or more indirect paths either by reflection from the surface of the earth or sea or from large man-made structures or refraction in a non-uniform atmosphere. At frequencies below approximately 40 MHz, it may also include more than one path through the ionosphere.

multipath error: The error in a radar-observed parameter caused by multipath.

multiple-time-around echo: *See:* **second-time-around echo**.

multistatic radar: A radar system having two or more transmitting or receiving antennas with all antennas separated by large distances when compared to the antenna sizes. *See also:* **bistatic radar.**

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

nodding-beam height finder: A height-finding radar with a fan beam oriented with its narrow beamwidth in elevation and which mechanically sector scans (nods) in elevation to locate the target and determine its elevation angle.

noncoherent moving-target indication (MTI): A form of MTI radar in which a moving target is detected by using the clutter echo as the reference signal. Note that (1) no internal reference signal is required; (2) sometimes called *externally coherent MTI.*

noncooperative target recognition (NCTR): *See:* **target recognition**.

north-stabilized plan-position indicator (PPI): A special case of azimuth-stabilized PPI in which the reference direction is north.

nutating feed: A technique of conical scanning in which the polarization remains unchanged.

observation time: The time interval over which a radar echo signal may be integrated for detection or measurement.

off-broadside: For a planar or linear array, a direction other than normal to the array surface. For planar arrays, the off-broadside direction is usually measured in two orthogonal coordinates. *See also*: **broadside.**

offset plan-position indicator (PPI): A PPI that has the zero position of the time base at a point other than the center of the display, thus providing the equivalent of a larger display for a selected portion of the coverage area. *Syn:* **off-center plan-position indicator.**

open-center plan-position indicator (PPI): A PPI in which the display of the initiation of the time base precedes that of the transmitted pulse.

operator loss: A loss in effective signal-to-noise ratio manifested by reduced detection probability or increased false-alarm rate when detection is performed by a human operator rather than an ideal thresholding device.

OTH: *See*: **over-the-horizon radar.**

over-resolved target detection: Target detection techniques designed to optimally or practically detect singly spread or doubly spread targets.

over-the-horizon (OTH) radar: Radar using sufficiently low carrier frequencies, usually in the HF band typically from about 5 MHz to 30 MHz, so that ionospherically refracted sky-wave propagation can allow detection at ranges (nominally from perhaps 1000 km to 4000 km) far beyond the ranges allowed by line-of-sight propagation. At HF, the surface wave, or ground wave, mode of propagation can allow detection of low-altitude targets at ranges from perhaps 40 km to 200 km, depending on the size of the target and the radar.

PAR: *See*: **precision-approach radar**. Sometimes used for perimeter acquisition radar.

passive angle tracking (PAT): A tracking technique that uses a received signal other than the backscattered radar emissions with which to track an object, jammer, or other signal source. Passive homing, home-on-jam (HOJ), and track-on-jam (TOJ) are examples of PAT using a radar receiving system.

passive bistatic radar: A set of techniques using broadcast, communications, radar, or radio-navigation signals as illumination sources rather than using a dedicated radar transmitter. Other terms that have been used include *passive coherent location (PCL), passive and covert radar (PCR), covert radar*, *noncooperative radar*, *broadcast radar*, *parasitic radar,* and *opportunistic radar*.

pattern-propagation factor: Ratio of the field strength that is actually present at a point in space to that which would have been present if free-space propagation had occurred with the antenna beam directed toward the point in question. This factor is used in the radar equation to modify the strength of the transmitted or received signal to account for the effect of multipath propagation, diffraction, refraction, and pattern of an antenna.

P-band: A letter-band designation no longer applicable and which should not be used. Originally it denoted frequencies in the vicinity of 230 MHz, which are no longer allowed for radar usage. Later it was sometimes applied to denote the 420 MHz to 450 MHz International Telecommunication Union (ITU) allocated radiolocation band which is now part of the UHF band.

NOTE—See IEEE Std 521-2002 [B8] for UHF band specifications.

pencil beam: Antenna beam with a narrow radiation lobe with approximately equal azimuth and elevation beamwidths.

permanent echo: A signal reflected from an object fixed with respect to the radar site.

phase-comparison monopulse: A form of monopulse employing receiving beams with different phase centers as obtained, for example, from side-by-side antennas or separate portions of an array. The information on target displacement from the antenna axis appears as a relative phase between signals received at the two phase centers. *See also:* **amplitude-comparison monopulse; monopulse.**

phased array: An antenna consisting of a number of radiating elements having signals that may be independently controlled in phase and sometimes amplitude to form a beam in a desired direction.

phase shifter: A device that adjusts the phase difference between its input and output. The phase control may be affected by an electronic signal in electronically scanned arrays.

planar array: An array antenna distributed over a planar surface. Planar arrays may scan the beam in two angular coordinates.

plan-position indicator (PPI): A type of radar display format.

plumbing: A colloquial expression for pipe-like waveguide circuit elements and transmission lines. *Syn:* **microwave plumbing**.

polyphase code: A pulse compression waveform in which a long pulse is subdivided into many subpulses and the phase of each subpulse is chosen with a quantization less than π radians. The Frank polyphase code is an example in which the phases are selected so as to obtain a discrete version of the continuous analog linear frequency modulation waveform.

PPI: *See*: **plan-position indicator**.

precipitation clutter: Echoes from rain, snow, hail, sleet, and other hydrometeorological particles.

precision-approach radar (PAR): A radar system located on an airfield for observation of the position of an aircraft with respect to an approach path and specifically intended to provide guidance via radio communications to the aircraft during the approach.

PRF: *See*: **pulse-repetition frequency**.

PRI: *See*: **pulse-repetition interval**.

primary surveillance radar: A radar system in which the return signals are the echoes obtained by reflection from the target. Since this is the normal method of radar operation, the word *primary* is omitted unless necessary to distinguish it from *secondary. See also:* **secondary surveillance radar**.

pulse burst: A sequence of closely spaced pulses. Pulse bursts are usually generated coherently and batch-processed for Doppler resolution, and often have a total burst duration much less than the radar echo delay time.

pulse compression: A method for obtaining the resolution of a short pulse with the energy of a long pulse of width T by internally modulating the phase or frequency of a long pulse so as to increase its bandwidth $B >> 1/T$, and using a matched filter (also called a *pulse compression filter*) on reception to compress the pulse of width T to a width of approximately $1/B$. Used to obtain high range resolution when peak-power limited. *See also*: **chirp; coded-pulse; Costas code.**

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

pulsed-Doppler radar: A Doppler radar that uses pulsed transmissions. The radar transmits *N* coherent pulses within a coherent processing interval (CPI) and usually forms *N* Doppler filters using an FFT. Many radars will transmit several CPIs in a given direction to minimize blind ranges and Dopplers and/or to resolve ambiguities. *Syn:* **pulse-Doppler radar**.

pulse-Doppler radar: *See:* **pulsed-Doppler radar**.

pulse duration: *See:* **pulse width**.

pulse-forming line: A passive electric circuit in a radar modulator whose propagation delay determines the length of the modulation pulse.

pulse-repetition frequency (PRF). The number of pulses per unit of time, usually per second, to express the value in Hertz. *Syn:* **pulse-repetition rate**.

pulse-repetition frequency (PRF) stagger: The technique of varying the time between pulses of a pulse radar. This is useful in compensating for blind speeds in pulsed moving-target indication (MTI) radar. *See also*: **staggered-repetition-interval waveform.**

pulse-repetition interval (PRI): The time duration between successive pulses. PRI is the reciprocal of the pulse-repetition frequency (PRF). *Syn:* **pulse-repetition period**.

pulse-repetition period: *See:* **pulse-repetition interval**.

pulse-repetition rate: *See:* **pulse-repetition frequency**.

pulse train: A sequence of pulses at the pulse-repetition frequency (PRF) used to accomplish a function such as moving-target indication (MTI) or increased effective signal-to-noise ratio. A pulse train of duration less than the radar echo delay time is usually referred to as a *pulse burst. See also*: **pulse burst**.

pulse width: The time interval between the points on the leading and trailing edges at which the instantaneous value bears a specified relation to the maximum instantaneous value of the pulse, usually the time interval between the half-power points of the pulse. *Syn:* **pulse duration**.

pulse width discriminator (PWD). A device that passes only those video pulses whose duration falls within specified limits.

Q-channel: *See:* **quadrature video**.

quadrature video: One of a pair of coherent, bipolar video signals derived from the RF or IF signal by a pair of synchronous detectors with a 90° phase difference between the coherent oscillator (coho) reference inputs used for each. The quadrature component is often identified as *Q* and the other of the pair is in-phase video or *I*. *See also*: **in-phase video**. *Syn:* **Q-channel**.

quantization error: *See:* **quantizing error**.

quantizing error: An error caused by conversion of an analog variable having a continuous range of values to a quantized form having only discrete values, as in analog-to-digital conversion. The error is the difference between the original (analog) value and its quantized (digital) representation. *Syn:* **quantization error**.

quantizing loss: (A) In phased arrays, a loss in peak gain that occurs when the beam is phase steered by digitally controlled phase shifters, due to the quantizing errors in the phase shifts applied to the various

radiating elements. **(B)** In signal processing, a loss that occurs when elements of a composite signal (for example, complex amplitudes of pulses in a pulse train) are quantized (digitized) before being combined. *See also:* **quantizing error**.

radar: An electromagnetic system for the detection and location of objects that operates by transmitting electromagnetic signals, receiving echoes from objects (targets) within its volume of coverage, and extracting location and other information from the echo signal. Note that (1) radar is an acronym for radio detection and ranging; (2) radar equipment can be operated with the transmitter turned off, as a passive direction finder on sources radiating within the band of the receiving system. *See also*: **passive angle tracking; passive bistatic radar**.

radar-absorbent material (RAM): Material used to reduce the radar cross section (RCS) of an object. Also used in anechoic chambers to reduce reflection from the walls.

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

radar altimeter: *See:* **radio altimeter**.

radar beacon: A transponder used for replying to interrogations from a radar. *See also:* **secondary radar**.

radar cross section (RCS): A measure of the reflective strength of a radar target; usually represented by the symbol σ and measured in square meters. RCS is defined as 4π times the ratio of the power per unit solid angle scattered in a specified direction to the power per unit area in a plane wave incident on the scatterer from a specified direction. More precisely, it is the limit of that ratio as the distance from the scatterer to the point where the scattered power is measured approaches infinity. Three cases are distinguished:

a) Monostatic or backscatter RCS when the incident and reflected scattering directions are coincident but opposite in sense,

b) Forward-scatter RCS: Energy reflected or scattered in the same direction as the incident wave,

c) Bistatic RCS: Energy reflected or scattered in any direction other than the incident direction or opposite of the incident direction.

If not identified, RCS is usually understood to refer to case a). In all three cases, RCS of a specified target is a function of frequency, transmitting and receiving polarizations, and target aspect angle (except for a sphere). For some applications, e.g., statistical detection analyses, it is described by its average value (or sometimes its median value) and statistical characteristics over an appropriate range of one or more of those parameters. *Syn*: **backscatter cross section; bistatic-scatter cross section; effective echoing area; forward-scatter cross section**.

NOTE—See also IEEE Std 1672-2006 [B5] and IEEE Std 1502™-2007 [B4].

radar display: The visual representation of radar output data. See individual definitions and illustrations of various radar display formats in Table 1. The letter designations from A to P, plus R, for radar display formats were devised in the years during and following World War II in an effort to standardize nomenclature. Several of these letter designations are now rarely if ever used, as noted in the individual definitions, but they are still found in some technical literature. These displays are also referred to as *scopes,* as in A-scope, etc. The additional designations of plan-position indication (PPI) and range-height indication (RHI) are also defined. The standardized type designations do not cover all possible display formats.

Table 1—Radar displays

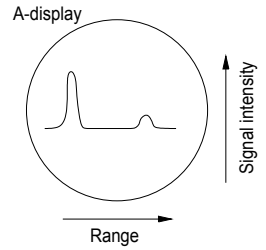
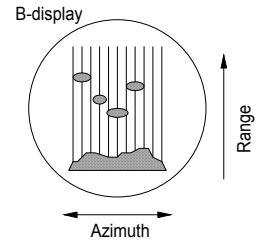
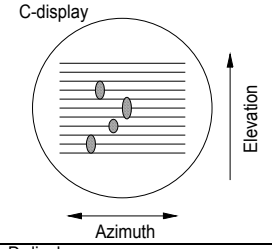
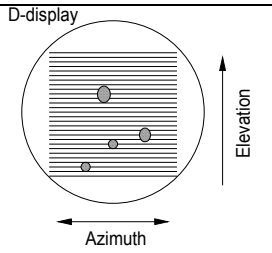
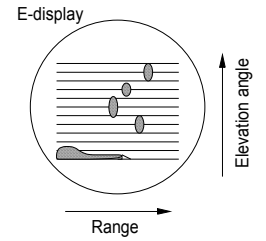
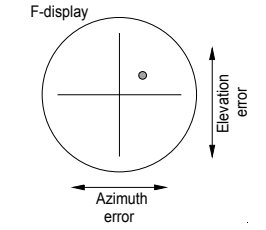
A-display	A display in which targets appear as vertical deflections from a horizontal line representing a time base. Time delay, or target range is indicated by the horizontal position of the deflection from one end of the time base. The vertical deflection is a function of signal amplitude.	
B-display	A rectangular display in which each target appears as an intensity-modulated blip, with azimuth indicated by the horizontal coordinate and range by the vertical coordinate.	
C-display	A rectangular display in which each target appears as an intensity-modulated blip with azimuth indicated by the horizontal coordinate and angle of elevation by the vertical coordinate.	
D-display [b]	(Deprecated or rare) Similar to a C-display, but composed of a series of horizontal stripes representing successive elevation angles. Each stripe is a miniature B-display with compressed vertical scale. Horizontal position of a blip represents azimuth, the gross vertical scale (the stripe in which the blip appears) represents elevation, and vertical position within the stripe represents range.	
E-display:	A rectangular display in which targets appear as intensity-modulated blips with range indicated by the horizontal coordinate and elevation angle by the vertical coordinate. The term "E-display" has also been applied to a display in which height or altitude is the vertical coordinate; but this usage is deprecated because of ambiguity. The preferred term for such a display is *range-height indication* (RHI).	
F-display	A rectangular display in which a target appears as a centralized blip when the radar antenna is aimed at it. Horizontal and vertical aiming errors are respectively indicated by horizontal and vertical displacement of the blip.	

Table 1—Radar displays *(continued)*

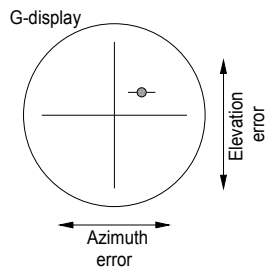
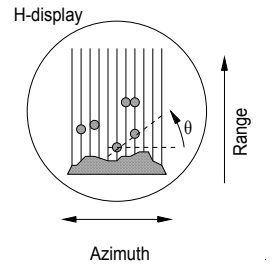
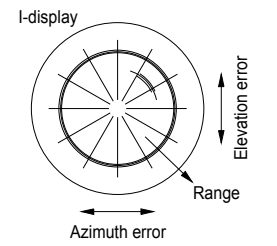
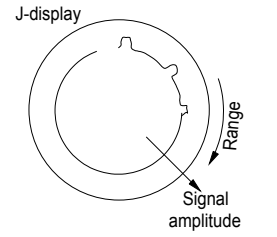
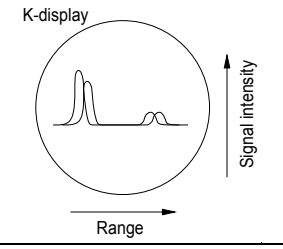
G-display [b]	(Rare) A modified F-display in which wings appear to grow on the blip, the width of the wings being inversely proportional to target range.	
H-display [b]	(Deprecated or rare) A B-display modified to include an indication of angle of elevation. The target appears as two closely spaced blips approximating a short bright line, the slope of which is in proportion to the tangent of the angle of target elevation.	
I-display [b]	(Rare) A display used in a conical-scan radar, in which a target appears as a complete circle when the radar antenna is pointed at it and in which the radius of the circle is proportional to target range. The incorrect aiming of the antenna changes the circle to a segment whose arc length is inversely proportional to the magnitude of the pointing error and the position of the segment indicates the direction in which the antenna should be moved to restore correct aiming.	
J-display	A modified A-display in which the time base is a circle and targets appear as radial deflections from the time base.	
K-display [b]	(Rare) A modified A-display used with a lobe-switching antenna, in which a target appears as a pair of vertical deflections. When the radar antenna is correctly pointed at the target, the deflections (blips) are of equal height, and when not so pointed, the difference in blip height is an indication of the direction and magnitude of pointing error.	

Table 1—Radar displays *(continued)*

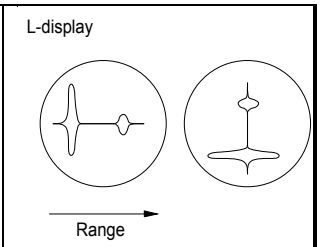
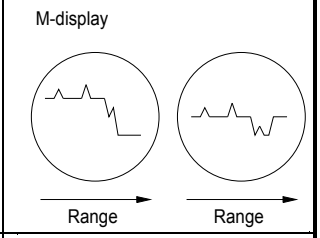
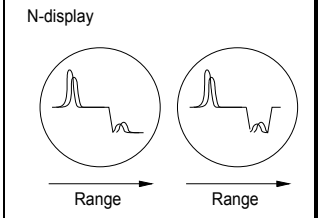
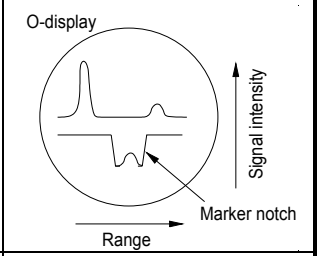
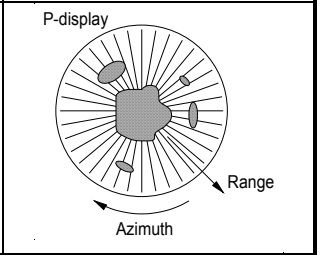
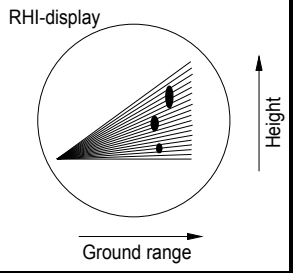
L-display	Deflections are of equal amplitude when the radar antenna is pointed directly at the target, any inequality representing relative pointing error. The time base (range scale) can be vertical, as in the L-display illustration, or horizontal. The L-display is sometimes known as a bearing-deviation indicator.	
M-display [b]	A type of A-display in which one target range is determined by moving an adjustable pedestal, notch, or step along the baseline until it coincides with the horizontal position of the target-signal deflection; the control that moves the pedestal is calibrated in range. The use of the term "M-display" is uncommon. This display is usually identified as a variant of an A-display.	
N-display [b]	(Rare) A K-display having an adjustable pedestal, notch, or step, as in the M-display, for the measurement of range. This display is usually regarded as a variant of an A-display or a K-display rather than as a separate type.	
O-display [a]	(Deprecated) An A-display modified by the inclusion of an adjustable notch for measuring range.	
P-display [a]	(Deprecated) A name for the type of display commonly known as plan-position indication (PPI).	
Plan-position indicator (PPI)	A display in which target echoes [blips] are shown in plan position, thus forming a map-like display, with radial distance from the center representing range and with the angle of the radius vector representing azimuth angle.	

Table 1—Radar displays *(continued)*

R-display	An A-display with a segment of the time base expanded near the blip for greater precision in range measurement and visibility of pulse shape. Usually regarded as an optional feature of an A-display rather than being identified by the term "R-display."	
Range-height indicator (RHI)	An intensity-modulated display in which horizontal and vertical distances of a blip from an origin in the lower-left part of the display represent target ground range and target height, respectively. The display is generated by successive range weeps starting at the origin and inclined at an angle that varies progressively in accordance with the elevation scan of the radar antenna at a selected azimuth. The height scale of the display is usually expanded relative to the range scale.	

[a]Deprecated.
[b]Rare.

radar equation: A mathematical expression that relates the range of a radar at which specific performance is obtained to the parameters characterizing the radar, target, and environment. The parameters in the radar equation can include the transmitter power, antenna gain and effective area, frequency, radar cross section (RCS) of the target, range to the target, receiver noise figure, signal-to-noise ratio required for detection, losses in the radar system, and the effects of the propagation path. *Syn:* **radar range equation**, **range equation**.

radar performance figure: The ratio of the pulse power of the radar transmitter to the power of the minimum signal detectable by the receiver. Now seldom used as a measure of performance.

radar range equation: *See:* **radar equation**.

radar relay: Equipment for relaying the radar video and appropriate synchronizing signals to a remote location.

radar shadow: Absence of radar illumination because of an intervening reflecting, diffracting, or absorbing object. The shadow is manifested on the display by the absence of blips from targets in the shadow area.

radiating element: *See*: **element**.

radio altimeter: An altimeter using radar principles for height measurement; height is determined by measurement of propagation time of a radio signal transmitted from the vehicle and reflected back to the vehicle from the terrain below. *Syn:* **radar altimeter**.

rain clutter. Radar echoes from rain that impair or obscure the echoes from desired targets. *See also*: **precipitation clutter**.

range: Distance between a radar and a target.

range curvature: A term applied to a number of signal and image effects [for a synthetic-aperture radar (SAR)] that are due to the spherical nature of RF wave fronts. These effects include quadratic phase used to synthesize an aperture, range walk, and image keystone distortions for spotlight SAR systems.

range equation: *See*: **radar equation**.

range-height indicator (RHI): A type of radar display format. *See also*: **radar display**.

range mark: A calibration marker used on a display to aid in measuring target range. *Syn:* **range marker**.

range marker: *See:* **range mark**.

range noise: The noise-like variation in the apparent distance of a target, caused by changes in phase and amplitude of the target-scattering sources, and including radial components of glint and scintillation error.

range offset processing: Synthetic-aperture processing in which the spectrum is translated from intermediate frequency (IF) to a carrier offset from zero frequency by approximately half the IF bandwidth. *See also:* **synthetic-aperture radar**.

range resolution: The ability to distinguish between two targets solely by the observation of their ranges; usually expressed in terms of the minimum range separation at which two targets at the same azimuth and elevation angles can be distinguished and (in the case of Doppler processing) in the same Doppler filter 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 it may be necessary to specify the separation at two or more power ratios where resolution of targets of different powers is important.

range walk: The migration of a point scatterer from range cell to range cell during the signal integration period. Can occur in synthetic-aperture radar; typically caused by range curvature and/or target rotational or radar line-of-sight translational motion. This also can occur in a very high resolution radar if the relative range rate between the target and the radar is high, relative to the ratio of the range cell to the integration period.

raster scan: A method of sweeping the electron beam of a cathode-ray tube screen or an antenna beam that is characterized by more than one sweep either from side to side or from top to bottom.

RCS: *See*: **radar cross section**.

receiver gating: The application of enabling or inhibiting pulses to one or more stages of a receiver only during the part of a cycle of operation when reception is either desired or undesired, respectively. *See also:* **gating**.

receiver operating characteristic (ROC) curves. Plots of probability of detection versus probability of false alarm for various input signal-to-noise power ratios and detection threshold settings.

refraction error: Error in angle and/or range due to the bending of one or more wave paths by changes in the refractive index of the propagation medium.

resolution cell: The one-dimensional or multidimensional region related to the ability of a radar to resolve multiple targets. The dimensions that involve resolution can include range, angle, and radial velocity (Doppler frequency). The three-dimensional (3-D) spatial resolution cell is, for example:

$$\theta_a \times \theta_e \times (c\tau/2)$$

where

θ_a is azimuth beamwidth
θ_e is elevation beamwidth
τ is pulse width
c is velocity of propagation of electromagnetic waves

Syn: **resolution element.**

resolution element: *See:* **resolution cell.**

resource management: The optimal ordering and control of the different tasks of a multifunction phased-array radar (MFR) so that the tasks are performed according to priority to control usage and stay within bounds of such resources as radar power, timeline and processing. *See also*: **multifunction phased-array radar.**

RF tomography: A multistatic radar system concept in which widely spaced transmitters and receivers are used to detect and image targets internal to the volume or area bounded by the transmitters and receivers.

RHI: *See*: **range-height indicator.**

ring-around: (A) The undesired triggering of a transponder or repeater by its own transmitter. **(B)** The ring-type (constant-radius echo) presentation on a plan-position indicator (PPI) display that occurs from a very large radar cross-section (RCS) target when the radar has high azimuth sidelobes.

ROC curves: *See*: **receiver operating characteristic curves.**

sampling gate: A device that extracts information from the input wave only when activated by a selector pulse or sampling pulse.

SAR: *See*: **synthetic-aperture radar.**

S-band: A radar-frequency band between 2 GHz and 4 GHz, usually in one of the International Telecommunication Union (ITU) allocated bands 2.3 GHz to 2.5 GHz or 2.7 GHz to 3.7 GHz.

NOTE—See IEEE Std 521-2002 [B8].

scanning: A programmed motion given to the main beam of an antenna for the purpose of searching a larger angular region than can be covered with a single position of the beam, or for measuring the angular location of a target; also, the analogous process using range gates or some frequency-domain filters.

scanning loss: (A) In a radar using a continuously scanning beam, the reduction in sensitivity due to motion of the beam between transmission and reception of the signal (sometimes called transit-time loss). **(B)** In an electronic scanning radar, the reduction in signal power due to scanning of the beam from broadside (the direction normal to the array face). *Contrast:* **beamshape loss.**

scintillation: Random variations in the received signal from a complex target that can occur due to changes in aspect angle or other causes. Because this term has been applied variously to target fluctuation and scintillation error, use of one of these more specific terms is recommended to avoid ambiguity.

scintillation error: Error in radar-derived target position or Doppler frequency caused by interaction of the scintillation spectrum with frequencies used in sequential measurement techniques. *Contrast:* **glint.**

scope: The face of a cathode-ray tube or a display of similar appearance. The term *scope* is a colloquial abbreviation of the word *oscilloscope.*

searchlighting: The process of projecting a radar beam continuously at a particular object or in a particular direction as contrasted to scanning.

search radar: A radar used primarily for the initial detection of targets in a particular volume of interest.

sea return: The radar response from the sea surface. *See also*: **sea clutter spikes.**

sea clutter spikes: Localized areas of high amplitude, usually of relatively short duration, observed in backscatter from the sea surface. There are many different electromagnetic scattering mechanisms that result in what may be broadly terms *spikes,* including Bragg scattering (from wind-driven resonant capillary waves), breaking waves (whitecaps), and burst (specular) scattering from the crest of waves, just before they break.

secondary surveillance radar: A cooperative target identification system such as the military identification friend or foe (IFF) Mark XII or the civil air traffic control radar beacon system (ATCRBS) in which an interrogator transmits a coded signal that asks for a reply. The transponder on the vehicle or platform queried answers with a coded reply. Note that (1) the term *secondary radar* is more widely used in Europe than in the U.S.; (2) the interrogator antenna is often mounted on the radar antenna and the reply from the transponder is often included on the radar display with the echo detection. *See also*: **primary surveillance radar.**

second-time-around echo: An echo received after a time delay exceeding one pulse-repetition interval (PRI) but less than two pulse-repetition intervals. Third-time-around, etc., echoes are defined in a corresponding manner. The generic term *multiple-time-around* is sometimes used.

sector display: A limited display in which only a sector of the total service area of the radar system is shown.. Usually the sector to be displayed is selectable.

sector scanning: The repeated scanning of a limited volumetric sector by a radar. *See also*: **sector display.**

self-screening jamming: An electronic countermeasures (ECM) tactic wherein a vehicle carries jammers or off-board launching systems, which radiate noise or pulsed energy in the frequency bands of hostile electronic systems as self-protection.

self-screening range: Range at which a specified target carrying its own specified active jamming [electronic countermeasures (ECM)] can be detected by a specified radar with specified probabilities of detection and false alarm. *Syn:* **burn-through range.**

semiactive guidance: A bistatic-radar homing system in which a receiver in the guided vehicle derives guidance information from electromagnetic signals scattered from a target that is illuminated by a transmitter at a third location. *See also*: **illuminator.**

sensitivity time control (STC): Programmed variation of the gain (sensitivity) of a radar receiver as a function of time within each pulse-repetition interval (PRI) or observation time in order to prevent overloading of the receiver by strong echoes from targets or clutter at close ranges. Also called *swept gain,* especially in British usage.

sequential lobing: *See:* **lobe switching.**

sidelobe blanker: A device that employs an auxiliary wide-angle antenna and receiver to sense whether a received pulse originates in the sidelobe region of the main antenna and if so to gate it from the output signal.

sidelobe canceler: A device that employs one or more auxiliary antennas and receivers to allow linear subtraction of interfering signals from the desired output if they are sensed to originate in the sidelobes of the main antenna.

sidelobe jamming (SLJ): Radar jamming whose signal enters the victim radar through an antenna sidelobe.

sidelooking airborne radar (SLAR): A high-resolution (in both range and angle) airborne imaging radar, without synthetic-aperture radar (SAR) processing, directed sidelooking (perpendicular to the line of flight) using large, narrow-beamwidth antennas.

sidelooking radar: A ground mapping radar used aboard aircraft involving the use of a fixed antenna beam pointing out the side of an aircraft either abeam or squinted with respect to the aircraft axis. The beam is usually a vertically oriented fan beam having a narrow azimuth width. The narrow azimuth resolution can either be obtained with a long aperture mounted along the axis of the aircraft [sidelooking airborne radar (SLAR)] or by the use of synthetic-aperture radar (SAR) processing.

signal-to-clutter ratio: The ratio of target echo power to the power received from clutter sources lying within the same resolution element.

signal-to-noise ratio: In radar, the ratio of the power corresponding to a specified target measured at some point in the receiver to the noise power at the same point in the absence of the received signal.

silent lobing: A method for scanning an antenna beam to achieve angle tracking without revealing the scanning pattern on the transmitted signal.

simple target: A target that can be represented by only one major scattering center so that its radar cross section (RCS) is relatively insensitive to viewing aspect over small angular displacements. Examples are a sphere or an object shorter than a half wavelength. Also called a *point target.*

single-scan probability of detection: *See:* **blip-scan ratio.**

singly spread targets: Target returns distributed in one dimension of the radar such as range or Doppler. *See also*: **doubly spread targets.**

slant distance: The distance between two points which are not at the same elevation. Used in contrast to *ground distance.*

slant range: The slant distance between a radar and a target.

SLAR: *See*: **sidelooking airborne radar.**

space feed: A phased-array antenna where the source signal reaches the radiation elements by way of a space path.

space-time adaptive processing (STAP): In airborne moving-target indication (MTI), a method of processing that compensates for the adverse effects of platform motion by adaptively placing antenna nulls in the directions of large clutter echoes and/or large noise or jamming sources. It simultaneously employs the signals received from the multiple elements of an adaptive phased-array antenna (spatial domain) and the signals from multiple pulse-repetition periods (time domain) to provide adaptive processing in both the time and spatial domains.

speckle: A mottled effect in coherent radar images, such as those from synthetic-aperture radar (SAR) and laser radar caused by random additive and subtractive interference of signals from individual scatterers within each resolution cell. This is the same as target fluctuation for isolated targets.

split-gate tracker: A form of range tracker using a pair of time gates called an *early gate* and a *late gate,* contiguous or partly overlapping in time. When tracking is established, the pair of gates straddles the received pulse that is being tracked. The position of the pair of gates then gives a measure of the time of arrival of the pulse (i.e., the range of the target from which the echo is received). Deviation of the pair of gates from the proper tracking position increases the signal energy in one gate and decreases it in the other, thus producing an error signal that moves the pair of gates so as to reestablish equilibrium.

spotlight synthetic-aperture radar (SAR): A form of SAR in which very high along-track resolution is obtained by steering the real antenna beam to dwell longer on a scene or target than allowed by a fixed antenna.

squeezable waveguide: A variable-width waveguide for shifting the phase of the radio-frequency wave traveling through it by mechanically squeezing the dimensions of a rectangular waveguide.

squint: (A) The angle between the major lobe axis of each lobe and the central axis in a lobe-switching or simultaneous-lobing (monopulse) antenna. **(B)** The angular difference between the axis of antenna radiation and a selected geometric axis, such as the axis of the reflector, the center of the cone formed by movement of the radiation axis, or the broadside direction of a moving vehicle.

squint-mode synthetic-aperture radar (SAR): A SAR in which the beam is pointed other than at right angles to the flight path of the airborne radar platform.

squitter: Random output pulses from a transponder caused by ambient noise or by an intentional random triggering system, but not by the interrogation pulses.

stacked-beam radar: A radar that forms two or more simultaneous receive beams at the same azimuth but at different elevation angles. The beams are usually contiguous or partly overlapping. Each stacked beam feeds an independent receiver channel. The transmit elevation beamwidth is large enough to cover the elevation of the stacked beams.

staggered-repetition-interval waveform: A waveform in which the pulse-repetition interval (PRI) changes from pulse to pulse, to fill blind speeds or to distinguish echoes having ambiguous range or Doppler shifts. This is contrasted with changing PRI from scan to scan or from one group of pulses to another, which can be described as multiple-PRI or PRI-diversity waveforms. *See*: **pulse-repetition-frequency (PRF) stagger.**

stalo (STALO): Acronym for stable local oscillator, a highly stable radio-frequency local oscillator used for heterodyning signals to produce an intermediate frequency (IF).

stand-in jamming: A support electronic countermeasures (ECM) tactic wherein the jamming platform is placed within the lethal ranges of hostile weapon-control systems, is the radiation of noise or pulsed energy in the frequency bands of such hostile systems and radiates to protect friendly forces from hostile fire.

stand-off jamming: A support electronic countermeasures (ECM) tactic that is conducted outside the lethal ranges of hostile weapon-control systems, where noise or pulsed energy is radiated in the frequency bands of such hostile systems, to protect friendly forces from hostile fire.

STAP*: See*: **space-time adaptive processing.**

STC: *See*: **sensitivity time control.**

stepped frequency: A radar system that steps the transmission frequency on successive pulses by anything up to its instantaneous bandwidth, usually for the purposes of synthesizing wide bandwidths over a pulse train and therefore high range resolution.

subarray: A group of elements in a phased array that are controlled together. Subarrays often use a common time delay, to compensate for the time of signal arrival at the subarray relative to other subarrays. *See also:* **element, phased array.**

subclutter visibility: The ratio by which the target echo power may be weaker than the coincident clutter echo power and still be detected with specified detection and false-alarm probabilities. Target and clutter powers are measured on a single pulse return, and all target radial velocities are assumed equally likely.

superrefraction: *See:* **ducting.**

superresolution: An algorithmic technique for achieving higher resolution than system parameters would imply, by exploiting prior knowledge. Usually applied to antenna beamwidth. *See also:* **angular resolution; range resolution.**

surveillance radar: A radar used to detect, locate, and track targets over a large volume of space.

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

synchronous detector: A device whose output is proportional to the amplitude of a vector component of an input radio-frequency (RF) or intermediate-frequency (IF) signal measured with respect to an externally supplied reference signal.

synthetic-aperture radar (SAR): A coherent radar system that generates a narrow cross range impulse response by signal processing (integrating) the amplitude and phase of the received signal over an angular rotation of the radar line of sight with respect to the object (target) illuminated. Due to the change in line-of-sight direction, a synthetic aperture is produced by the signal processing that has the effect of an antenna with a much larger aperture (and hence a much greater angular resolution).

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

synthetic-aperture radar moving-target indication (SAR-MTI): A synthetic-aperture imaging radar that also detects moving targets (especially slow-moving ground vehicles) and displays them on the SAR image.

TACCAR: *See*: **time-averaged-clutter coherent airborne radar.**

target: (A) Specifically, an object of radar search or tracking. **(B)** broadly, any discrete object that scatters energy back to the radar.

target classification: *See*: **target recognition.**

target fluctuation: Variation in the amplitude of the echo from a complex target caused by changes in target aspect angle, motion of target-scattering sources, or changes in radar wavelength (i.e., the amplitude component of target noise). Rapid fluctuation is usually modeled as independent from pulse to pulse within a scan and independent from scan to scan. The terms *scintillation* and *amplitude noise* have been used in the past as synonymous for target fluctuation and also to denote location errors caused by target fluctuation, and should be avoided because of this ambiguity.

target identification: Identification of a particular target such as the name painted on the side of a ship, an aircraft's side-number, or the flight number of a commercial aircraft. Primary radar cannot usually provide the identity of a target, but secondary radar systems including transponders can be used for such cooperative target identification. *See also*: **target recognition.**

target noise: Random variations in observed amplitude, location, and/or Doppler of a target caused by changes in target aspect angle, rotation or vibration of target-scattering sources, or by changes in wavelength. *See also:* **glint; scintillation error; target fluctuation.**

target recognition: The use of a radar to recognize one class of target from another. *See also:* **noncooperative target recognition (NCTR); target classification.**

terahertz (THz) radar: Radar operating at carrier frequencies of the order of 10^{12} Hz or above.

terrain-avoidance radar: A radar that provides information about the ground environment so that an aircraft can fly around high ground or obstacles.

terrain echoes: *See*: **ground clutter.**

terrain-following radar: An airborne radar that works with the aircraft flight control system to achieve flight that follows the contour of the earth's surface at some given altitude.

thinned array: A phased array in which radiating elements are not deployed at all possible locations in the array.

three-dimensional (3-D) radar: A radar capable of producing 3-D position data on a multiplicity of targets.

threshold: A value of voltage or other measure that a signal must exceed in order to be detected or retained for further processing.

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

time-averaged-clutter coherent airborne radar (TACCAR): An airborne moving-target indication (MTI) radar that uses a technique to compensate for the changing Doppler frequency from fixed clutter due to the motion of the aircraft (or other vehicle) carrying the radar or as the moving radar antenna scans in angle. The clutter is sampled over some range interval, the average Doppler frequency of the clutter in the range interval is used to set the frequency of a voltage-controlled oscillator (VCO) in a phase-lock loop to cause the mean Doppler frequency of the clutter echo to coincide with a null of the MTI Doppler frequency response over the range of observation.

time-difference-of-arrival: *See:* **time-of-arrival location.**

time-of-arrival (TOA) location: A process whereby the position of a radiating transmitter can be located by means of the relative time delay between its signals as received in multiple receivers of known relative position. *Syn:* **time-difference-of-arrival.**

TOA: *See:* **time-of-arrival location.**

tracking: The process of following a moving object or a variable input quantity. In radar, target tracking in angle, range, or Doppler frequency is accomplished by keeping a beam or angle cursor on the target angle, a range mark or gate on the delayed echo, or a narrowband filter on the signal frequency, respectively. This process may be carried out manually or automatically for one or more of the preceding input quantities. The beam, range gate, or filter can be either centered on the input quantity or can be coarsely placed, with interpolation measurements providing accurate data to a computer that does the fine tracking. Tracking may utilize a filter to smooth the measurement data and measure target motion characteristics. *See also:* **automatic tracking; tracking radar; track-while-scan.**

tracking radar: A radar whose primary function is the automatic tracking of targets. *See also:* **automatic tracking; tracking.**

track-while-scan (TWS): An automatic target tracking process in which the radar antenna and receiver provide periodic video data from a search scan, together with interpolation measurements, as inputs to computer channels that follow individual targets. *See also:* **tracking.**

transmit-receive (TR) box: *See:* **transmit-receive switch.**

transmit-receive (TR) module: An active transmit-receive electronic module, usually with integrated circuits, consisting of an antenna element (or direct connection thereto), transmitter, receiver, duplexer or

circulator, phase shifters, and power conditioner employed at the radiating locations of a phased-array radar.

transmit-receive (TR) switch: An RF switch, frequently of the gas discharge type, which automatically decouples the receiver from the antenna during the transmitting period. Employed when a common antenna is used for transmission and reception.

transponder: Receiver-transmitter equipment, the function of which is to transmit signals automatically when the proper interrogation is received from a radar or an interrogator.

trapping: *See:* **ducting.**

trilateration: *See:* **multilateration.**

TR switch: *See*: transmit-receive switch.

true-motion display: A display in a vehicle- or ship-mounted radar that shows the motions of the radar and of targets tracked by that radar, relative to a fixed background; accomplished by inserting compensation for the motion of the vehicle carrying the radar.

two-dimensional (2-D) radar: A radar that provides information in range and one angle coordinate, as in a 2-D air-surveillance radar that uses a fan-beam antenna to obtain range and azimuth angle.

two-step sequential detection: *See*: **alert-confirm detection.**

TWS: *See*: **track-while-scan.**

UHF radar: *See*: **ultra-high-frequency radar.**

ultra-high-frequency (UHF) radar: A radar operating at frequencies between 300 MHz and 1000 MHz, usually in one of the International Telecommunication Union (ITU) bands allocated for radiolocation: 420 MHz to 450 MHz or 890 MHz to 942 MHz. Radars between 1 GHz and 2 GHz, although within the UHF band as defined by the ITU, are described as L-band radars, and those between 2 GHz and 4 GHz as S-band radars.

NOTE—See IEEE Std 521-2002 [B8].

ultra narrowband (UNB) radar: A radar operating with minimal bandwidth, typically 10 kHz or less, and more formally, operating with a fractional bandwidth of less than 0.000001 (1 in a million). Practical applications of UNB radar waveforms require multistatic concepts of operation and are commonly utilized to operate in conjunction with RF tomography modes of operation.

ultrawideband (UWB) radar: A radar is UWB if the fractional bandwidth B_f of the radiated far field exceeds 0.25.

NOTE—See also IEEE Std 1672-2006 [B5] and Sabath, Mokole, and Samaddar [B10].

V-band: A radar-frequency band between 40 GHz and 75 GHz, usually in the International Telecommunication Union (ITU) allocated band 59 GHz to 64 GHz. Included within the definition of millimeter-wave radar. *See also:* **millimeter-wave radar.**

NOTE—See IEEE Std 521-2002 [B8].

V-beam radar: A ground-based, three-dimensional (3-D) radar system for the determination of range, bearing, and, uniquely, the height or elevation angle of the target. It uses two fan-shaped beams, one

vertical and the other inclined, that rotate together in azimuth so as to give two responses from the target; the time difference between these responses, together with range, are used in determining the height of the target.

VCO: *See*: **voltage-controlled oscillator.**

velocity response: The clutter filter frequency response defined by the ratio of power gain at a specific target Doppler frequency to the average power gain over all target Doppler frequencies of interest. Applied to moving-target indication (MTI) radars.

very-high-frequency (VHF) radar: A radar operating at frequencies between 30 MHz and 300 MHz, usually in one of the International Telecommunication Union (ITU) allocated bands 138 MHz to 144 MHz or 216 MHz to 225 MHz.

NOTE—See IEEE Std 521-2002 [B8].

VHF radar: *See*: **very-high-frequency radar**.

video: Refers to the signal after envelope or phase detection, which in early radar was the displayed signal. Contains the relevant radar information after removal of the carrier frequency.

video integration: A method of utilizing the redundancy of repetitive video signals to improve the output signal-to-noise ratio, by summing successive signals. Also called *post-detection integration* or *noncoherent integration.*

video mapping: The electronic superposition of geographic or other data on a radar display.

video stretching: The increasing of the duration of a video pulse.

visibility factor: (A) (pulsed radar) The ratio of single-pulse signal energy to noise plus interference power per unit bandwidth that provides stated probability of detection for a given false-alarm probability on a display, measured in the intermediate-frequency (IF) portion of the receiver under conditions of optimum bandwidth and viewing environment. **(B)** [continuous-wave (CW) radar] The ratio of single-look signal energy to noise power per unit bandwidth using a filter matched to the time on target. The equivalent term for radar using automatic detection is *detectability factor;* for operation in clutter environment, a *clutter visibility factor* is defined.

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

voltage-controlled oscillator (VCO): An oscillator whose frequency is a function of the voltage of a control signal.

volumetric radar: A surveillance radar with coverage extending over a significant sector in two angular coordinates.

waveform diversity: Adaptivity of the radar waveform to dynamically optimize the radar performance for the particular scenario and tasks. May also exploit adaptivity in other domains, including the antenna radiation pattern (both on transmit and receive), time domain, frequency domain, coding domain and polarization domain.

W-band: A radar-frequency band between 75 GHz and 110 GHz, usually in one of the International Telecommunication Union (ITU) allocated bands 76 GHz to 81 GHz or 92 GHz to 100 GHz. Included within the definition of millimeter-wave radar.

NOTE—See IEEE Std 521-2002 [B8]

X-band: A radar-frequency band between 8 GHz and 12 GHz, usually in the International Telecommunication Union (ITU) allocated band 8.5 GHz to 10.68 GHz.

NOTE—See IEEE Std 521-2002 [B8].

Annex A

(informative)

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