



CAD-CAM-CNC Programming

3D Modeling

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CAD\CAM\CNC GLOSSARY of Terms

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- A -

A-Axis- The axis of circular motion of a machine tool member or slide about the X-axis. Values along the A-axis are degrees of rotation about the X-axis.

Absolute System- A numerical control system in which all positional dimensions, both input and feedback, are given with reference to a common datum point.

ACIS- component software that provides a solid modeling "engine" (also called a "kernel") used by many commercial and research organizations as the core of CAD/CAM/CAE applications. Creates models in the SAT format. (Note- ACIS is not an acronym). (Spatial Technology Corp.)
 See also component software, Parasolid

ActiveX- a set of technologies that enable interactive content over the Web. With ActiveX, developers can create visual software components in any language that can be embedded into forms and Web pages. ActiveX controls are built on COM, DCOM, and OLE. (Microsoft Corp.)
 See also COM, DCOM, OLE

Advanced Graphics Port (AGP)- an extension of Intel's PCI bus. This dedicated port directly links the system graphics to system memory to speed graphics display. AGP runs at 66 MHz, at twice the speed of the PCI bus. (Intel Corp.)
 See also PCI

Alpha software- though there's no formal definition, this term generally refers to an early working version of software that is being tested internally by its developer. After this phase, the software will often undergo beta testing by end users.
 See also Beta software

Animated GIF- a GIF image that includes a number of frames that are played back rapidly to create an animation. Used mostly in Web applications.
 See also Graphics Interchange Format, World-Wide Web

Anti-aliasing- a technique for smoothing jagged lines on a graphics display.

Applet- a small program that generally provides a specific function, such as a calculator. Often associated with programs written in Java and downloaded over the Web.
 See also Java

APT Programming- Automatically Programmed Tools. A universal computer assisted programming system for multi-axis contouring programming. The original NC programming system, developed for AeroSpace, first used in building and manufacturing military equipment.

Algorithm- A computational method for solving problems. Much like a recipe in cooking, or a plan of attack in the military. Developing the algorithm in machining is the pre-planning process that creates the orderly procedure for machining processes to occur.

Alphanumeric- A system of code that consists of the characters A-Z and numerals 0-9.

Analog- Pertaining to a system that that uses electrical voltage magnitudes or ratios to represent physical axis positions.

Analyst- A person skilled in the development and definition of techniques to solve problems.

Application Programming Interface (API)- the standard set of functions provided by a program, operating system, or piece of hardware. APIs are typically used to provide independence and division of labor. Two programs or systems that are integrated via an API can both be individually altered and still work together so long as both conform to the same API.

Arc Clockwise--G02- An arc generated by coordinated motion between two axes. Curvature of the arc is clockwise with respect to the part and the cartesian planes.

Arc Counterclockwise- G03-An arc generated by coordinated motion between two axes. Curvature of the arc is counter-clockwise with respect to the part and the cartesian planes.

Architecture, Engineering, and Construction (AEC)- a broad term for the segment of the CAD market that encompasses architecture, building, construction, structural engineering, civil engineering, mapping, and geographic information systems.

ASCII- (American Standard Code for Information Exchange) A data transmission code that has been established as an American Standard by the American Standards Association.

Aspect ratio- the ratio of width to height for a graphics display.

Associativity- a link between two different functions or modules in a CAD system, such that when a change is made to one area, related areas are updated as well. For instance, a 3D model can be associated with drawings so that a change in the model is reflected in the drawings. Bi-directional associativity means that the updates happen both way no matter where the change was made, i.e. from function A to function B as well as function B to function A.

Auxiliary Function--M Codes-A programming function used in CNC machining that controls functions other than axis motion. Tool changing, coolant on and off, starting and stopping the spindle, etc.

Axis- A principal direction along which the relative movements of a tool or work piece occur. Three linear axes, occurring at 90 degree angles from each other, named X, Y and Z.

Axis Inhibit- A feature of an NC unit that enables the operator to withhold command information from a machine tool slide.

Axis Inversion- The reversal of plus and minus values along an axis. Mirror imaging is used to make a left-handed part from a right-handed tool path. When axis inversion is used circular interpolation is also reversed.

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- B -

Backlash- A relative movement between interacting mechanical parts as a result of looseness.

Batch Processing--Technique in which items to be processed must be coded and collected into groups prior to processing.

B-Axis--The axis of circular motion of a machine tool member or slide about the Y-Axis.

Benchmark (noun)- standard measure of performance, typically for computing and graphics hardware.

Benchmark (verb)- process of evaluating hardware and software to select the most appropriate product.

Beta software- though there's no formal definition, this term generally refers to a new release of software that is being tested by end users. Typically, end users do not pay for Beta releases. During this phase, developers learn about bugs and fix them prior to the software's official release.
See also alpha software, beta testing

Beta testing- generally, the process of having users test an early version of a new or revised program.
See also beta software, alpha software

Bezier curve- polynomial used to describe complex curves and surfaces. The location of midpoints controls the shape of a Bezier curve.

Bi-cubic spline (B-spline)- mathematical interpolation method of describing complex curves and surfaces.
See also NURBS

Bill of materials (BOM)- a list of assemblies, components, and parts that make up a product. Often used as the key data that links design and manufacturing.
See also MRP II

Bit- for binary digit, a unit of computer information equivalent to the result of a choice between two alternatives- on/off, yes/no.
See also byte

Binary Code--Code based on binary numbers expressed as either 1 or 0, true or false, on or off.

BIT- Binary Digit-A binary digit has only two possible states. Eight BITS make up one BYTE.

BCL- Basic Control Language ...EIA/ANSI 494. A CNC controller language.

Block--A single line of NC code is a block, a block represents sufficient information to a CNC machine to perform a single line or arc movement.

Block Delete- A function that permits selected blocks of code to be ignored by the control system, at the operators discretion.

Boolean- the function of using addition, difference, or intersection. In solid modeling, used to created and modify geometry.
See also solid modeling

Boundary conditions- in finite-element analysis, the way in which a model is constrained.
See also finite-element analysis

Boundary Representation (B-rep)- in solid modeling, a model-building approach in which geometry is represented by edges, faces, and vertices.
See also CSG, solid modeling

Browser- software that allows viewers from any platform to view pages in HTML format over the Internet or intranet. Popular examples are Netscape Navigator and Microsoft Internet Explorer.
See also Internet, Intranet

Buffer Storage-A place in which information in a control system or computer is stored for use at a later time.

Bug--A programmed error or oversight, a glitch.

BYTE--A sequence of eight adjacent binary digits (BITS) ,eight bits of information.
See also bit

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- C -

Cache- high-speed memory that keeps frequently used data and instructions readily available so the CPU does not have to retrieve them from slower main memory.
See also CPU

CAD- (Computer Aided Design) The using of computers to assist and develop phases of design.

CAM--(Computer Aided Manufacturing) The use of computers to assist in manufacturing.

Cancel- A command that will discontinue any canned cycles or sequence commands.

Canned Cycle- A preset sequence of events initiated by a single G coded command.

Cartesian Coordinates- A three dimensional system whereby the position of a point can be defined with reference to a set of axes at right angles to each other.

C-Axis- The axis of circular motion of a machine tool member or slide about the Z-axis. C-axis values are degrees of rotation about the Z-axis.

Chip-A single piece of silicon cut from a slice by scribing or breaking. A chip can contain one or more circuits.

Circular Interpolation- The process of generating up to 360 degrees of arc using only one block of information as defined by EIA.

CL Data- -Processor output that contains information regarding cutter location.

Client- in client-server computing, a system (PC, workstation, or terminal) that accesses programs and data from a server.

See also client-server computing

Client-server computing- a method of running computers in a network, where high-speed, large-memory servers provide services to clients such as PCs and workstations.

See also client, server

Cloud of points- a set of x-y-z coordinates obtain from a 3D scanner or digitizer. The data can then be turned into a continuous surface and used in a 3D model. Often used in reverse engineering applications.

See also reverse engineering, surface modeling

CNC- Computerized Numerical Control.

Command- A signal or series of signals that initiates one step or a series of steps in the execution of a program.

Commerce at Light Speed (CALS)- a joint Department of Defense (DOD) and industry strategy for transition of paper-intensive processes to highly automated, integrated processes for defense system acquisition, design, manufacturing, and life cycle support. Formerly known as continuous acquisition and life cycle support.

Common Object Model (COM)- part of Microsoft Windows DNA application architecture; provides foundation for producing language-independent object-oriented, binary, reusable software components. COM components can be written in any language and used from any language. (Microsoft Corp.)

See also Windows DNA

Common Object Request Broker Architecture (CORBA)- technology for distributing software objects; provides mechanisms by which objects transparently make requests and receive responses. Developed by the Object Management Group, a consortium of vendors and users. Competes with Microsoft's DCOM as a standard. (Open Management Group)

See also DCOM, ORB

Complex Instruction-Set Computing (CISC)- a computing architecture. Systems built upon it require several machine cycles to execute operations because the microprocessors must handle multipurpose instructions. Intel's Pentium and Pentium Pro processors are examples of CISC chips; however, Intel notes that these processors contain RISC-like features, and that there are more similarities than differences between RISC and CISC processors today.

See also RISC

Component software- a program that performs specific functions that is in turn used by application developers to create end-user software. In CAD, component software is often used to handle basic solid modeling functions in 3D design software. By using component software, an application developer can reduce its costs and development time.

See also ACIS, Parasolid

Computer Graphics Metafile (CGM)- a standard format for defining 2D vector data.

See also vector data

Computer-Aided Design (CAD)- the use of computers to assist in the creation and modification of a design, most commonly, designs with a heavy engineering content. Usually refers to drafting and modeling software.

See also CAE, CAM

Computer-Aided Engineering (CAE)- the use of computers in design, analysis, and manufacturing of a product, process, or project. Sometimes refers more narrowly to the use of computers only in the analysis stage.

See also CAD, CAM

Computer-Aided Manufacturing (CAM)- the use of computers to assist in the creation or modification of manufacturing control data, plans, or operations. Sometimes refers more specifically to the programming of numerical controlled (NC) machines.

See also CAE, CAD

Compile-To generate a machine language program from a computer program written in a high level source code.

Console- The part of a computer system used by the operator for communication with the computer system.

Constraints- values in a geometric model that define relationships, i.e. a line is tangent to a circle. Constraints are often used to drive parametric or variational geometry-based systems; the algorithms used to work with constraints are known as constraint management.

Constructive Solids Geometry (CSG)- a solid modeling method using primitives to build more complex models and Boolean operations of add, difference, and intersection.

See also B-rep, wireframe, solid modeling

CPU- -Central Processing Unit of a computer. The memory and logic area of a computer that includes processing and execution of instructions.

CRT- Cathode Ray Tube-A device that displays alphanumeric data to the machine operator.

Cutter Diameter Compensation- -CDC-A system in which the programmed tool path may be altered to compensate for cutter diameter differences.

Cutter Offset- -The distance from the part surface to the axial center of a cutter (the radius of the cutter).

Cutter Path- -The path defined by the center of the cutter.

Cycle- A sequence of operations that is repeated. The time the repetition requires is cycle time.

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- D -

Data- -The representation of information in the form of NC Words, symbols, numbers, letters, characters and/or digits.

Database- -A comprehensive collection of information in a specific format applicable to a user's needs.

Database Management System (DBMS)- software that tracks and manages data.
See also relational DBMS

Debug- -To troubleshoot, detect, locate and remove mistakes from a program.

Decimal Code- -A code system in which each allowable position has ten possible states.

Depth cueing- a rendering technique to provide depth perception by dimming lines further away from the viewer.

Design in context- typically, the ability to work on a single part in a solid modeling system while the assembly in which it is used is still displayed and which can be referenced. See also solid modeling

Desktop Management Interface (DMI)- a standard for describing and accessing information about PCs and PC components. Provides a common path for technical support, IT managers, and individual users to access information about all aspects of a PC, including processor type, installation date, attached printers and other peripherals, power sources, and maintenance history. Developed by the Desktop Management Task Force (DMTF). (Desktop Management Task Force)
See also Desktop Management Task Force

Desktop Management Task Force (DMTF)- an industry consortium whose aim is to develop, support and maintain management standards for PC systems and products, including the Desktop Management Interface (DMI), with the goal of reducing total cost of ownership. (Desktop Management Task Force) See also Desktop Management Interface, total cost of ownership

Digit- A single character in any numbering system.

Digital- -Relating data in the form of digits.

Direct3D- an application programming interface (API) offered by Microsoft for Windows that allows programmers to write instructions to graphics hardware without having to know how these devices are configured. Developed primarily for computer games. (Microsoft Corp.)
See also Application Programming Interface, OpenGL

Display- -A visual representation of data.

Distributed Common Object Model (DCOM)- an enhancement to COM that allows any software components written to the COM model to interact, even if they reside on separate machines. (Microsoft Corp.)
See also Windows DNA, COM

Downtime- -Time during which equipment is inoperable because of faults.

DNC- Direct Numerical Control-A system in which machine coded programs are introduced into the CNC controller from a remote computer.

Dot pitch- the size of the dots on a monitor screen, measured in millimeters. Generally ranges from 0.24 mm to 0.30 mm. For monitors with a Trinitron tube (developed by Sony Corp.), dot pitch is sometimes called effective dot pitch or slot mask size.

Dots/inch (dpi)- the resolution of a hardcopy device or graphics display.
See also resolution, hardcopy

Drawing Exchange Format (DXF)- a file format for CAD drawings used to transfer CAD data from one system or program to another, especially those files created by AutoCAD (Autodesk Inc.)

Dwell Time- -A timed delay of programmed or established duration used in specific machining operations.

DWG format (DWG)- the file format for native AutoCAD drawing files (Autodesk Inc.)
See also DXF

Dynamics- method of determining motion that results from forces

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- E -

Edit- -To modify the form of data.

EDM- Electrical Discharge Machining

EIA Standard Code- -A standard code for positioning, linear motion, and contouring control systems proposed by the U.S. EIA Standard RS-244.

End-Of-Block Character- -A character representing the end of a programmed block of information.

End of Program- -A miscellaneous function (M02) that represents the completion of a programmed cycle.

End Points- -The extremities of a span.

Engineering Document Management (EDM)- the process of organizing, managing, and tracking drawings and other documents, usually with the aid of computers.

Enterprise Resource Management (ERP)- a system used to handle a wide range of business functions, including accounting, sales, distribution, materials management, production planning, and human resources. Some MRP II systems have evolved into ERP systems. See also MRP II, PDM

Executive Program- -A set of programming instructions that allows a CNC lathe to have the capability to perform lathe functions or a CNC mill to perform milling functions. A set of instructions designed to output specific functions.

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- F -

Facilities Management (FM)- the task of managing the space, utilities, and other resources in a building, plant, or factory, often with the assistance of CAD software

Fahrenheit- a joint project between Silicon Graphics Inc. and Microsoft that will result in a suite of Application Programming Interfaces (API) for the Microsoft's DirectX multimedia architecture on Windows and for Silicon Graphics' UNIX platform; it will integrate Microsoft's Direct3D and DirectDraw with Silicon Graphics OpenGL, OpenGL Scene Graph and OpenGL Optimizer.
See also API

Feature-based modeling- a method of building and editing 3D models (usually solid models) by using standard features such as holes, slots, bosses, etc.
See also solid modeling

Feed- -A programmed or manually established rate of movement of the cutting tool into the work piece for the required machining operation.

Feed Rate- -F Word-A multi-character code containing the letter F followed by digits that determine the machine slide rate of movement.

Feed Rate Override- -A variable manual control function that allows the control system to increase or reduce programmed feed rates.

File- -An organized collection of relevant, orderly data.

File Transfer Protocol (ftp)- a protocol for the Internet that allows for direct downloading or uploading of files.

Finite-Element Analysis (FEA)- a computer-based method that breaks geometry into elements and links a series of equations to each, which are then solved simultaneously to evaluate the behavior of the entire system. Most often used for structural analysis, but widely applicable for other types of analysis and simulation, including thermal, fluid,

and electromagnetic.

See also finite-element modeling, preprocessing, post processing.

Finite-Element Modeling (FEM)- the process of setting up a model to be analyzed with the finite-element method, typically done graphically with geometry, where the model is meshed and boundary conditions are specified. Sometimes refers to the evaluation and reporting of results of such an analysis as well.
See also boundary conditions, finite-element analysis, meshing, pre-processing, post-processing

Firmware- Programs or controlled instructions that are not changeable by the user and that are often held in ROM, Read Only Memory.

Fixed Block Format- -A format where data blocks appear in sequentially arranged order.

Fixed Cycle- - A preset sequence of events initiated by a single G coded command.

Flat shading- rendering method whereby each polygon face has a constant shade.
See also rendering

Floating license- a method of licensing software so that X number of concurrent users anywhere on the network can use a copy at any one time, versus licensing the software for a particular system or user.

Floating point- a method of calculation and storage of numbers in which the decimal point moves instead of staying in a fixed position to handle significant digits.

Floating Zero- -A characteristic of a machine control unit that allows the zero reference point to be established at any point of travel along an axis.

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- G -

Gauge Height-A predetermined Z axis clear plane retraction point along the Z-axis to which the cutter retreats allowing safe X Y axis travel.

Geographic Information System (GIS)- computer system or software that includes both graphics data as well as textual information for applications in mapping, demographics, etc.

Gigabyte (GB)- a unit of measure that typically identifies the capacity of a computer's memory, storage space, or information-handling abilities. One GB is 1,073,741,824 bytes or 1,000 MB.
See also megabytes

GIGO- -Anacronym for "Garbage In, Garbage Out", when a programmer is given garbled inaccurate information (geometry), the BEST that can be expected is an inaccurate tool path. ALWAYS, proof every number given to you from any Engineer, if you don't you will be re-programming the work!

G Code- -Active Preparatory Function-An NC word addressed by the letter G and followed by a numeric value, G Codes are flags that when executed by the machine control unit, initiate axis motions, plane changes, feed rate changes, etc.

Graphical User Interface (GUI)- an interface to a computer that uses icons to represent desktop objects, such as documents and programs, that the user can access and manipulate with a pointing device, such as a mouse.

Graphics board- special circuitry typically added as a separate board to a computer to handle graphics processing. Also called video cards, graphics cards, and graphics accelerators.

Graphics Interchange Format (GIF)- a raster format for graphics, particularly photos, illustrations, and icons. Widely used for Web applications.
See also World Wide Web

Graphics library- a set of software functions specifically for graphics. Typically provided separately from the application program and the hardware.
See also API, OpenGL

*****Warning- G Codes have different uses and functions from one Machine Tool Builder [MTB] to another, use caution when changing to unfamiliar machines!**

G00- Rapid Travel-Axis motion at maximum speed.-Milling-Turning-

G01- Linear Interpolation-Straight linear axis motion at a controlled feed rate. -Milling-Turning-

G02- Clockwise circular motion using two axes in a single program block.- Milling-Turning-

- G03**- Counter-clockwise circular motion using two axes in a single program block.-Milling-Turning-
- G04**- A dwell, stoppage of axis motion, for a programmed length of time. -Milling-Turning-
- G17**- X,Y plane selection.-Milling-
- G18**- X,Z plane selection.-Milling-
- G19**-Y,Z plane selection.-Milling-
- G20**- **G70**- -Inch units(G20 or G70 depends on the MTB)-Milling-Turning-
- G21**- **G71**- Metric units(G21or G71 depends on the MTB)-Milling-Turning-
- G28**- Automatic return to a reference point.-Milling-Turning-
- G29**- Automatic return from a reference point.-Milling-Turning-
- G40**- Milling-Cancel Cutter Diameter Compensation
- G40**- Turning-Cancel Tool Nose Radius Compensation.
- G41**- Milling-Cutter Diameter Compensation on, cutter left.
- G41**- Turning-Tool Nose Radius Compensation Left
- G42**- Milling-Cutter Diameter Compensation on, cutter right.
- G42**- Turning-Tool Nose Radius Compensation Right
- G70**- Turning-Canned Finishing Cycle
- G71**- Turning-Canned Roughing Cycle
- G72**- Turning-Canned Facing Cycle
- G74**- Turning-Canned Peck Drilling Cycle
- G75**- Turning-Canned Grooving Cycle
- G76**- Turning-Canned Threading Cycle
- G80**- Cancel Canned Cycle.-Milling-
- G81**- Canned Drilling Cycle.-Milling-
- G82**- Canned Counter Bore Cycle.-Milling-
- G83**- Canned Deep Hole Drilling Cycle.-Milling-
- G90**- Absolute Positioning.-Milling-
- G91**- Incremental Positioning.-Milling-
- G92**- Repositioning or re-setting the origin point.-Milling-
- G98**- Milling-The initial machine reference positioning system. (Machine Reference Zero)
- G98**- Turning-Linear Feed rate Per Time.
- G99**- Milling-Cancel G92 position set. (Part Reference Zero)
- G99**- Turning-Feed rate Per Revolution

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-H -

Hard Copy- A readable output of data on paper.

hardcopy device- a peripheral device used to create permanent, printed output from a computer or workstation.

Hardware- The components that make up a computer or control system.

Hard-Wired- Having logic circuits interconnected on a backplane to give a fixed pattern of events.

Hewlett-Packard Graphics Language (HPGL)- a format for graphics printing, especially of CAD data, developed and used by Hewlett-Packard Co. and emulated by many others. This format is sometimes used to exchange CAD data among systems. (Hewlett-Packard Co.)

HyperText Markup Language (HTML, HTM)- the standard markup coding used to create content for the Web.
See also World-Wide Web

HyperText Transport Protocol (HTTP)- the protocol used to move HTML files over the Internet or intranet.
See also Internet, Intranet, HTML

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Incremental Dimensioning- A method of expressing a dimension with respect to the preceding point. NOT a good idea, incremental dimensioning allows users to fall into a trap. If a single error in data is entered incorrectly at the beginning of a project, ALL points determined afterwards will have that amount of error built into them.

Independent Software Vendor (ISV)- a company that offers commercial software and that does not offer hardware.

Industry Foundation Classes (IFC)- object-oriented universal software language for defining AEC/FM project models, allowing the sharing of the information globally, across disciplines, and technical applications throughout a project life cycle. Supports specific AEC processes such as architectural design, HVAC engineering design, construction management, and facilities management. Commercial software based on IFC will be able to understand and manipulate objects created by others, and each such application can create new objects with intelligent relationships to the others' objects. (International Alliance for Interoperability)
See also International Alliance for Interoperability

Inhibit- To prevent an action or event.

Initial Graphics Exchange Specification (IGES)- neutral file format used to exchange vector and text data among CAD systems. It is the format for graphical vector data in the Computer-Aided Acquisition and Logistics Support (CALS) document.
See also vector data, CALS

Inkjet printer/plotter- a hardcopy device that uses liquid ink sprayed through miniature nozzles onto the paper in dot matrix patterns to form text and graphics. Color inkjets use several ink nozzles connected to containers of colored inks.

Input- Transfer of external data into the control system.

Integrated Drive Electronics (IDE)- An interface standard that connects hard-disk drives to PCs. Extended IDE (EIDE), also known as AT Attachment (ATA)-2 or Fast ATA, is another such interface.

Interference checking- the process of identifying if and where two or more pieces of geometry (usually solids) intersect. When moving parts are involved, a kinematics analysis is used to detect interferences.
See also kinematics

International Alliance for Interoperability (IAI)- an organization formed to define, promote, and publish specifications for Industry Foundation Classes as a basis for sharing AEC project information globally, across disciplines, and technical applications throughout a project life cycle. (International Alliance for Interoperability)
See also Industry Foundation Classes

Interpolation- A function of a control whereby data points are generated between given coordinate positions.

International Standards Organization (ISO)- is a worldwide, non-governmental federation of national standards bodies from some 100 countries.

Internet- the public, worldwide "network of networks" based on TCP/IP protocols.
See also Intranet

Intranet- a private network that uses the same technologies (TCP/IP, HTTP, HTML, etc.) that make up the Internet. Typically, intranets are internal to a company or organization, secure from the Internet at large.

See also TCP/IP, HTTP, HTML, Internet

ISO- International Organization of Standardization.

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- J -

Java- a programming language developed by Sun Microsystems that can be read and translated to run on any platform. Most often used in Internet/Web applications (Note- Java is not an acronym). (Sun Microsystems Corp.)
See also Internet, World-Wide Web

Jig- A fixturing device used most often for drilling operations.

Jog- A control function that momentarily operates a drive into the machine.

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- K -

Kilobyte (KB)- a unit of measure that typically identifies the capacity of a computer's memory, storage space, or information-handling abilities. One KB is 1,024 bytes.

Kinematics- method of analyzing a moving mechanical system without regard to forces. Inverse kinematics is a method of determining mechanism geometry from a desired motion.
See also dynamics, interference checking

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- L -

Leading Zeros- Redundant zeros to the left of a number.

Letter Address- Often called NC Words, such as X, Y, Z, F, G, M.

Linear Interpolation- -A control function whereby data points are generated between given coordinate positions to allow simultaneous movement one, two or more axes of motion in a linear path.

Level-of-Detail control (LOD)- the ability to vary the amount of details displayed in a graphics image to improve performance. For instance, at a distance, models can appear as simple 3D figures, but as users zoom in, a more detailed representation is presented.

Local-area network (LAN)- two or more computers linked via cables and software so they can share data, programs, peripherals.

Lofted surface- a surface created by fitting a shape to a series of 2D cross-sections.
See also swept surface, surface modeling

Loop- -Repetitive operations can be programmed in a continuous mode until the desired functions have been completed.

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- M -

Machine Code- Code obeyed by a computer that needs no further translation.

Machining Center- Machine tools, normally Numerically Controlled, capable of automatically repeating many operations such as drilling, reaming, tapping, milling, and boring multiple faces on a work piece.

Machine Tool- A power driven machine used to form or shape metal and other materials.

Macro- A group of instructions that can be stored and recalled to solve a recurring problem.

Magnetic Tape- A tape made of plastic or mylar that is covered with magnetic particles. It stores information by selective polarization of portions of the surface.

Manufacturing Resource Planning (MRP II)- a system used to plan and manage manufacturing operations. The bill of materials (BOM) for products release to manufacturing is a key part of the MRP II data. Evolved from materials requirements planning (MRP).

See also ERP, PDM

Manual Data Input- MDI-A mode of control that allows the operator to input data into the control system, the data input is identical to the data that can be input by other means such as tape or DNC.

Manual Part Programming- The preparation of a manuscript in machine control language and format to define a sequence of commands for processing by a CNC machine.

Manuscript- A written or printed copy, in symbolic form, containing the same data as that punched on cards or retained in a memory unit.

Megabyte (MB)- a unit of measure that typically identifies the capacity of a computer's memory, storage space, or information-handling abilities. One MB is 1,048,576 bytes.

Megahertz (MHz)- millions of Hertz (cycles/sec) is a commonly used measure of the clock speed of a CPU. All else being equal, a CPU running at a higher MHz will be faster than one running at a slower clock speed.
See also CPU

Memory- An organized collection of storage elements into which a unit of information consisting of a binary digit can be stored and from which can later be retrieved.

Meshing- the process of dividing geometry into a grid of elements for finite-element analysis.
See also finite-element analysis

Microsoft Foundation Classes (MFC)- an application framework that provides reusable C++ object classes that can be used to reduce the amount of programming necessary to develop Windows-based applications such as CAD and to include OLE capability within these applications. (Microsoft Corp.)
See also OLE

Mirror- a function for creating entities in a 2D or 3D CAD program; such entities are mirrored yet opposites copies of the original.

Mirror Image- The reversal of plus and minus values along an axis. Mirror imaging is used to make a left-handed part from a right-handed tool path. When axis inversion is used circular interpolation is also reversed. Use of (INV,X1Y0) is a Type II language command.

Modal- Pertaining to information that is retained by the system until new information is obtained that replaces it.

Module- An interchangeable plug-in item containing components.

MTB- Machine Tool Builder.

MultiMedia Architecture (MMX)- architectural design enhancements to the Intel Pentium CPU chip to handle multimedia operations. (Intel Corp.)

Multipurpose Internet Mail Extensions (MIME)- a specification for exchanging text (in different character sets) and multimedia (sound, images, etc.) among different systems using Internet mail standards.

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- N -

N/C- Numerical Control-The technique of controlling a machine or process by using command instructions in coded numerical format.

Newsgroup- a service of the Internet that acts like a bulletin board for a special or specific interest discussion group. Users can log into a newsgroup and read questions, answers, and comments left by other users. In a binary newsgroup users can upload or download files, images, programs, etc.

Non-Uniform Rational B-Spline (NURBS)- a mathematical description of geometry that provides easy manipulation along with accurate description of entities and surfaces, from simple to complex.
See also B-spline

Nonlinear finite-element analysis- analysis technique used when materials, geometries, loads, or boundary conditions deviate from a straight-line behavior.
See also finite-element analysis

Numerical Control programming (NC programming)- method of creating the instructions to drive an numerically-controlled (NC) machine tool (sometimes called computer-numerical controlled, CNC). Often done from the CAD model.

Null- Pertaining to a zero output from a device.

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- O -

Object Linking and Embedding (OLE)- a standard set of functions that allow users to link or embed one file or object within another, even if created with a different application. For instance, a spreadsheet can be embedded into a CAD file and be made active within the CAD program. OLE builds on COM/DCOM, providing higher level services to application programmers such as structured storage, making it easier for applications to organize, add, and remove data without requiring them to create large numbers of directories and files on the disk. (Microsoft Corp.)
See also COM, DCOM

Object Request Broker (ORB)- an application framework that provides interoperability between software objects, even if they are built in different languages and run on different machines. (Object Management Group)
See also CORBA

OLE for Design and Modeling (Modeling) and **OLE for Design and Modeling (Geometry and Topology) (OLE D&M)**- a method of combining data and functionality from two different CAD/CAM systems into one model by defining a standard way to extract design information out of CAD/CAM databases for simultaneous display. OLE D&M (Geometry and Topology) adds to this by defining a standard mechanism for communicating spatial arrangement of graphical objects for CAD/CAM/CAE and GIS software. Over 50 CAD/CAM software vendors are involved in the OLE D&M Specification. (Microsoft Corp.)

Open Database Connectivity (ODBC)- provides a common interface for accessing heterogeneous databases. Based on Structured Query Language (SQL.) Allows developers to build client/server applications without targeting a specific DBMS.
See also SQL, DBMS

Open Graphics Library (OpenGL)- a rendering-only applications programming interface (API) widely used by CAD/CAM/CAE software, originally developed by Silicon Graphics Inc., for creating 2D/3D graphics. Lets applications create high-quality color images independent of windowing systems, operating systems, and hardware. Functions include modeling, transformations, color, lighting, smooth shading, texture mapping, NURBS, fog, alpha blending, and motion blur. (Silicon Graphics Inc.)
See also Non-Uniform Rational B-Spline, rendering

OpenDWG Alliance- a non-profit organization aimed at documenting and promoting the Autodesk AutoCAD DWG format, as it exists now, as an open drawing exchange standard. Alliance members are commercial CAD/CAM/CAE software vendors (although Autodesk is not a member). The Alliance provides documentation, specifications, utilities, and subroutines for working with DWG files. (OpenDWG Alliance)
See also DWG

Operating system (OS)- The main program that controls the computer's hardware operations. Microsoft's Windows 3.1, Windows 95, and Windows NT are examples of operating systems typically used to run PCs; different variants of the UNIX operating system generally run workstations.
See also Unix, Windows NT

Offset- -A displacement in the axial direction of the tool equal to the difference between the actual tool length and the programmed tool length.

Optional Stop- A miscellaneous function similar to Program Stop(M01) except that the control ignores the command unless the operator has previously pushed a button to validate the command.

Output- Data transferred from an internal storage unit to storage or an output device.

Overshoot- The amount by which axis motion exceeds the target value.

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- P -

Parabola- A plane curve generated by a point moving so that it's distance from a fixed second point is equal to it's distance from a fixed line.

Parabolic Interpolation- Control of a cutter path by interpolation between three fixed points, with the assumption that the intermediate points are on a parabola.

Parametrics- a capability of 2D and 3D modeling systems in which the user defines dimensions and constraints to which the model must conform. Alterations are then automatically reflected in related areas. Strictly speaking, parametrics work in only one direction, i.e., altering entity A will affect entity B, but not vice-versa. In practice, however, most systems allow the changes to operate in either direction.

See also variational geometry

Parasolid- a solid modeling engine used by many commercial and research organizations as the core of CAD/CAM/CAE applications. (Unigraphics Solutions Inc.)
See also ACIS, component software

PDES Inc. (PDES)- an industry/government consortium whose aim is to speed development and implementation of the STEP standard.
See also STEP

Pen plotter- a hardcopy device that draws links on paper, or other flat medium, by moving one or more pens across the surface of the medium; with more than one pen, multiple colors are possible.

Peripheral Component Interconnect (PCI)- a high-performance bus that provides a processor-independent data path between the CPU and peripherals for graphics, video, SCSI, LAN, etc. (PCI Special Interest Group)
See also AGP

Personal Computer (PC)- on the computing continuum, a PC is a desktop device generally built around Pentium microprocessors from Intel Corp. and the Windows operating systems from Microsoft Corp.
See also PW

Personal Workstation (PW)- on the computing continuum, a personal workstation is a desktop device that runs 32-bit operating environments such as UNIX or Windows NT. This type of computer is based on CISC or RISC platforms, supports 2D/3D graphics generally through a standard such as OpenGL, and is "tuned" to run engineering applications.

See also PC

Phong shading- rendering method whereby shading is performed on individual pixels.
See also rendering

Photorealism- the process of generating computer images that closely resemble photographs.

Pixel- for "picture element," the smallest definable dot of graphics data. Typically used in the description of graphics processors, displays, and monitors.
See also resolution

Plug-and-play (PnP)- typically, the ability to plug a peripheral into a computer and have it be automatically configured without any direction from the user. Sometimes refers to software add-ons as well.

Plug-in- a software extension for browsers that adds specific functionality. Many plug-ins provide the ability to view various file formats. Add-on programs for some CAD systems are also now being referred to as plug-ins as well.
See also browser

Points/inch (ppi)- the resolution of a hardcopy device or graphics display. The same as dots/inch.
See also resolution

Post-processing- in general, the evaluation, display, and reporting of data that results from some type of solution method. In finite-element analysis, it refers to the generation of displays showing stress, displacement, and other results; the generation of animations; and the creation of reports.
See also finite-element analysis, finite-element modeling, pre-processing

Pre-processing- in general, the preparation of data for further processing. In finite-element analysis, it refers to the process of setting up a model to be analyzed with the finite-element method, including definition of geometry, creation of the finite-element mesh, specifying materials, loads, and boundary conditions, and any solution options.
See also finite-element analysis, finite-element modeling, post-processing

Product Data Management (PDM)- software and systems that organize, manage, and track product, drawing, and model data, typically via a database management system. Evolving into systems that can be used across the enterprise and not just in design.
See also ERP, MRP II

Point Cloud- a set of x-y-z coordinates obtained from a 3D scanner or digitizer. The data from an "ordered" point cloud can then be turned into a continuous surface and used in a 3D model. Often used in reverse engineering applications.
See also reverse engineering, surface modeling

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- Q -

Query- A search or inquiry for the definition, content or data search of any subject of interest or issue of contention.

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- R -

Radiosity- an way to illuminate models so that the visibility of a surface of an object is assessed relative to every other surface and light source. Produces soft shadows.

Random Access Memory (RAM)- the storage area of a computer that holds programs and data.

Rapid prototyping (RP)- various manufacturing processes as well as a burgeoning industry. RP processes involve devices--ranging from office modelers to four-ton machines--that accept 3D CAD files, slice the data into cross-sections, and construct layers from the bottom up, bonding one on top of the other, to produce physical prototypes for applications such as engineering form, fit, and function; soft tooling for prototypes; and patterns for hard tooling. The RP industry consists of RP systems, materials, and after-market products as well as a services sector.

Raster data- a method of defining 2D graphic data with black-and-white or colored dots as opposed to vector data. Raster data resolution is typically defined by the number of pixels or dots/inch. See also vector data, resolution, pixel

Ray tracing- a rendering method that approximates illumination by casting a ray from the viewer into the model for each pixel in an image. See also rendering

Redline- To review, mark up, make notes of detailed focus, special interest a 3D model or CAD drawing for further comment.

Redlining software- software that allows users to display a CAD drawing or model and adding comments, revision notes, etc. (from the days of paper when engineers used red pencils on blueprints to accomplish the same task). See also viewing and markup software

Reduced Instruction-Set Computing (RISC)- a computing architecture. Systems built upon it generally take only one clock cycle to execute operations because the microprocessors handle fewer instructions; this typically translates into faster processing speeds. See also CISC

Refresh rate- the number of times a monitor redraws an image, measured in hertz. Also called vertical scan rate or vertical frequency. The higher the refresh rate, the less the screen will seem to flicker. Some experts recommend 75MHz as a minimum. Refresh rates are now described in milliseconds -2ms or 5ms refresh rates are common in 2008.

Relational Database Management System (RDBMS)- a database system in which data are stored in tables related by common members. See also DBMS

Rendering- process of adding shading, colors, reflectivity, textures, etc. to a model to make it appear realistic.

Resolution- the acuity of a graphics display, monitor, or hardcopy device. Typically measured in total pixels, horizontal X vertical (i.e. 1,280 X 1,024), or dots/inch (dpi). See also pixel, dots/inch

Reverse engineering- in general, the processing of understanding the design and functionality of a product using a sample of the product itself. For CAD, the term refers more narrowly to the process of scanning or digitizing the shape of an object and turning that data into a model which can then be treated as a normal CAD model, ultimately to re-manufacture the part or product. See also Cloud of Points and/or Point Cloud

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- S -

SAT- a file format for 3D solid geometry, created by systems that use the ACIS solid modeling engine. (Spatial Technology Corp.) See also ACIS

Server- in client-server computing, a system that performs processing and delivers data to any number of clients in a network. See also client-server computing

SLA format (SLA)- the 3D file format used by Stereolithography Apparatus (SLA) rapid prototyping machines. Can also be used as a general 3D file format for viewing. (3D Systems Inc.) See also rapid prototyping, Stereolithography

Small Computer Systems Interface (SCSI)- a CPU-to-drive (or other peripherals) interface. Ultra-Wide SCSI supports 40 MB/sec data transfer from the peripheral to the system. The newer Ultra 2 Wide SCSI doubles data transfer to 80

MB/sec.

Solid modeling- a geometric modeling method that completely and unambiguously describes both the exterior and interior of a part or assembly in three dimensions.
See also CSG, BREP

Spun Surface- a surface created by spinning a 2D profile of a trace path around a centerline axis.

SPECmarks- industry-standard benchmarks developed by the Standard Performance Evaluation Corp. (SPEC) to measure of a computer's integer and floating point performance. (Standard Performance Evaluation Corp.)
See also floating point processor

Standard for the Exchange of Product model data (STEP (ISO 10303))- a set of ISO standards which provide for the exchange of engineering product data. Provides industry specific Application Protocols (AP) to specify the representation of product information for various applications, including drafting, associative drafting, configuration controlled 3D assemblies, automotive design, and many others. (PDES Inc.)
See also ISO

Stereolithography (SL)- a rapid prototyping (RP) process, introduced in 1987 by 3D Systems Inc. launched the RP industry. A Stereolithography Apparatus (SLA) machine builds physical models in this manner- it focuses an ultraviolet (UV) light onto the surface of a vat filled with liquid photopolymer. The light beam, moving under computer control, draws each layer of an object onto the surface of the liquid. Wherever the beam strikes the surface, liquid changes to solid. 3D parts are built from the bottom up, one layer at a time; when the part is finished, it is exposed to UV light for curing. (3D Systems Inc.)

Structured Query Language (SQL)- standard for database management systems that provides a common way of accessing data stored in the system.

Surface modeling- a 3D modeling method of describing geometry by its surfaces. Typically used where surface shape is critical, for example, automobile body panels. Surface modeling software generally provides many functions for creating, editing, and evaluating surfaces.
See also cloud of points, lofting, swept surface

Swept surface- a surface created by sweeping a 2D profile along a trace path.
See also surface modeling

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- T -

Tagged Image File Format (TIFF)- a graphics file format that efficiently represents raster data such as photographs or illustrations.
See also raster data

Tessellation- the process of converting geometry into a set of polygons and accompanying information such as color, translucency, texture, etc.

Total cost of ownership (TCO)- the "true" cost of owning a computer, including hardware, software, training, support, maintenance, and so on.

Transmission Control Program/Interconnect Protocol (TCP/IP)- a standard networking protocol, widely used thanks to its ability to work with multiple platforms and implementation for the Internet.
See also Internet

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- U -

Uniform Resource Locator (URL)- the address assigned to every Web page from its domain name. For example, CAEnet's URL is <http://www.penton.com/cae/>

Universal Serial Bus (USB)- a standard 12-Mbps serial expansion bus for connecting peripherals to a PC, providing plug-and-play capability and daisy-chaining (adding new devices to the last device rather directly to the system itself).
See also plug-and-play

UNIX- developed by AT&T Bell Laboratories in the late 1960s, a mature, 32-bit (some are 64-bit), multi-user, multitasking operating system. Many hardware developers have created their own versions of UNIX based on software licensed from AT&T. Examples include IBM's AIX, Silicon Graphics Inc.'s IRIX, and Sun's Solaris. See also Windows NT, operating system.

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- V -

Value Added Reseller (VAR)- a dealer of hardware and software that "adds value" to the product before reselling it, e.g. by integration, services, programming, training, etc.

Variational geometry- a capability of 2D and 3D modeling systems in which the user defines a model by dimensions and constraints, which are then solved by a series of simultaneous equations to create and modify geometry. The changes, then, work in both directions, i.e. changes in entity A will affect be reflected in entity B and vice-versa. See also parametrics

Vector data- a method of defining 2D or 3D graphics by lines, arcs, circles, etc. in contrast to raster data. See also raster data

Video bandwidth- the speed at which a monitor can display pixels, generally measured in one second.

Viewing and markup software- software that allows users to display a CAD drawing or model and adding comments, revision notes, etc. Typically, viewing and markup software will work with numerous types of CAD (vector) and graphics (raster) file formats, in addition to standard documents (word processing and spreadsheets, for instance).

Virtual Reality (VR)- Refers to the ability to interact with data in a way that enables the users to "enter" and navigate through a computer-generated 3D environment and change their viewpoint and interact with objects created within that environment in a way that mimics the real world.

Virtual Reality Modeling Language (VRML)- a language that lets Web browsers view and interact with 3D models; requires a special viewer.

Virtual prototyping (VP)- the use of computer models and simulations to supplant the use of physical prototypes and models for evaluating and testing product designs.

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- W -

Windows Distributed Internet Applications Architecture (Windows DNA)- a framework for software that combines the benefits of the Web and client/server computing, Based on based on COM. (Microsoft Corp.)
See also COM

Windows NT- a 32-bit, high-end, platform-independent, operating system developed by Microsoft Corp. Its features include symmetric multiprocessing, multitasking, networking, security, and an easy-to-use interface. It competes with the UNIX operating system. (Microsoft Corp.)
See also UNIX, operating system

Wired for Management (WFM)- an Intel-led effort to develop guidelines for computer platforms that can be centrally managed over networks to reduce total cost of ownership. (Intel Corp.)
See also total cost of ownership

Wireframe- a geometric model that describes 3D geometry by outlining its edges, similar to a "stick figure."

World (WRL)- the file format for VRML models.
See also Virtual Reality Modeling Language

World Wide Web (WWW)- a hyper-linked, browsing, multimedia environment that operates over the Internet or intranets.
See also Internet, Intranet

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- X -

X Window System- an interface that enables multiple log-in sessions to occur on-screen, simultaneously, in different windows.

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- Y -

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- Z -

Zero Administration for Windows (ZAW)- Microsoft's effort to reduce the total cost of ownership (TCO) for Windows platforms. (Microsoft Corp.)

See also total cost of ownership

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