Systems Fundamentals of Computer Aided Design

Product realization systems. Review of part specification and CAD

- Design drafting
- Design interpretation
- Inspection and measurement
- Architecture of CAD
- CAD hardware and software
- Geometric modeling
- CAD data exchange
- CAD system examples
Computers in The Engineering Office

The type of computer can be used to assist engineer's job function.
The fundamentals of computing applied to engineering and the hardware available for carrying out engineering tasks will be examined.

Computer facilities and services can be divided into 2 areas: hardware and software.
Computers in The Engineering Office

Computers are classified as analog or digital.

Analog computers are generally used for mathematical problem solving. (control electronic, mechanical equipment)

Digital computers count by digits in distinct steps. (electric wall clock)

Historical Background of Computing

(1830s) C. Babbage developed the idea of a mechanical digital computer. (undertake laborious calculations; store the results for further use)

(1904) A. Fleming invented the first diode. (allow current to flow in one direction)

L. De Forest devised the triode valve. (control the flow of current)
Historical Background of Computing

(1940s) Thermionic valves was used in the first electronic computers. (filling large rooms; generating large amounts of heat)
(1947) The first transistor was developed at Bell Lab. (valve computer !)
2nd generation computer; the transistor was introduced.
3rd generation computer; based on small-scale integrated circuits. (early 1960s)
4th generation computer;

Historical Background of Computing

4th generation computer technology reduces in size of computers
increases in performance of large computers.
are becoming cheaper year by year.
SORTED HISTORIC COMPUTERS LIST

- 1. Pre-1960’s Mainframes (Vacuum Tubes)
- 2. Transistorized Mainframes
- 3. Early Supercomputers (1964 - 1979)
- 5. Supercomputers (1991 - present)
- 6. Mainframes (Integrated Circuits -- No Microprocessor)
- 7. Embedded Computers and Military-Specific Computers
- 8. Minicomputers (Transistorized/discrete)
- 9. Minicomputers (Integrated Circuits -- No Microprocessor)
- 14. Desktop Workstations and Enterprise systems

Basic Architecture of a CAD System

- Major Classes:
  - Main frame
  - Mini computer
  - Workstation
  - Microcomputer
  - Based.

- Application Areas:
  - Mechanical
  - Architectural
  - Construction
  - Circuit design
  - Chip design

- Cost:
  - High end
  - Low end
Computers in The Engineering Office

Hardware & Software
There are four major functions which must be addressed when dealing with the application of a computer system.

• Input
• Output
• Processing
• Storage

CAD/CAM
Hardware
Mainframe based CAD
System Organization
(a) Basic elements
(b) Workstation elements
Hardware for CAD Systems

Hardware

is used to describe the physical equipment (electronic circuitry) and its peripherals (mouse, printer).
Hardware for CAD Systems

Two types of computer hardware exist:

Hardware in office environment; is in the design/manufacturing office

Hardware in shopfloor; is used to control machinery and processes.

- CRT and LCD
- Keyboard
- Mouse
- Tablet
- button/dial boxes
- light pen
- touch screen
- track balls
- joy stick
- punched cards
- CMMs
- Scanners
- 3D scanners

<table>
<thead>
<tr>
<th>Device</th>
<th>Resolution</th>
<th>Speed</th>
<th>Cost</th>
<th>Fatigue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mouse</td>
<td>Medium</td>
<td>High</td>
<td>Low</td>
<td>Medium</td>
</tr>
<tr>
<td>Keyboard</td>
<td>Exact</td>
<td>Low</td>
<td>Low</td>
<td>Medium</td>
</tr>
<tr>
<td>Tablet</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Position Joystick</td>
<td>Medium</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Velocity Joystick</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Light pen</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
<td>High</td>
</tr>
</tbody>
</table>
Only about 50 years ago, it took a whole room to hold a computer. Now, handheld units like the Blackberry are the size of a couple of decks of cards. What’s next?

How about a PC – keyboard, display and all – that you carry around in pocket like a handful of pens?

Future hardware input devices include,

• virtual reality gloves
• voice
• scanned input and recognition
• vision systems

Previous output devices include

- Text printers
- Graphics printers
- Plotters
- CRT
- Rapid prototyping
- Virtual reality vision systems
Future hardware input devices include,

P-ISM
One gadget package looks like a set of pens.
It’s got a cell phone with a handwriting function, a projector that throws a keyboard onto your desk, another that beams out a display, a camera and scanner and a personal ID device with a cash pass function.

Computers in The Engineering Office

Two types of digital computers:
(mainframe & minicomputer)
Mainframe: large installation, fair-sized room (temperature & humidity controlled), only accessible to large company, data processing application
Minicomputers: smaller, less powerfull simpler than a mainframe, for small companies,
Computers in The Engineering Office

Mainframe is capable of allowing greater number of people to use the computer at the same time. (=Multi-user systems=)

The facilities of typical mainframe installation
- Processing (execute the programs)
- Storage
- Hard copy service (print / plot)

Computers in The Engineering Office

- Text terminal
- Modem
- Public telephone line
- Local area network
- Workstation
- Personel Computer
- Graphic terminal
- Mainframe Installation
Computers in The Engineering Office

The first computer configuration

In 1963 Sketchpad was invented by Sutherland in MIT. It ran on the Lincoln TX-2 computer.

Computers in The Engineering Office

• Sketchpad computer program written by Ivan Sutherland 1963 his PhD thesis.
• be the ancestor of modern computer-aided drafting (CAD),
• development of computer graphics in general.
Computers in The Engineering Office

• computer graphics be utilized for artistic and technical purposes
• a novel method of human-computer interaction.
• utilize a complete graphical user interface.
• used an x-y point plotter display as well as the light pen.

Computers in The Engineering Office

• organized its geometric data pioneered the use of "objects" and "instances" in computing and pointed forward to object oriented programming.
• ran jobs in batch job mode only, using punch cards or magnetic tape.
Typical PC configuration

- Processor (CPU)
- Data storage system (tape drive, hard (fixed) disk, soft (floppy) disk, optical disk (CD-ROM, DVD-ROM), flash memory)
- Remote-harddisk
- Monitor
- Input devices (keyboard, mouse, digitizer, trackball, scanner)
- Output devices (printer, plotter)
Computers in The Engineering Office

CAD Workstations

Many CAD programs need a lot of computing power and most CAD systems use good-quality graphics screens to display drawings. One possible configuration consists of a minicomputer with 4 graphics terminal, a printer and a plotter.

Computers in The Engineering Office

CAD stations can be linked either directly or through a local area network (LAN) to the manufacturing or production, or,

with numerical control (NC) equipment to program to NC machines in manufacturing operations or in robotics.
Computers in The Engineering Office

Supercomputer tends to become tomorrow's normal computer.

In the 1970s most supercomputers were dedicated to running a vector processor. Mid-1980s saw machines with a modest number of vector processors working in parallel become the standard.

Computers in The Engineering Office

In 1990s, attention turned from vector processors to massive parallel processing systems with thousands of "ordinary" CPUs, some being off the shelf units and others being custom designs. Parallel designs are based on RISC microprocessors, such as the PowerPC or PA-RISC, and most modern supercomputers are now highly-tuned computer clusters using commodity processors combined with custom interconnects.
INPUT (POINTING) DEVICES

CAE applications make use of computer graphics then one of the most important hardware facilities which provides an interface between the engineer and the software is the graphics pointing device.

Mouse  Digitizer (tablet)
Light pen  Joystick
Scanner

Computers in The Engineering Office

Movement of mouse over a flat surface causes a corresponding movement of cross-hair on the graphics screen.

2-button
3-button
infrared
  optic
wireless
Principles of mouse operation

Digitizer disks have an arrangement of slots. As they rotate an infrared light beam is cut by the material between the slots. It produces electrical pulses.

Computers in The Engineering Office
Digitizer & Tablet
Tablet consists of a flat surface over. The cursor can have any number of function buttons which are interpreted by the software. Electromagnetic communication between a coil in the puck and an accurately arranged grid of wires in the tablet.
Computers in The Engineering Office

Digitizer can be used for three tasks:
- As a pointing device to the screen
- As a menu selection device
- As a means of digitizing manually produced drawings.

Digitizing Three Dimensions

3D digitizer system from records x, y and z coordinates of an object by touching its surfaces with a pen.
It measures the tip position in 3D space and outputs directly to popular CAD and graphics programs.
**Computers in The Engineering Office**

**Joystick**

It has been used for many years as a graphical input device for CAE software but is used very rarely nowadays.

One major advantage of a joystick is the simple construction.

---

**Computers in The Engineering Office**

**Trackball**

It is one of the oldest input devices used on many large mainframe-based CAD systems.

It consists of a ball nested in a holder, and from 1 to 3 buttons for entering coordinate data into the system.
Computers in The Engineering Office

Light Pen
It is the oldest of all pointing devices and was used with the very first CADD systems.

It is very low-cost device and, simple to operate.

Computers in The Engineering Office

Scanner
It is an input device used for converting drawing created traditional tools to a CAD drawing.

Vector image ➔ Raster image
OUTPUT DEVICES

The result of CAE task is always some form of human-readable output.

Report

Drawing

Parts list

Stock inventory

Computers in The Engineering Office

Printer

It is used to get text output and documents.

• Text-only printers
• Dot matrix printers
Computers in The Engineering Office

Daisy wheel printer
Text-only printer similar to a manual typewriter. Plastic or metal hub with spokes like an old-fashioned wagon wheel minus the outer rim. At the end of each spoke is the carved image of a type character.

Computers in The Engineering Office

Line printer. Form of high speed printer in which one line of type is printed at a time.

They are mostly associated with the early days of computing, but the technology is still in use.

Print speeds of 600 to 1200 lines-per-minute (approximately 10 to 20 pages per minute) were common.
Computers in The Engineering Office

• Dot matrix printer
It can reproduce text and graphics.

9 / 24 pin dot matrix printer
Computers in The Engineering Office

• Other printers
  - ink jet printer
  - laser printer
  - thermal printer

Computers in The Engineering Office

Plotters
They are used for larger drawings such as A3 or greater.
Choosing a plotter depends on:
• the space considerations in the design office
• the size of paper to be used
• speed of reproduction
• mode of operation
• the variety of different line widths or colours
Computers in The Engineering Office

Pen plotters

- Flat bed plotters
- Drum type plotters

Electrostatic plotters

Computers in The Engineering Office

Flat bed plotter (for small paper)
Single-sheet form is placed on the flat bed.
Pens are selected from a carousel / bank
The pen in use is moved over the paper.
Drum Plotter
The paper is supplied on a roll.
The pens are moved in one direction along the length of the roller on a gantry.
The roller construction makes the plotter more compact.

Electrostatic Plotter
It is more common.
It operates on a similar principle of laser printer.

It can produce large quantities of drawing without a paper change.
Software for CAD Systems

Software is the computer program which is run and executed by the computer.

Software is expected to perform many tasks with more speed, and accuracy than a person.
Software will not perform a task better.

---

Software

<table>
<thead>
<tr>
<th>Operating System</th>
<th>Analysis Module</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unix, Windows, Apple,</td>
<td>Finite Elements</td>
</tr>
<tr>
<td></td>
<td>Plastic Flow</td>
</tr>
<tr>
<td></td>
<td>Kinematics/Collisions</td>
</tr>
<tr>
<td></td>
<td>Dynamics</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CAD Software</th>
<th>Importing/Exporting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geometrical model</td>
<td>Surface formats: IGES, DXF, CDL</td>
</tr>
<tr>
<td>2D/3D</td>
<td>Solid Formats:</td>
</tr>
<tr>
<td>Exact or faceted with planar polygons</td>
<td>PDES/STEP, ACIS, SAT</td>
</tr>
<tr>
<td>Mass properties</td>
<td>Files for systems such as NASTRAN</td>
</tr>
<tr>
<td></td>
<td>Can be linked to a user written program</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Editing</th>
<th>Rendering</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parametric</td>
<td>Hidden line</td>
</tr>
<tr>
<td>Object Organization</td>
<td>Shaded Image</td>
</tr>
<tr>
<td>Named Objects</td>
<td>Ray Tracing</td>
</tr>
<tr>
<td>Layers</td>
<td>Real Time Rotations</td>
</tr>
<tr>
<td>Part libraries</td>
<td></td>
</tr>
<tr>
<td>Drawing Output</td>
<td>Drafting module</td>
</tr>
</tbody>
</table>
CADD Software Structure

Addition & modification

Geometric database

Graphical display of drawing or design

Hard copy output

Database contains 2D or 3D geometry of the drawing.
(mathematical model)

User interface

CAD/CAM learning curve
Software Selection

The size of the company and the amount of investment capital available will be one of the main deciding factors but there are many other questions to be considered:
• Mainframe or PC/workstation platform?
• Two dimensions or three? Lines, surfaces or solids?
• Other analysis tools needed? Will the ability to transfer the geometry to these modelling and analysis systems be needed?

Software Selection ...

• Compatibility with other systems needed?
• How good is the maintenance and support from the suppliers?
• How much, how good and how long is the training?
• How easy is it to expand the system?
Software Trends

- Software changes more *slowly* than hardware: bounded by basic principles.
- Software bottleneck
- Integration and automation of the development process

- **Solid** modeling seems to be the key technique to *automate* and integrate CAD/CAM.
Commercial CAD/CAM Software

**TABLE 3.3 Some of the Commercial CAD/CAM Systems**

<table>
<thead>
<tr>
<th>Name of System</th>
<th>Vendor</th>
<th>Capabilities*</th>
</tr>
</thead>
<tbody>
<tr>
<td>AutoCAD</td>
<td>Autodesk Inc, Sausalito, California</td>
<td>WF, SF, SM (with ASM)</td>
</tr>
<tr>
<td>PDGS</td>
<td>Ford Motor Company, Dearborn, Michigan</td>
<td>WF, SF</td>
</tr>
<tr>
<td>CATIA</td>
<td>IBM</td>
<td>WF, SF, SM, Mfg, AT</td>
</tr>
<tr>
<td>Pro/Engineer</td>
<td>Parametric Technology Corporation, Waltham, Massachusetts</td>
<td>WF, SF, SM, Mfg, AT</td>
</tr>
<tr>
<td>I-DEAS</td>
<td>SDRC-Structural Dynamics Research Corporation, Milford, Ohio</td>
<td>WF, SF, SM, Mfg, AT</td>
</tr>
<tr>
<td>Unigraphics</td>
<td>EDS, Troy, Michigan</td>
<td>WF, SF, SM, Mfg</td>
</tr>
<tr>
<td>EMS</td>
<td>Intergraph Corporation, Huntsville, Alabama</td>
<td>WF, SF, SM, AT</td>
</tr>
<tr>
<td>ICEM CFD/CAE</td>
<td>Control Data Systems, Arden Hills, Minnesota</td>
<td>WF, SF, SM, Mfg, AT</td>
</tr>
<tr>
<td>ICAD</td>
<td>ICAD, Cambridge, Massachusetts</td>
<td>WF, SF, SM, Mfg, AT, IMC</td>
</tr>
</tbody>
</table>

* WF, wireframe modeling; SF, surface modeling; SM, solid modeling; AT, analysis tool such as plastic, dynamic, fluid flow analysis; Mfg, manufacturing modules; IMC, intelligent modeling capabilities.

Software for CAD Systems

AutoCAD is PC-based CAD software products (late 1982).

Mechanical Desktop is an integrated package of advanced 3D modeling tools.

Pro/ENGINEER or Pro/E (3D) feature-based, solids modeling system. It was developed by Parametric Technologies Corporation (PTC) in the late 1980s.

SolidWorks is mechanical design automation software.

I-DEAS (Integrated Design Engineering Analysis Software) is a CAD, CAM, and CAE package.

CATIA (Computer Aided Three-dimensional Interactive Application) was created by Dassault Systems of France and is marketed worldwide by IBM.
I-DEAS vs. AutoCAD

- 2D Modeler
  - (AutoCAD)
  - mostly 2D
  - limited 3D modeling
  - limited surface modeling
  - PC-based

- 3D Modeler
  - (I-DEAS/Pro-E/UG/CATIA)
  - full 3D solid modeling
  - powerful surface modeling
  - feature-based, parametric solid modeler
  - Workstation-based

Graphics Standards

- CAD/CAM is an application program: invoke graphics functions: Device dependency.
- Program, data, programmer portability. (Portability): Needs standards:
- Virtual Device: Java VM
- GKS, GKS-3D, Phigs, CGM, CGI (VDI), IGES, STEP, VRML, X3D
Standards for CAD Data Exchange

Model data exchange

Share geometric data between locations.
Share geometric data between different proprietary modelers and CAD systems.
Transfer geometric data to other software applications.
- analysis, CNC, etc.
Model data exchange

Current trend
More design authority delegated to suppliers.
Suppliers must match their designs to a number of specified variants.
To support process, great deal of design data must be exchanged.
This requires CAD systems of manufacturers and suppliers to be able to exchange geometric (and other) data.

Model data exchange

how to implement
3 possible solutions to such an exchange problem:

1) All use the same CAD package.
2) Use special translator applications to change data from one format to specific one needed.
3) Use a neutral format for data exchange.
Model data exchange

Data exchange requires standardization:

A neutral format must be standardized
Some standards have formal acceptance:
National and International standards
Some are de facto standards, developed by particular companies which chose to make public the specifications.

Typical Situation

- Major company uses CATIA
- Partner uses Unigraphics
- Major supplier uses I-DEAS
- Small supplier uses AutoCAD
- Small supplier uses Solid Edge
The Problem

• Every CAD system uses its own proprietary data format
• Design data must be converted from one format to the other

The solution

So need arises for communication of Software and Hardware via Standard Codes of Graphics Data

The Solution....!

• Turnkey System
  – Software and Hardware obtained from one supplier (May prove satisfactory)
  – Suppliers of Turnkey system rarely manufacture all items of system

• Alternatively
  – User choose specialist software and hardware for best combination which suits to his application
Types of Standards for CAD

- Graphics Standards
- Data Exchange Standards
- Communication Standards

Aim of Graphics Standardisation

- To provide versatility in the combination of Software and Hardware items of turnkey systems
- To allow the creation of portable application software package, applicable for wide range of hardware makes and configurations
Aim of Graphics Standardisation

• To allow the transfer of graphic data between two or more different companies which may have completely different CAD systems

Data Exchange Standards

• To address the problem, many standards for CAD data exchange have been developed
• CAD systems can import and export to many of these standard formats
Evolution of Data Standards

<table>
<thead>
<tr>
<th>Interfaces</th>
<th>Standardization Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAD/CAD CAD/CAM</td>
<td>National &amp; European</td>
</tr>
<tr>
<td>IGES</td>
<td>PDES</td>
</tr>
<tr>
<td>PDDI</td>
<td>PDES</td>
</tr>
<tr>
<td>SET</td>
<td></td>
</tr>
<tr>
<td>VDA/FS</td>
<td></td>
</tr>
<tr>
<td>CAD*I</td>
<td></td>
</tr>
<tr>
<td>CIM-OSA</td>
<td></td>
</tr>
<tr>
<td>EDIF</td>
<td></td>
</tr>
</tbody>
</table>

Product Data Structure

STEP
(A full data model)

Definition of Terms

- IGES (Initial Graphics Exchange Specification)
- VDI (Virtual Device Interface) or CGI (Computer Graphics Interface)
- GKS (Graphics Kernel System)
- Siggraph (Graphics Standards Planning Committee of Special Interest Group on Graphics)
- ACM (Association for Computing Machinery)
- CORE (an American software equivalent to GKS)
- PHIGS (Programmers Hierarchical Interface for Graphics) has been proposed to eliminate restrictions of GKS
- SET (Standard d’Echange et de Transfert) --- French
- VDA/FS (German standard) -- DIN
- ANFOR (French National Standard Body)
Levels of Graphics Standards
Communication

- Level-1 (Comm. b/w Graphics Utility SW & Graphics Output Device (screens, plotters etc))
  - VDI (Virtual Device Interface) or CGI (Computer Graphics Interface) is the most important standard in this category
  - VDI specifies a standard format for transferring GD between Graphics utility & device drivers
Levels of Graphics Standards
Communication

• Level-2 (Comm. b/w Application SW & Graphics Utility)
  – **GKS** (Graphics Kernel System) most universally accepted standard developed in W. Germany in 1979.
    GKS provides interface between application package and Graphics utility programs for any CAD system
  – **CORE** (an American software equivalent to GKS)
  – **PHIGS** (Programmers Hierarchical Interface for Graphics) has been proposed to eliminate restrictions of GKS

Levels of Graphics Standards
Communication

• Level-3 (Communication between diff. CAD Systems)
IGES (Initial Graphics Exchange Specification)
  – Developed b/w 1979~1982
  – Partially adopted by ANSI
Standard format of codes for CADCAM data
Completely independent of any system supplier
Levels of Graphics Standards Communication

- Enables graphical and manufacturing data to be transferred between dissimilar systems
- Classifies different types of data in terms of entities
  - Geometry (Points, lines, arcs, planes, nodes etc)
  - Annotation (dimension types, center lines, arrow leaders etc)
  - Structures (geometric groups, macro definitions, circular arrays etc)

Direct Translation between CAD Systems

- Need a translator from every CAD package to every other
- For 4 CAD packages, need 6 translators
- For 6 CAD packages, need 16 translators!
Current Situation

- Translation using IGES is unreliable
  - geometry is corrupted
  - much cleanup required after translation

- Translation using STEP is not widespread
  - STEP translators only recently available

- Existing translators lose information
  - parametrics and constraints
  - features and history trees

Short-term Solutions

- To avoid data translation problems, many companies have standardized on a single CAD system
  - Ford
    - all suppliers must use I-DEAS
  - Chrysler
    - all suppliers must use CATIA
  - General Motors
    - all suppliers must use Unigraphics
A Better Solution

- A better solution is development of reliable data exchange standards, using a neutral interface

Requirements of an Interface

- The interface must be capable of handling all manufacturing data
- There should be no information loss (maintain the semantics during conversion)
- The system must be efficient to be capable of handling the realtime requirements of manufacturing
- The system should be open-ended to permit extensions or contractions
Requirements Continued

- The system should be adaptable to other standards
- The system must be independent of the computer and architecture used
- It must be possible to form application-oriented subsets of the standard to reduce costs
- The interface must be upward and downward compatible in a hierarchical control structure.
- Test procedures must be provided to verify effectively.

Initial Graphics Exchange Specification (IGES)

- Formatted ASCII file format
- Supports many 2D and 3D CAD entities
- Has gone through several versions since 1980
- Widely supported
Model data exchange

- This binary format simplifies electronic transmission.
Format used primarily for geometric data transfer
- Does also support some non-geometric entities such as notes and dimensions.

Problems with IGES

• Many incompatible “flavors”
• Unreliable translation, particularly for complex geometry
• No formal information modeling basis
• Insufficient support for conformance testing
Model data exchange

IGES Entity Examples

<table>
<thead>
<tr>
<th>Entity #</th>
<th>Entity Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>Circular arc</td>
</tr>
<tr>
<td>108</td>
<td>Plane</td>
</tr>
<tr>
<td>110</td>
<td>line</td>
</tr>
<tr>
<td>114</td>
<td>Spline surface</td>
</tr>
<tr>
<td>118</td>
<td>Ruled surface</td>
</tr>
<tr>
<td>126</td>
<td>NURBS curve</td>
</tr>
<tr>
<td>150</td>
<td>CSG block</td>
</tr>
<tr>
<td>162</td>
<td>Solid of revolution</td>
</tr>
<tr>
<td>206</td>
<td>Diameter dimension</td>
</tr>
</tbody>
</table>

Model data exchange

IGES and Solids

Vendors have been slow to include solids in translators. Some vendors (often CAM software) perceived solid usage as low, with little demand.

Some felt IGES definitions too limited to support their solid data structures.

Plenty of old IGES versions still in use.

Prior to 1988 no solid entities supported.

1988 CSG entities added to standard.

1991 B-rep entities added.
Communication Via IGES

IGES format

• An IGES file is composed of 80-character ASCII records, a record length derived from the punch card era. Text strings are represented in "Hollerith" format.
STEP

Standart for Exchange of Product Model Data

- Uses a formal model for data exchange
- Information is modelled using the EXPRESS language
- EXPRESS has elements of Pascal, C, and other languages
- It contains constructs for defining data types and structures, but not for processing data
- EXPRESS describes geometry and other information in a standard, unambiguous way

STEP Architecture

Layer 3: Application protocols
Layer 2: Resource information models
Layer 1: Implementation methods (EXPRESS)

Physical files

Conformance testing & test suites
Classes of STEP Parts

- Introductory
- Description methods
- Implementation methods
- Conformance testing methodology and framework
- Integrated resources
- Application protocols
- Abstract test suites
- Application interpreted constructs

Status of STEP

- STEP has been under development for many years, and will continue for many more
- Over a dozen STEP parts have been approved as international standards
- Many others are under development
Other Standards

- Standards for technical documents
- Standards for images
- Internet and Web standards

Continuous Acquisition and Life-cycle Support (CALS)

- Developed by US Department of Defense
- Prescribes formats for storage and exchange of technical data
- Technical publications an important focus
Important CALS Standards

• Standard Generalized Markup Language (SGML)
  – developed in 1960s IBM
  – document description language
  – separates content from structure (formatting)
  – uses “tags” to define headings, sections, chapters, etc.
  – HTML is based on SGML

• Computer Graphics Metafile (CGM)
  – Developed in 1986.
  – vector file format for illustrations and drawings
  – All graphical elements can be specified in a textual source file that can be compiled into a binary file or one of two text representations.

• IGES
  – also used for illustrations
Common Formats for Bitmap Images

- Joint Photographic Expert Group (JPEG)
- Standards
- Proprietary
  - Graphics Interchange Format (GIF)
  - Windows bitmap format (BMP)
  - Zsoft file format (PCX)
  - Tagged Image File Format (TIFF/TIF)
  - Targa file format (TGA)

Web and Internet Standards

- Hypertext Markup Language (HTML)
  - used to describe web pages
  - based on SGML
- Virtual Reality Modelling Language (VRML)
  - standard for description of 3D interactive environments and worlds
  - downloaded and displayed in a web browser
  - well suited to sharing of CAD data
Other CAD File Formats

• DXF

```cpp
// Here is the code to write a DXF file that will draw a circle in AutoCad.
//
void CDxf::Circle()
{

  // 1000 diameter circle
  // Creation of an output stream object in text mode.
  ofstream FichierDxf("TestDxf.dxf", ios::app);

  // Draw the circle
  FichierDxf << 0 << end;
  FichierDxf << "CIRCLE" << end;
  FichierDxf << 8 << end;  // Group code for layer name
  FichierDxf << 0 << end;  // Layer number
  FichierDxf << 10 << end;  // Center point of circle
  FichierDxf << 0.0 << end;  // X in OCS coordinates
  FichierDxf << 20 << end;
  FichierDxf << 0.0 << end;  // Y in OCS coordinates
  FichierDxf << 30 << end;
  FichierDxf << 0.0 << end;  // Z in OCS coordinates
  FichierDxf << 40 << end;  // radius of circle
  FichierDxf << 500.0 << end;

  FichierDxf.close();
}
```

Other CAD File Formats

• STL
  – 3D file format used as input for Stereo lithography

• SAT
  – solid model file format used by ACIS-based CAD systems
**Data Structure**

- Data Structure: A set of data items that are related to each other by a set of relations: Tree, Linked list

- Vertex based, edge based, face based data Structure
Different data structures

Database

- Advantages:
  1) eliminate duplication,
  2) standard,
  3) security,
  4) consistency,
  5) harmonize conflicts

- Types of DB: 1) relational, 2) hierarchical, 3) network, 4) OODB
relational tables

Hierarchical DB
Network DB

Database Management System (DBMS)

- DBMS: A layer of software between the physical DB and the users.
- Properties of CAD/CAM DB;
  - Large data items and heterogeneous types
  - Relationship among data items are complex
  - Frequent design changes
Typical DBMS

Modes of Graphics Operations

- Generation of **Shape model**
- Generation of **drawing** (drafting)

- 3 tasks of drafting:
  - model clean-up
  - documentation
  - plotting
model clean-up

• It is boring and *time consuming* activity
  – Overlapping entities
  – Non-recoverable work: Model DB does not have the information

• Time ration between model generation and model clean-up: 1:2 ~ 1:3
CAD systems may be considered as comprising a large number of functions for creating or manipulating the design model.

Traditionally, there are two ways in which this is achieved:

- Command-based systems
- Menu-driven systems
- Icon-driven systems
As computers become cheaper, and more powerful, the only interfaces of real importance are

*Graphical User Interfaces (GUI)*.

An example of novel technology is the visual scanner available for 3D input.

*Graphical User Interfaces (GUI)*

The current demands on user interfaces are,
- on-line help
- adaptive dialog/response
- feedback
- ability to interrupt processes
- consistent modules
- a logical display layout
- deal with many processes simultaneously
**Graphical User Interfaces (GUI)**

The common trend is to adopt a user interface which often have,

- Icons
- A pointer device (such as a mouse)
- Full color
- Support for multiple windows, which run programs simultaneously
- Popup menus
- Windows can be moved, scaled, moved forward/back, etc.

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**Command-based systems**

Command-based systems operate by reading a command and its parameters entered by the user, carrying out the required actions, then waiting for the next command. 

`command (optional parameters , target object)`
Menu-driven systems

The menu-driven approach contrasts markedly with the command approach.

The basic principle is that the user is at any time presented with a list or menu of the functions that are available to be selected.

Menu tree
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The most important of these rules are:
A clear, well presented screen layout.
Easy function selection by a well-structured menu system.
Meaningful function names.
Meaningful and helpful prompts to the user.
Easily accessible and clearly written help information.

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Clear screen layout
It ensures that the user can see immediately the effects of the use of the software functions.
Graphic-based
CAE package has a large number of functions.

Menu area
(having submenus with functions)
Menu System
The way of displaying the sequence of menu and submenu selection is by the use of cascading menu (child menu).
The other way of selecting software function is by means of icons.

Due to the learning difficulties of software, instead of written menus the functions are described by means of icons.
Icon menu system are generally popular with CADD users.
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Prompts for user
Most system have an area on the screen dedicated to providing the user with prompts and instruction relating to the function being carried out.
Some packages give various levels of prompting and some only display an instruction when requested.

Operating System (OS) Module
the software that manages the sharing of the resources of a computer.
An operating system processes system data and user input, and responds by allocating and managing tasks and internal system resources as a service to users and programs of the system.
Operating System

It provides the user of a computer with basic facilities to control and manage the computer system environment. The first computers did not have operating systems. Basic interface between a user and a computer. It enable to run application program and manage to store the files on disks.

DOS / WINDOWS / UNIX

Operating System

CP/M notable early disk-based operating system supported on many early microcomputers largely cloned in creating MS-DOS,

MS-DOS wildly popular as the operating system chosen for the IBM PC

IBM-DOS or PC-DOS IBM's version of it
Operating System

**Mac OS**
The major alternative throughout the 1980s in the microcomputer market tied intimately to the Apple Macintosh computer.

Operating System

**MSDOS**
*Microsoft System Disk Operating System*
It is the most common operating system in PC. BIOS is not part of MSDOS. It is built into the PC on ROM.
Operating System

By the 1990s, the microcomputer had evolved to the point where, as well as extensive GUI facilities, the robustness and flexibility of operating systems of larger computers became increasingly desirable.

Windows NT, served as the basis for Microsoft’s entire operating system line starting in 1999.

Windows Vista

UNIX

UNIX and VMS are two common operating systems for mainframes and workstations.
It was developed as a simple operating system for use a minicomputers.
It was written in the C prog. language.
It has been implemented on a wide range of computers from PCs to mainframes.
(MicroVAX, SUN, HP Apollo, Silicon Graphics, IBM RS6000)
UNIX

Hobbyist-developed reimplementations of Unix, assembled with the tools from the GNU Project, also became popular; versions based on the Linux kernel are by far the most popular, with the BSD derived UNIXes holding a small portion of the server market.

What is Programming Language?

an artificial language that can be used to control the behavior of a machine, particularly a computer. Programming languages, like human languages, are defined through the use of syntactic and semantic rules, to determine structure and meaning respectively.
Programming Languages

1st generation
The processor only operates using programming language (machine code).
Very few programmers can create programs directly using machine code.

2nd generation
Assembly language defines each machine code instruction as a mnemonic called an assembler.

Programming Languages

3rd generation programming languages (3GLs); instruct the computer step by step how to solve a problem.

4th & 5th generation programming languages; state the solution and a set of rules for achieving it.
Prolog, OPS5, and Mercury are the best known fifth-generation languages.
Assembly language

• class of low-level languages used to write computer programs,
• or to a particular such language.
• human-readable notation for the machine language used to control a specific computer architecture.
• was once widely used for all aspects of programming.

Today it is used in limited situations, primarily when direct hardware manipulation or unusual performance issues are involved.

High Level Language

It enables to define a program or solve a problem using a code.

Compiler: converts the program into a intermediate object code.

Linker: linkes between the library and programmer’s code (file)

Execution: runs code and gets results
High Level Language

FORTRAN (FORmula TRANslation)

It enables the programmer to write mathematical formulae in algebraic form for solution.

FORTRAN is a general-purpose, procedural, imperative programming language that is especially suited to numeric computation and scientific computing. Originally developed by IBM in the 1950s for scientific and engineering applications,

The first manual for FORTRAN appeared in 1956, with the first FORTRAN compiler delivered in 1957.
COBOL

is a third-generation programming language, and one of the oldest programming languages still in active use.

Its name is an acronym, for Common Business Oriented Language, defining its primary domain in business, finance, and administrative systems for companies and governments.

- COBOL-68
- COBOL-74
- COBOL-85
- COBOL 2002

BASIC (Beginner's All-purpose Symbolic Instruction Code)

is never compiled and linked. Quick and simple program. (1964)

PASCAL was developed in the late 1960s, first structured language.

C language combines high level language syntax with lower level assembly programming.
Modeling and Viewing

- Modeling is the art of abstracting or representing a phenomenon.
- 2.5 dimension: same thickness
- **Deleting a view** does not delete the graphic entity from DB
- Graphic entity should be explicitly deleted by the user from the DB

2.5 dimension and 3D shape model
Hierarchy of the geometric model DB
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- Two-dimensional (2D) computer drawing is the representation of an object in the single-view format which shows two of the three object dimensions or the mutiview format where each view reveals two dimensions.
Standard 2D views

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Three-dimensional (3D) computer drawing is the coordinate format. Three dimensional computer aided drawing allows the production of geometric models of a component or product for spatial and visual analysis.


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2D Vs 3D DOCUMENTATION

The product documentation has traditionally been recorded on 2D paper drawings. The trend is toward both an electronic paperless environment and using a 3D representation rather than 2D drawings.

Companies tend toward either a “model-centric” or a “drawing-centric” philosophy of how their products are documented.

A “drawing-centric” company may perceive 3D part models as a preliminary step to create 2D drawings, but the released 2D drawings are archived to document the final design.
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2D vs 3D DOCUMENTATION

A “model-centric” company may hold a view that the 3D part model contains the master information, and the 2D drawings are only an intermediate form of communication to transmit information to suppliers who need printed drawings.