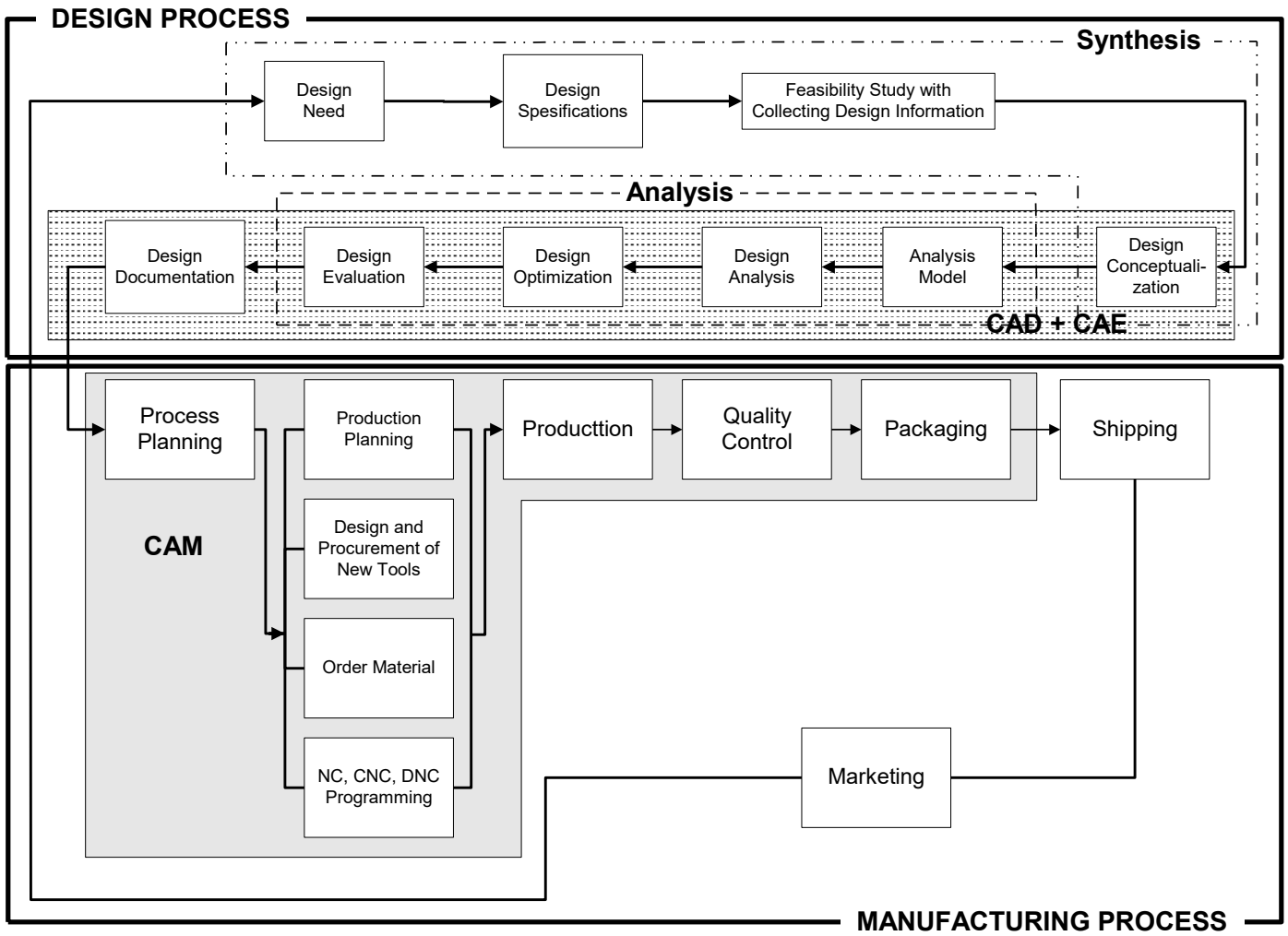
Contents

- Definitions of CAD/CAM/CAE
- Product development
  - Practical example
- Design models
- Hardware components
  - I/O devices
  - Graphics display
    - Vector-refresh
    - Raster

Product Cycle (CAD/CAM/CAE)



Computer-Aided Design

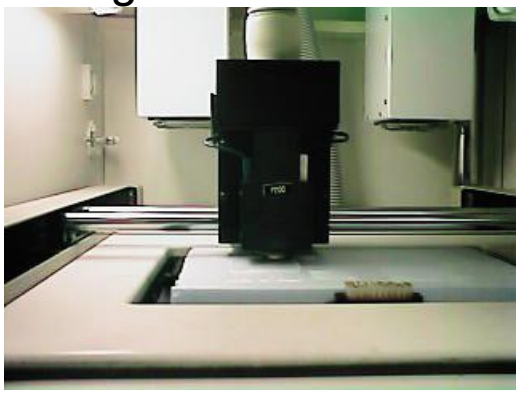
- Technology concerned with the use of computer systems to assist in the creation, modification, analysis, and optimization of a design
  - Design of the product itself from scratch, such as appearance, component position matching, material, etc.
  - Computer graphics and an application program facilitating engineering functions in the design process
  - From geometric tools to manipulate shapes to customized application programs (analysis and optimization)
  - Most basic role: define the geometry of design
  - Important components: computer-aided drafting system and geometric modeling system

Functions of the CAD System

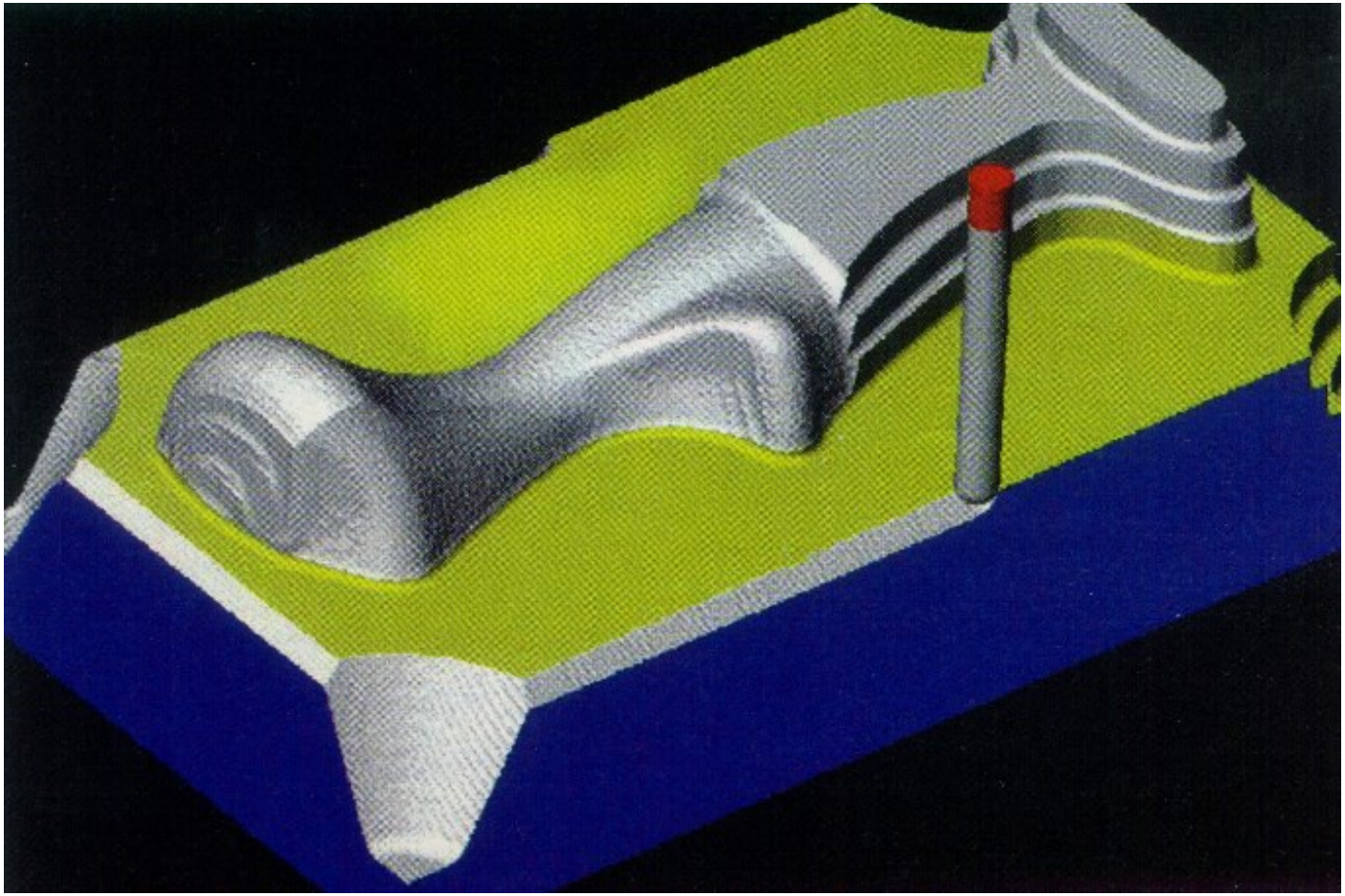
- Reuse of design components
- Ease of design modification and versioning
- Automatic generation of standard components of the design
- Validation/verification of designs against specifications and design rules
- Simulation of designs without building a physical prototype
- Automatic design of assemblies
- The output of engineering documents, such as manufacturing drawings, and bills of materials
- Direct output of designs to production units
- Direct output to rapid prototyping or rapid industrial prototyping machines

Computer-Aided Manufacturing

- Technology concerned with the use of computer systems to plan, manage, and control of manufacturing operations
  - Most mature area: NC(Numerical Control)
  - Robot programming for material handling, welding, assembling, etc.
  - Process planning
    - Group Technology
    - Feature recognition of feature based modeling
  - MRP(Material Requirement Planning)
  - Rapid Prototyping
    - Stereolithography
    - Selective Laser Sintering
    - Fused Deposition



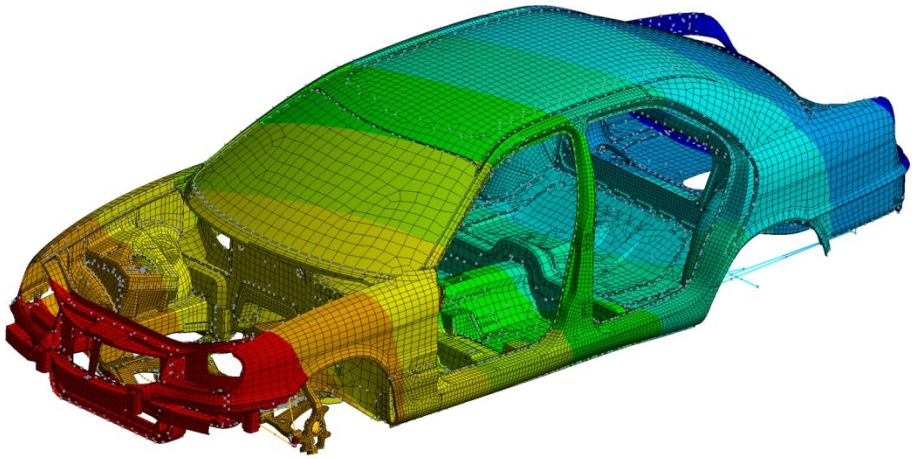
CAM: Example

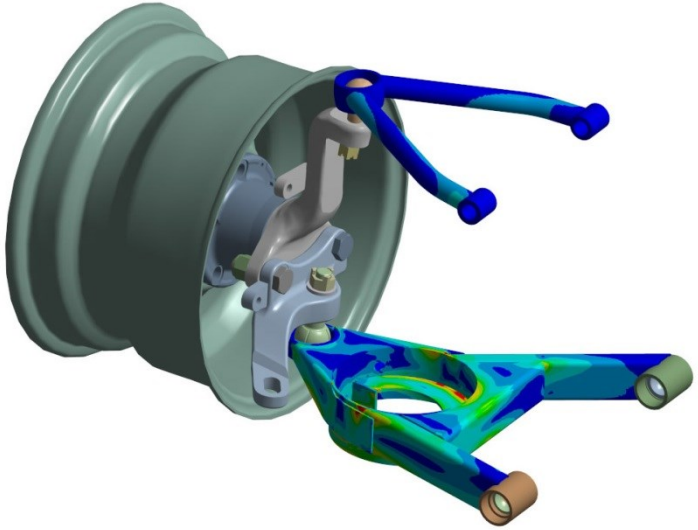


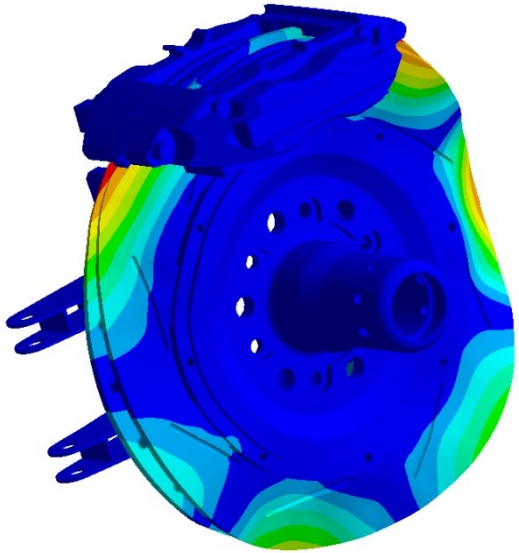
Computer-Aided Engineering

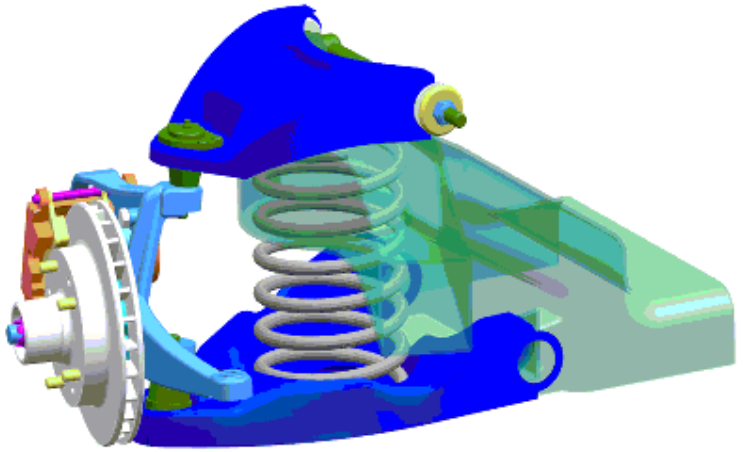
- Technology concerned with the use of computer systems to analyze CAD geometry, allowing the designer to simulate and study how the product will behave so that the design can be refined and optimized
  - Kinematic program, large-displacement dynamic analysis, etc.
  - Most widely used method of computer analysis: FEM
    - Stress, deformation, heat transfer, fluid flow, magnetic field, continuous field problem
  - Pre-processor: construction of the abstract model and generation of the finite elements
  - Post-processor: visualization of results
  - Design optimization

CAE: Example





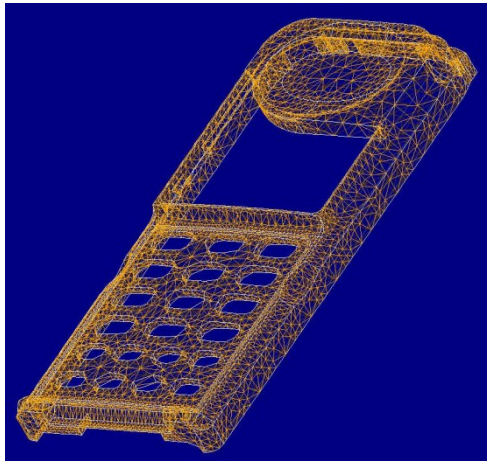




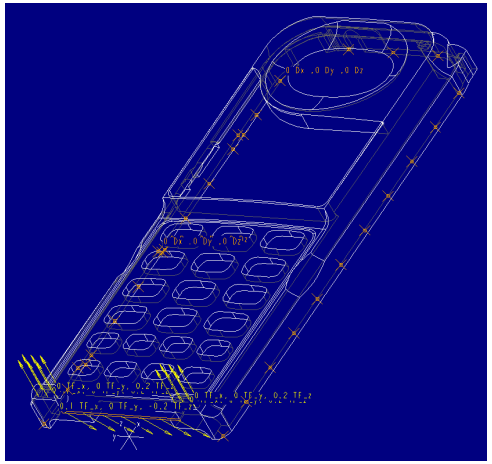
Example: Cellular Phone (CAD)

Solid Model

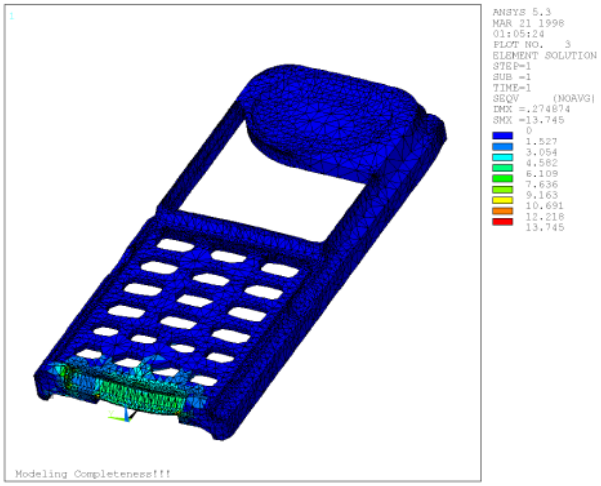
Example: Cellular Phone (CAE)



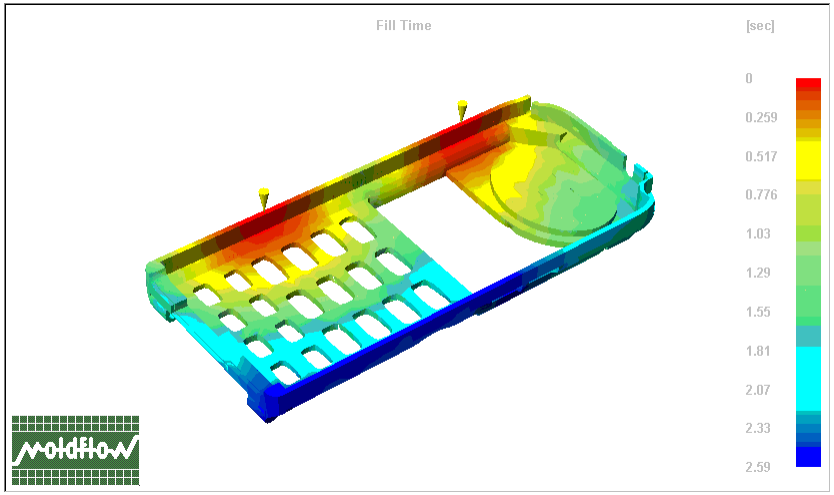
Finite Element Analysis Model



Boundary Conditions

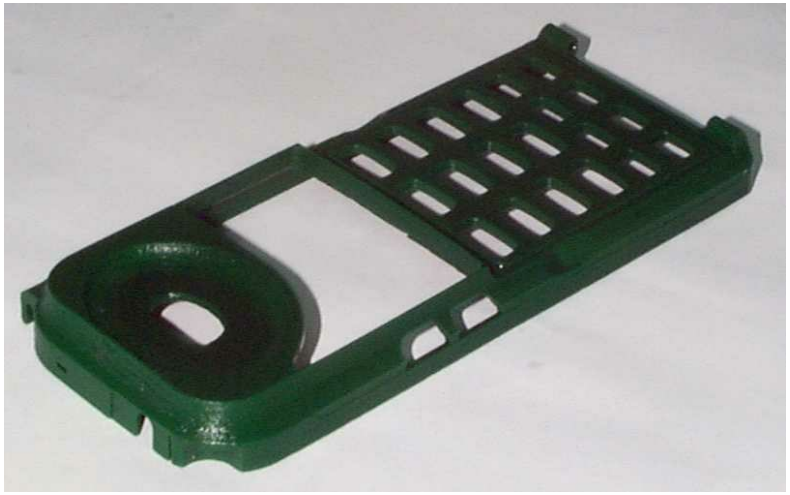


Stress Distribution

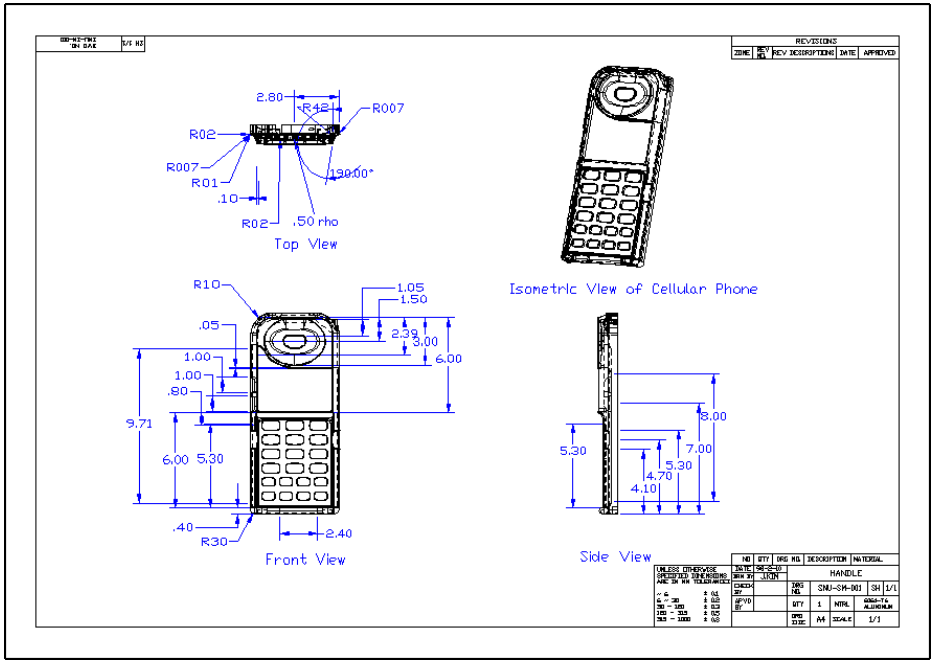


Fill-time Distribution

Example: Cellular Phone (RP/CAD)



Physical Prototype

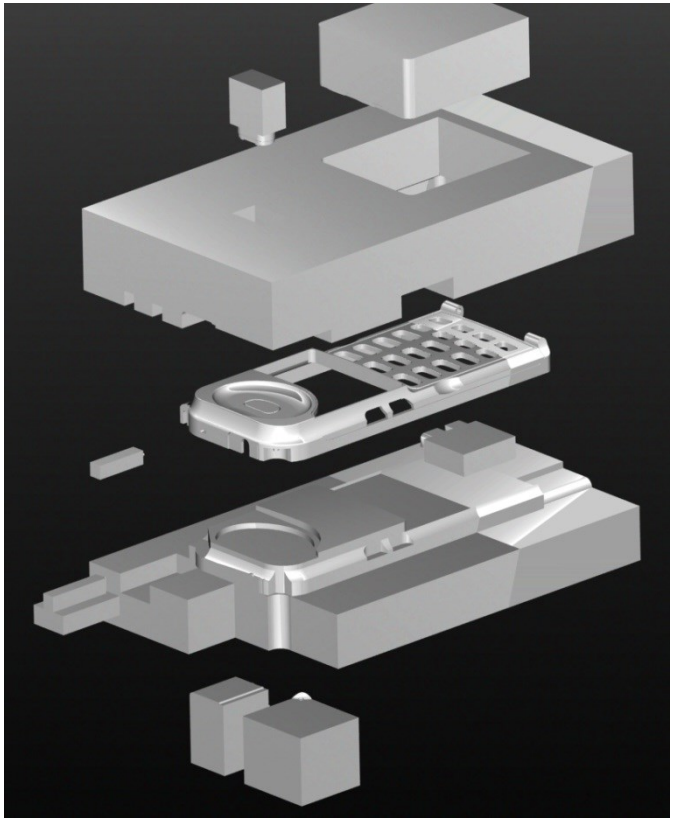


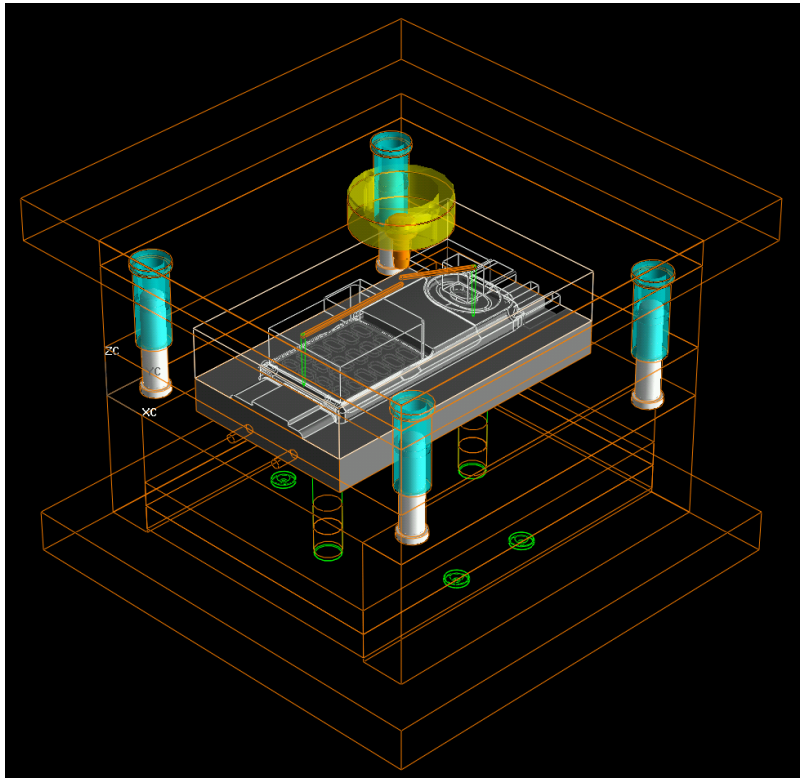
Part Drawing

Example: Cellular Phone (CAD)

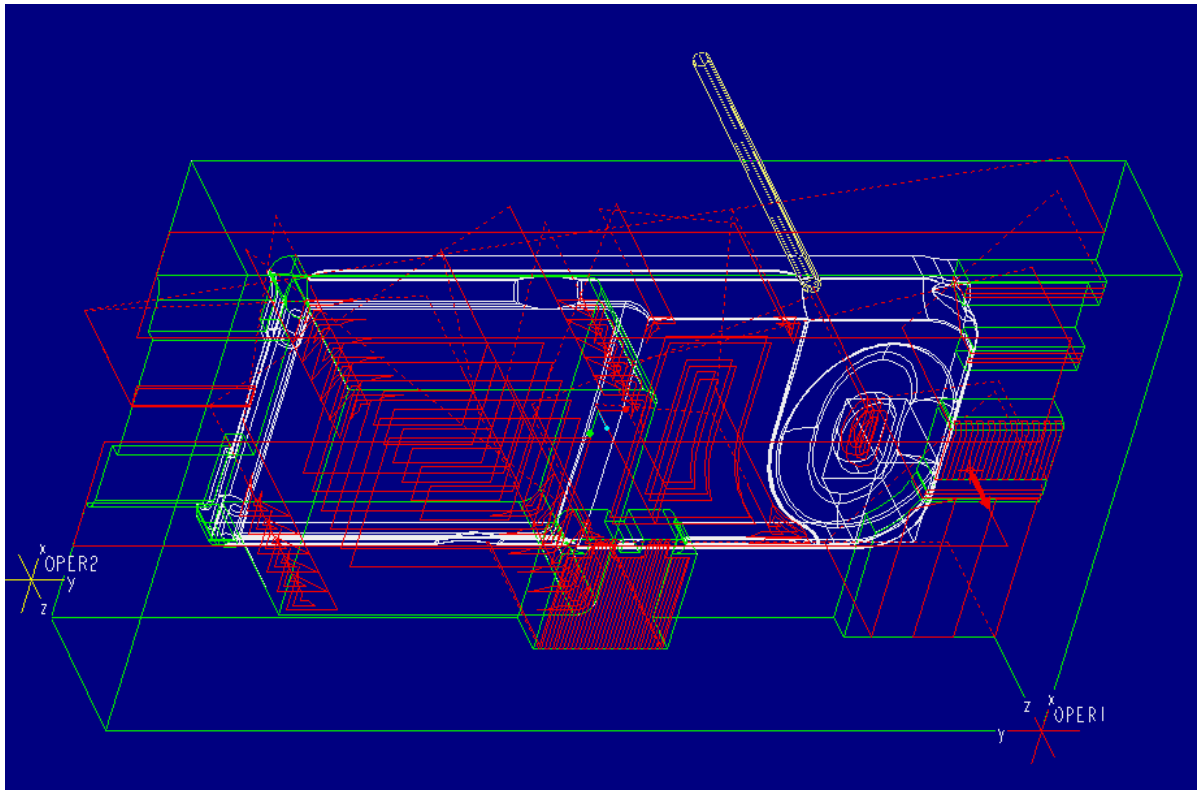
Injection Mold Design

- Core plate
- Cavity plate
- Side cores
- Mold base
- Ejector pins
- Cooling channels



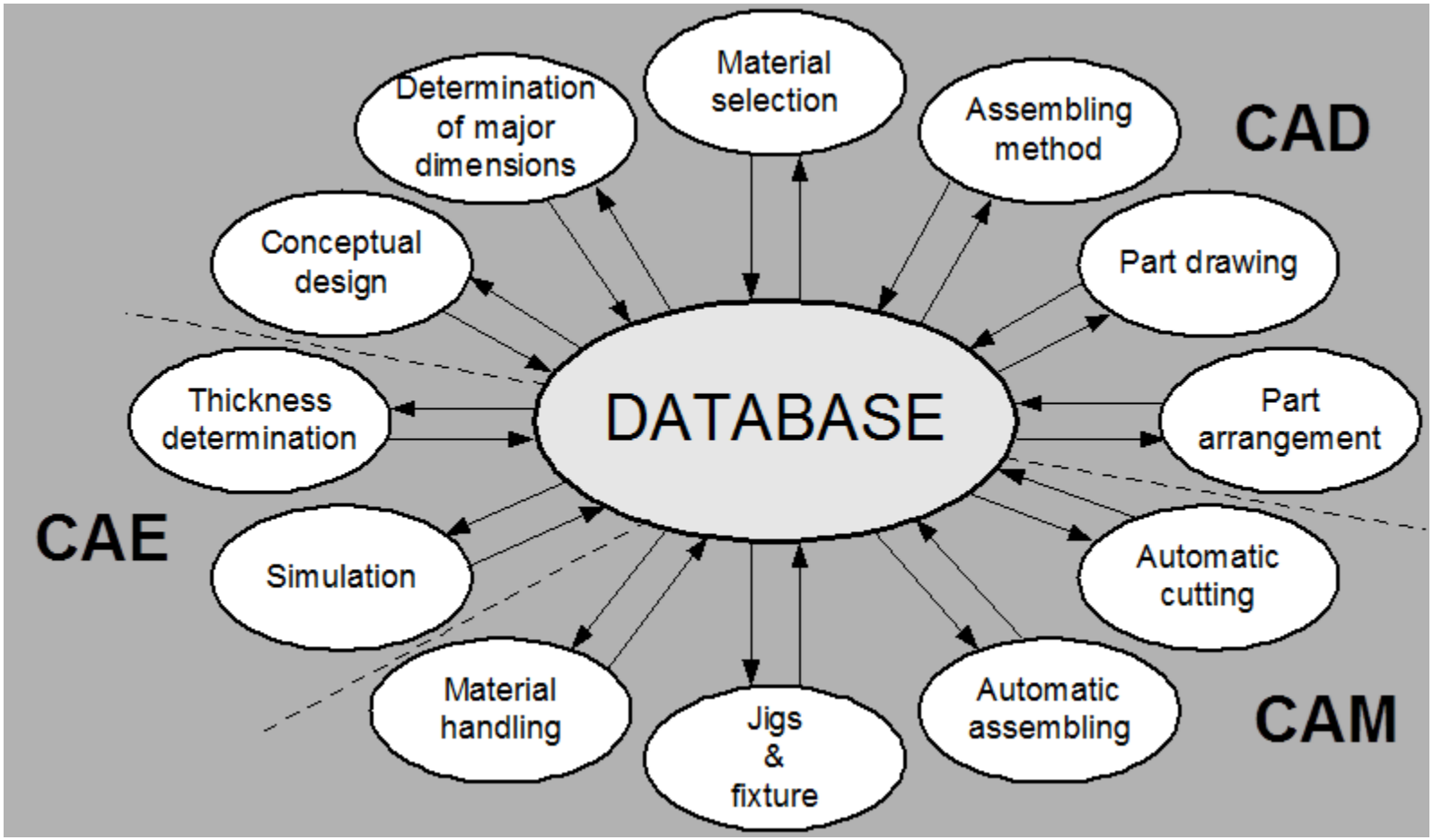


Example: Cellular Phone (CAM)



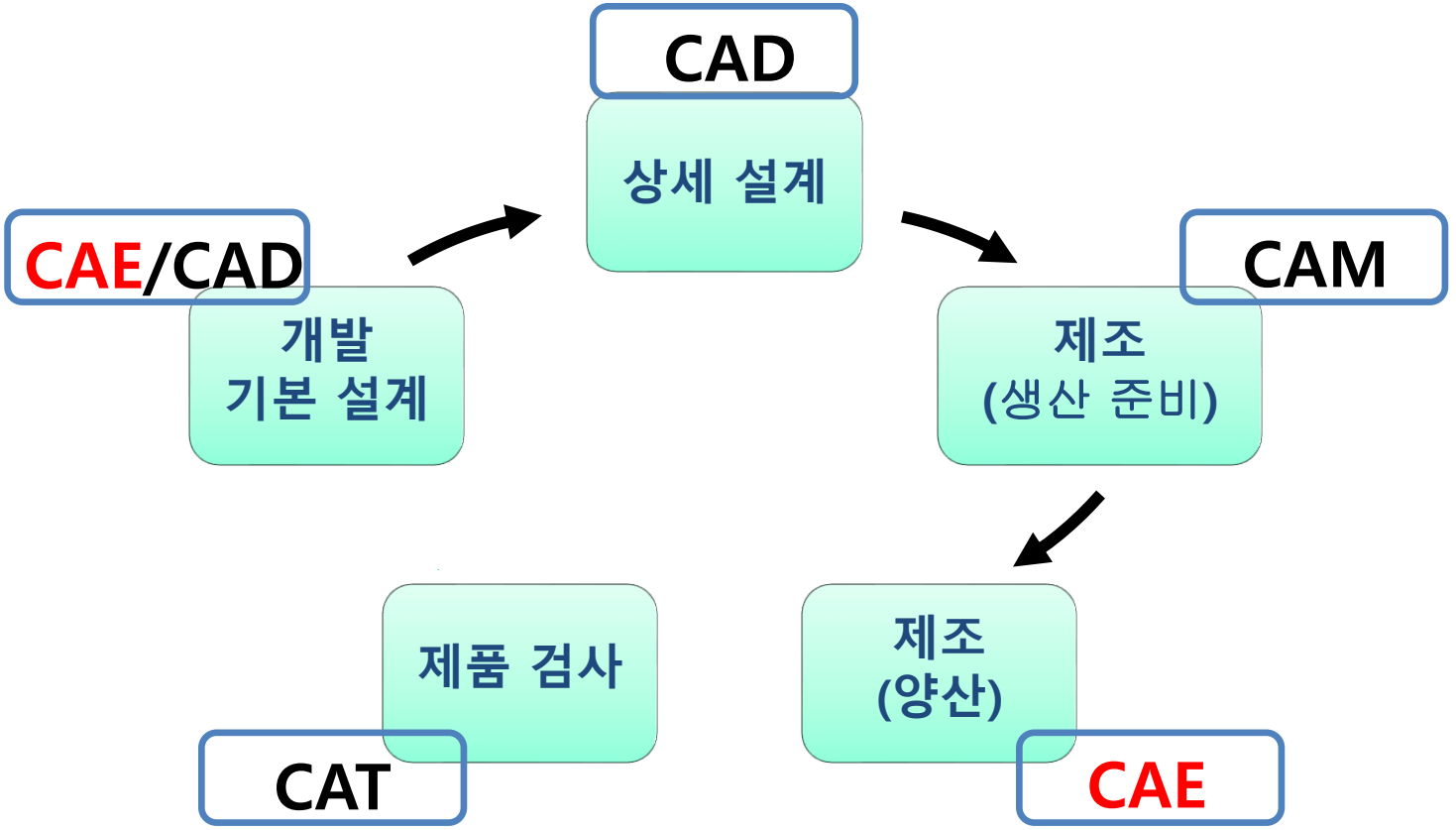
NC Tool Path to machine mold

Computer-Integrated Manufacturing (CIM)



생산공정의 디지털화 (Digital Manufacturing)

- CAD/CAE/CAM과 같은 컴퓨터에 의한 디지털 정보기술을 개발, 설계, 제조, 검사 등의 생산 프로세스에 활용



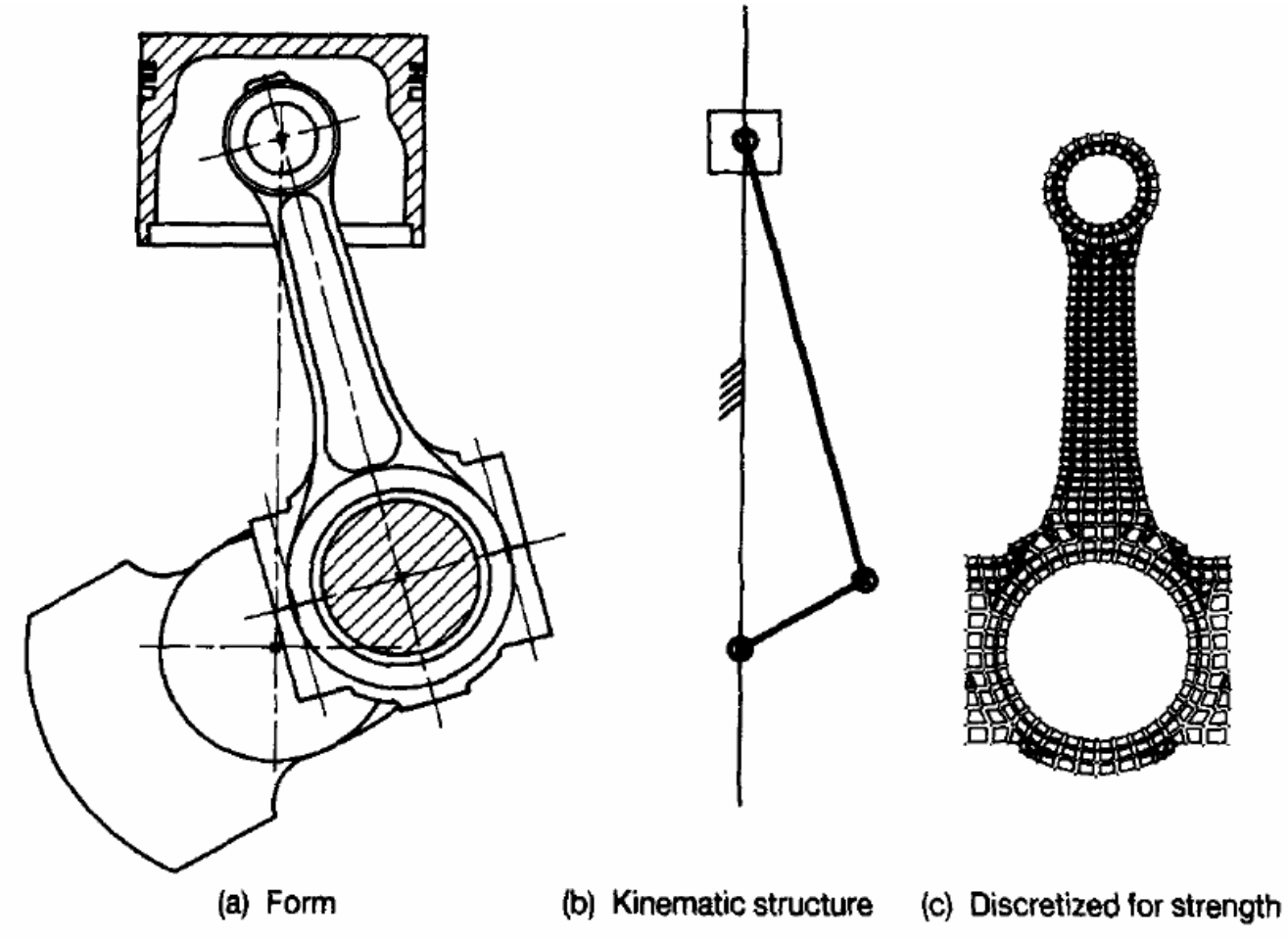
Modeling, Model

- 모델링 (Modeling)
  - 복잡한 시스템이나 현상을 단순화하여 표현하는 과정
  - 시스템의 주요 특징을 추출하고, 이를 통해 시스템의 동작이나 성능을 이해하고 예측하는 데 도움
  - 다양한 분야에서 사용되며, 공학에서는 주로 시스템 설계, 분석, 최적화에 활용
- 모델 (Model)
  - 모델링 과정을 통해 생성된 추상적인 표현
  - 시스템의 구조나 동작을 설명하며, 이를 통해 시스템의 성능을 평가하거나 예측
    - 물리적 모델: 실제 물리적 객체로, 시스템의 동작을 시각적으로 보여줌
    - 수학적 모델: 수학적 방정식으로 시스템의 동작을 설명
    - 컴퓨터 모델: 컴퓨터 시뮬레이션을 통해 시스템의 성능을 분석

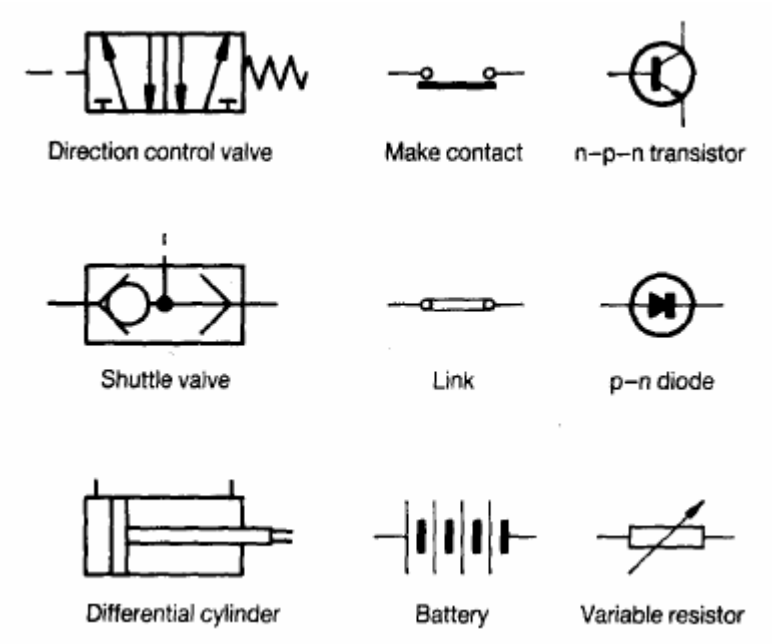
Kinds of Design Models

- Product development models
  - Generic product knowledge (design process models)
  - Product models (geometric & non-geometric)
  - Generic mfg process models (with physics-based and economic models)
  - Factory models (specific instances)
- Non-geometric models
  - wiring schematics
  - hydraulic piping diagrams
  - flowcharts
  - graph-based models

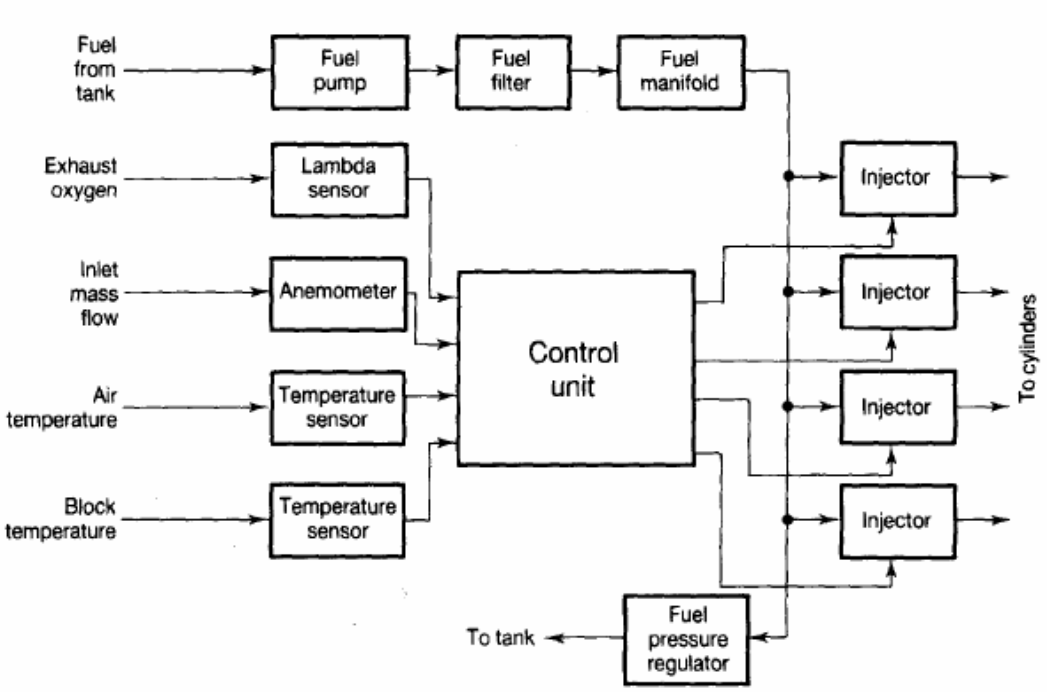
Different Design Models of Same Component



Some Non-geometric Models



Hydraulic Components

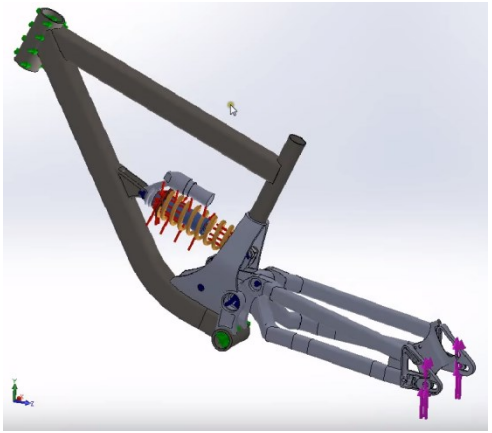


Control System Flowchart

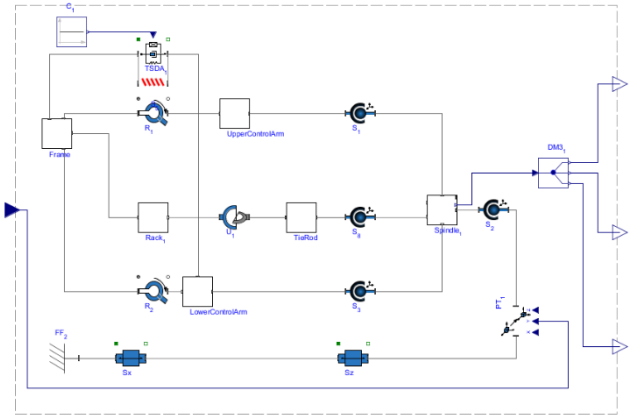
CAD vs. System Modeling

	CAD Modeling	System Modeling
Model	detailed 3D assembly model, complete with electric components, standard mechanical parts, wire harnesses and manufacturing information	schematic (mostly 2D) representing the data flow, input-output relationship and component hierarchy that depict the inner workings of a vehicle, plane, robot, plant or another complex system
Input	wall thickness, extrusion lengths, trim angles and other values that define the geometry of the design (geometric values and component shapes)	fan speed, valve modulation, temperature and power
Simulation	studying how stress, pressure and forces would affect the integrity of the design (mechanical behaviors)	computing the effects of varying inputs on the overall structure of the design

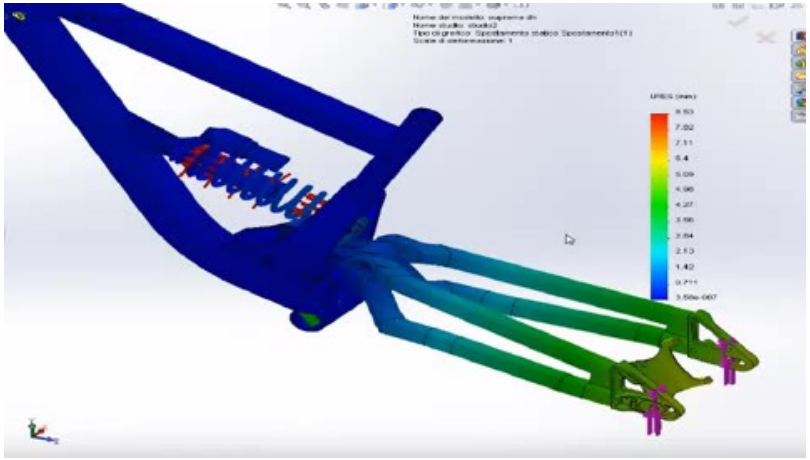
CAD vs. System Modeling: Component

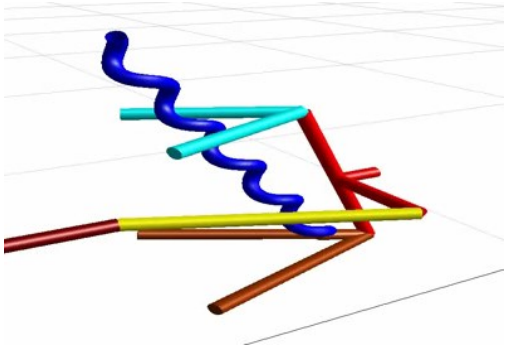


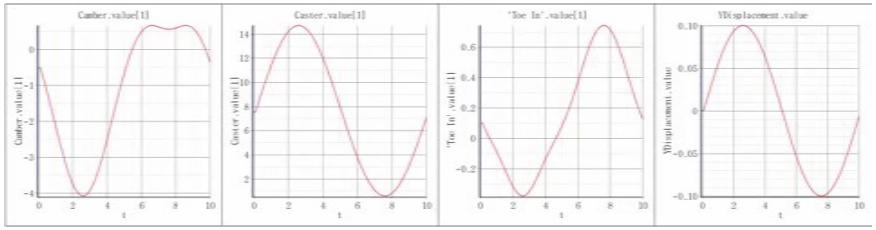
3D Geometric Model



1D Model

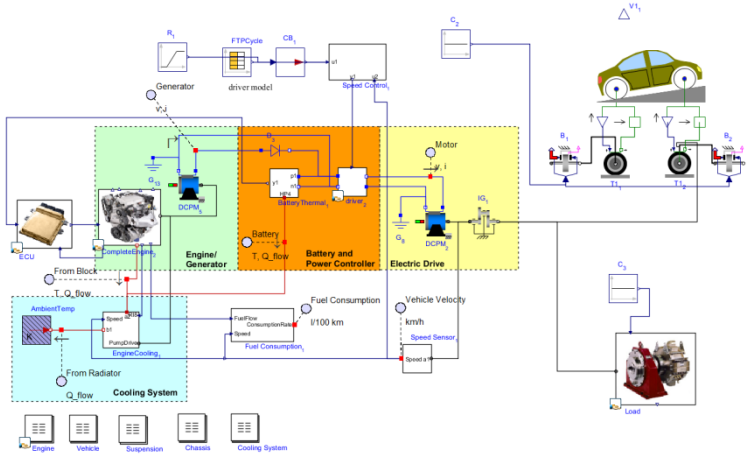




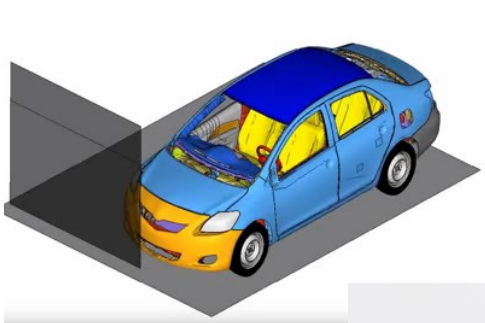


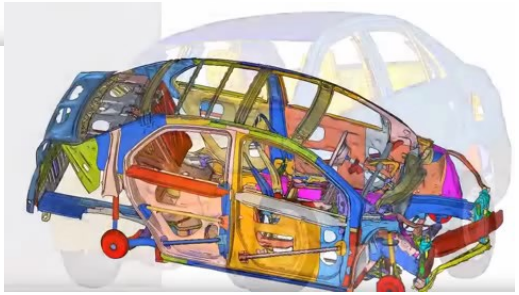
CAD vs. System Modeling: Vehicle

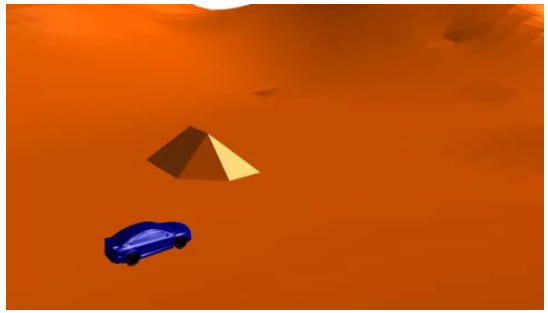
3D Geometric Model

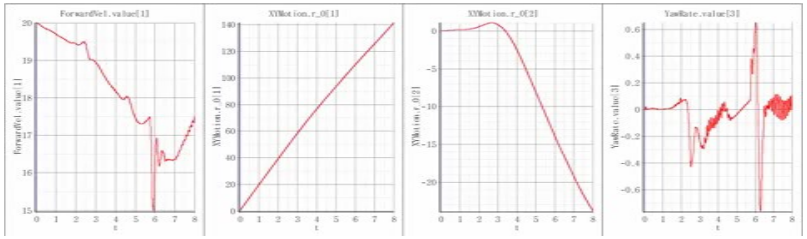


1D Model



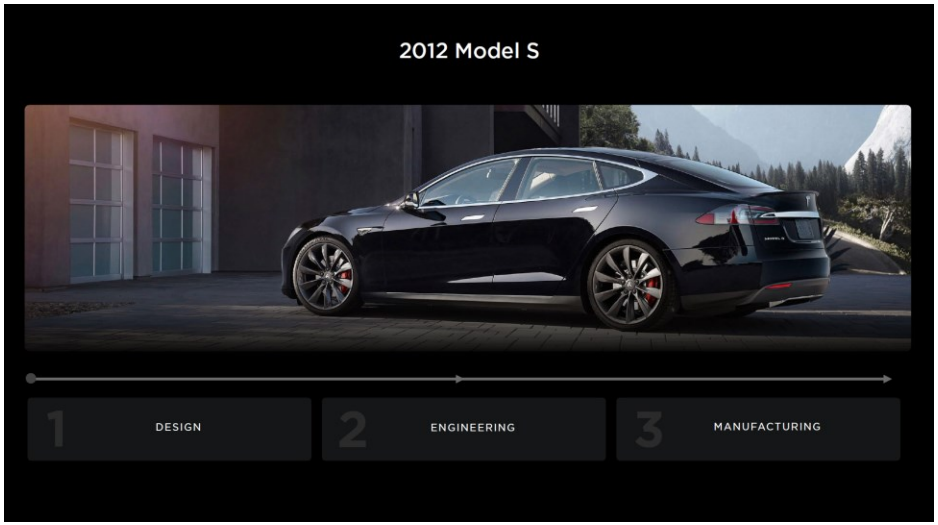


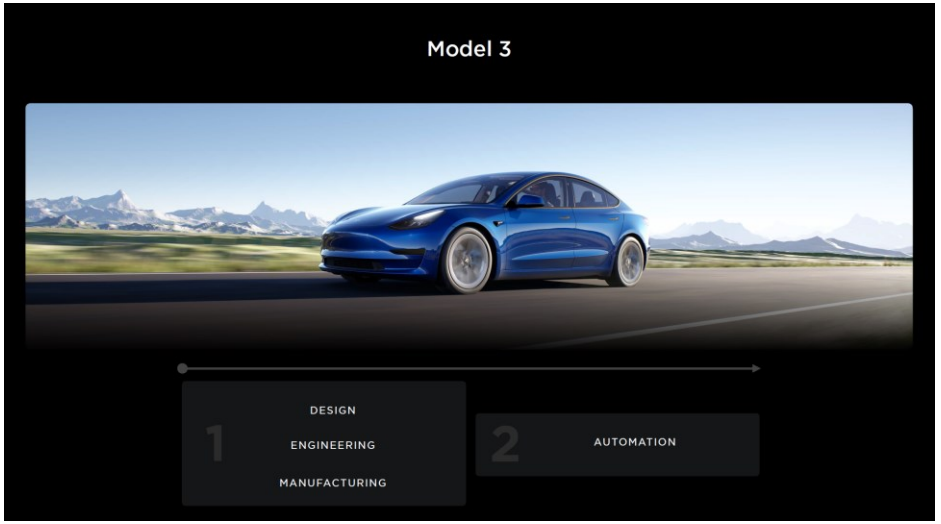


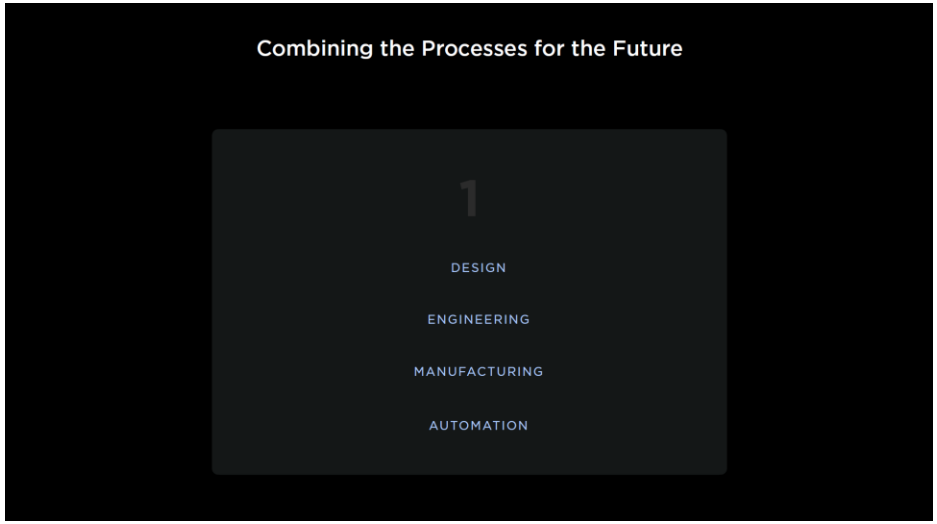


2023 investor Day (2023.03.01)

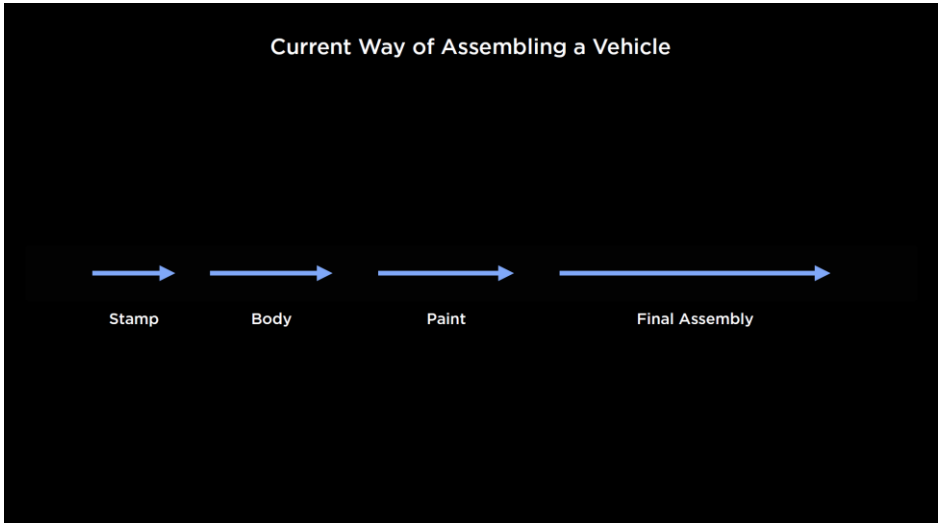
Vehicle Design

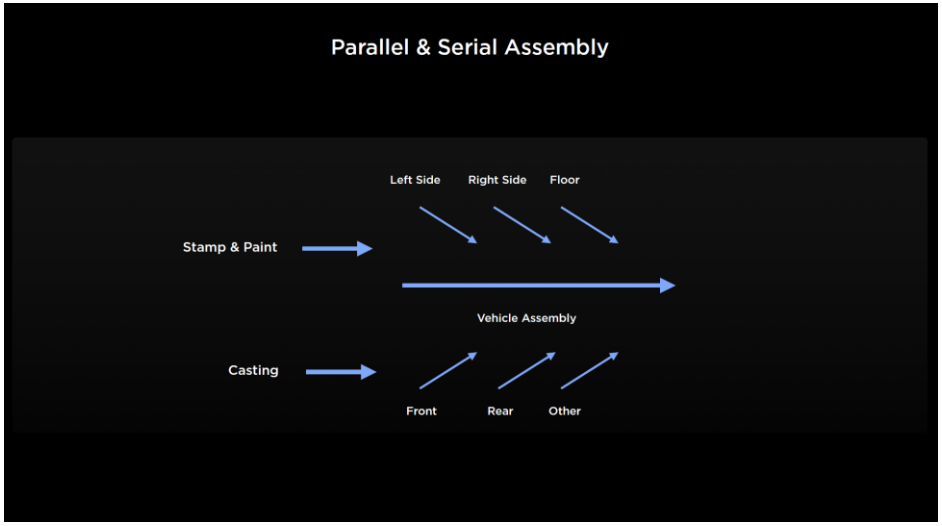


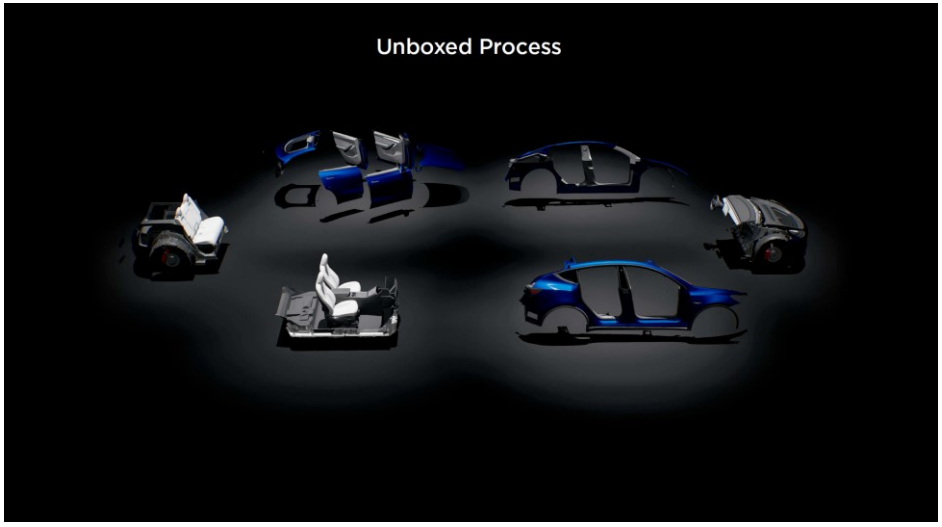




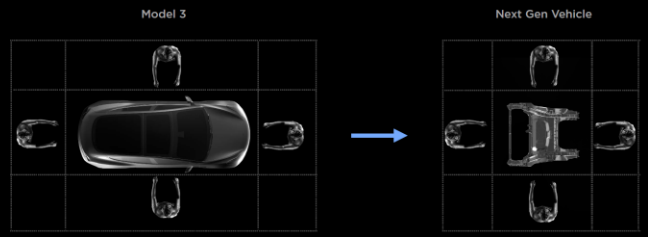
Vehicle Manufacturing & Assembly







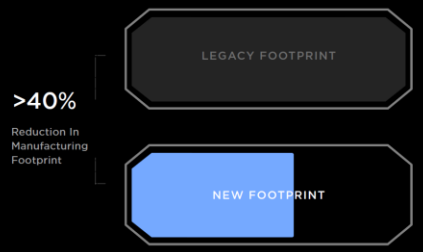
More People Can Work Simultaneously on Next Generation Vehicle



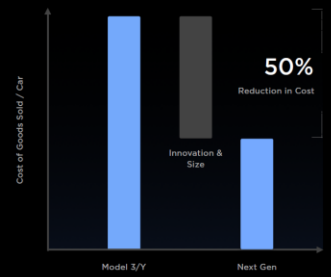
44%
Operator Density Improvement

30%
Space Time Efficiency Improvement

Next Generation Vehicle Manufacturing Efficiencies

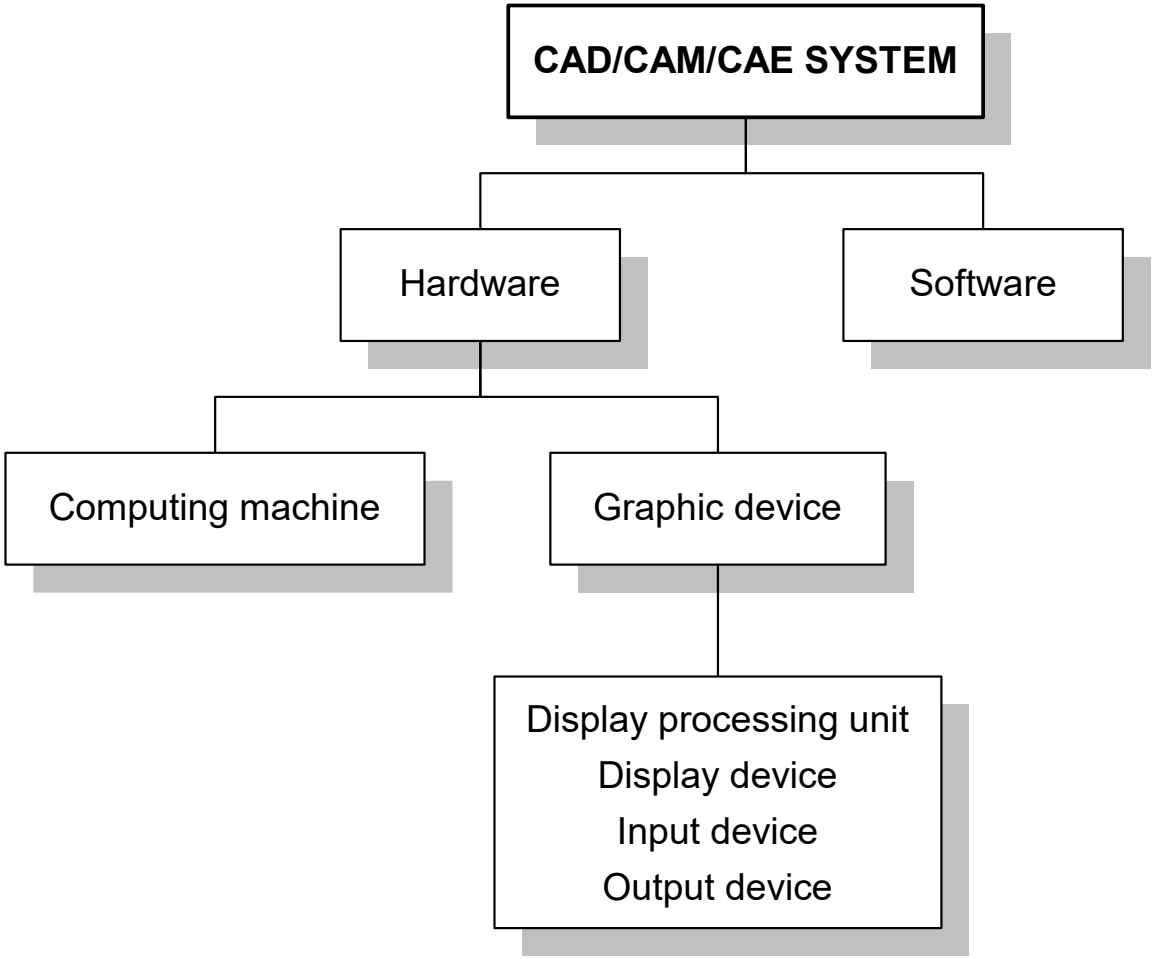


>40%
Reduction In Manufacturing Footprint



50%
Reduction in Cost

Components of CAD/CAM/CAE Systems

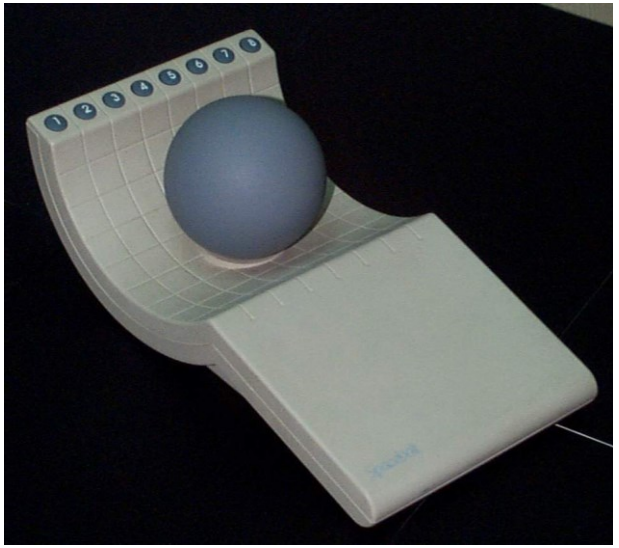


Input Devices (1)

- To locate points and lines: cross-hair cursors on the screen
- To select menu items
- To manipulate parts of constructed images

Mouse

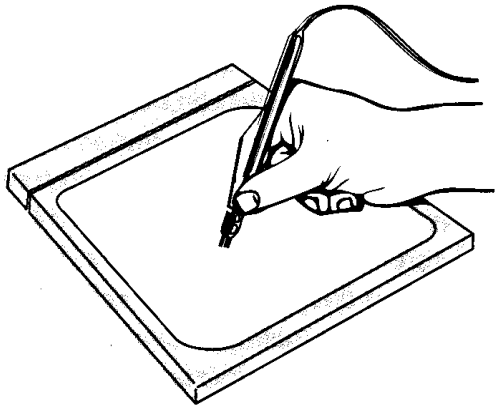
Data tablet with
a puck and a stylus



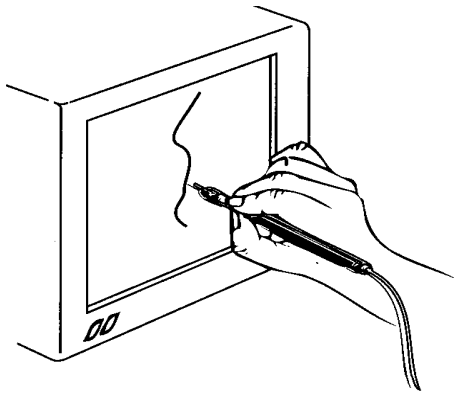
Space ball

Input Devices (2)

- Digitizer



- Lightpen



- Touch-sensitive screens

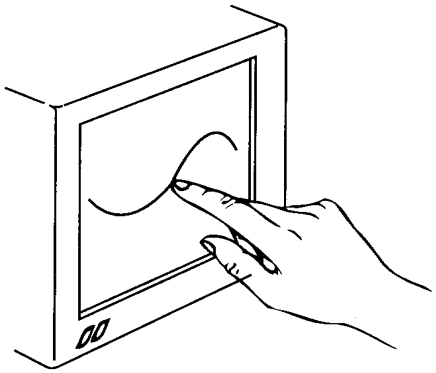


Image scanner

Joysticks, trackball

Input Devices (3)

- Keyboard
- Mouse
- Trackball
  - A 2D input device, usually used on a mouse or a laptop computer
- Space ball
  - Hand held, non-movable; It uses a strain gauge to detect pull, push and twist applied to the ball, and translate them into 3D locations; used for navigation in virtual environments, CAE, etc.
- Head Mounted Display
  - Although it is primarily a display device, it can also track position and orientation
- Joystick
  - Similar to the space ball, can be movable and non-movable

Input Devices (4)

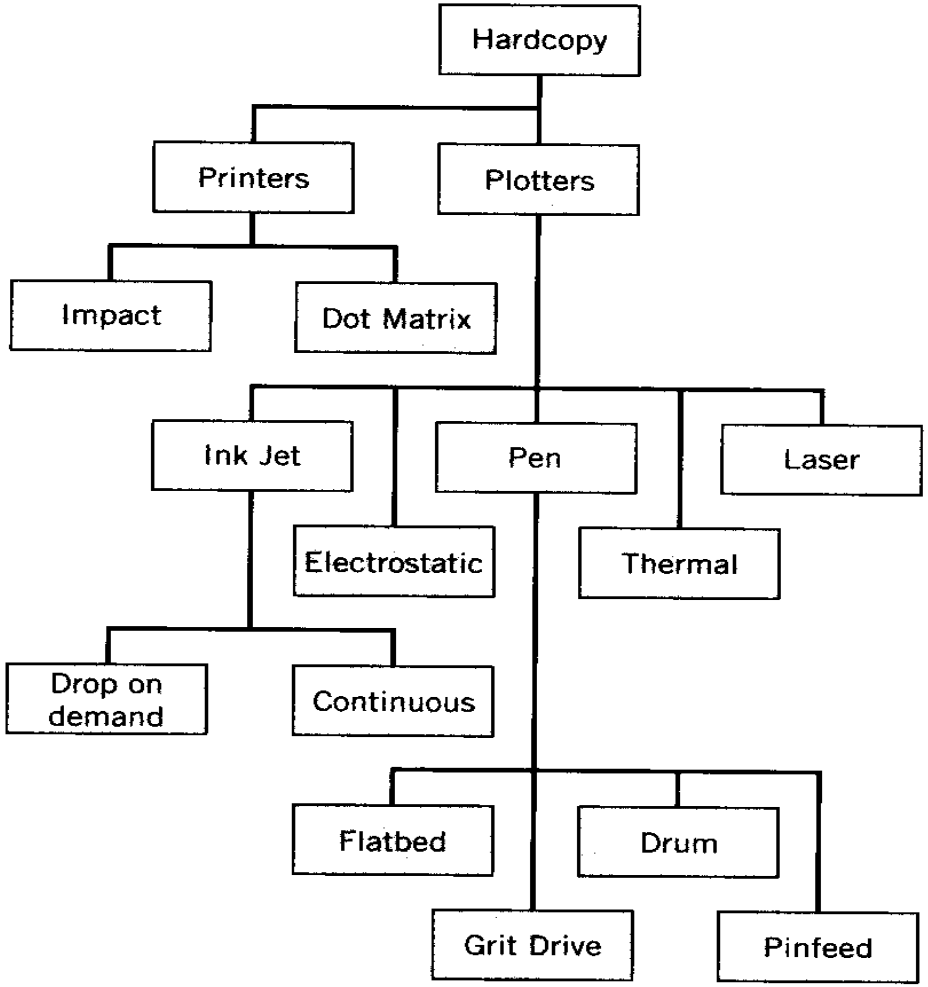
- Data globe
  - A globe with sensors, used to control virtual hand for grasping, dropping and moving an object in a virtual environment
- Image scanner
  - Input still picture, photo or slides as images into computer
- Touch panel
  - Highly transparent and embedded over a display surface
- Digital camera
  - Directly stores photo shots as images on a diskette
- Digital video recorder
  - Input a video clip in digital form; often used for teleconferencing

Input Devices (5)

- Laser range scanner
  - Input discrete and scattered points on a 3D surface model from which a digital one can be built
- Motion capture
  - Input full-body, facial, hand movements

Output Devices (1)

- Printer
- Plotter



Output Devices (2)

- Stereoscopic viewing glasses
  - User wears them to perceive stereoscopic view of 3D scenes displayed on screen
  - Used in screen-based Virtual Reality (VR)
  - High resolution, limited head-movement
- Head-mounted display (HMD)
  - Two small TV screens are embedded in a rack and placed in front of the two eyes
  - It allows full-freedom head movement and gives the feel of immersion
  - Widely used in Virtual Reality (VR)

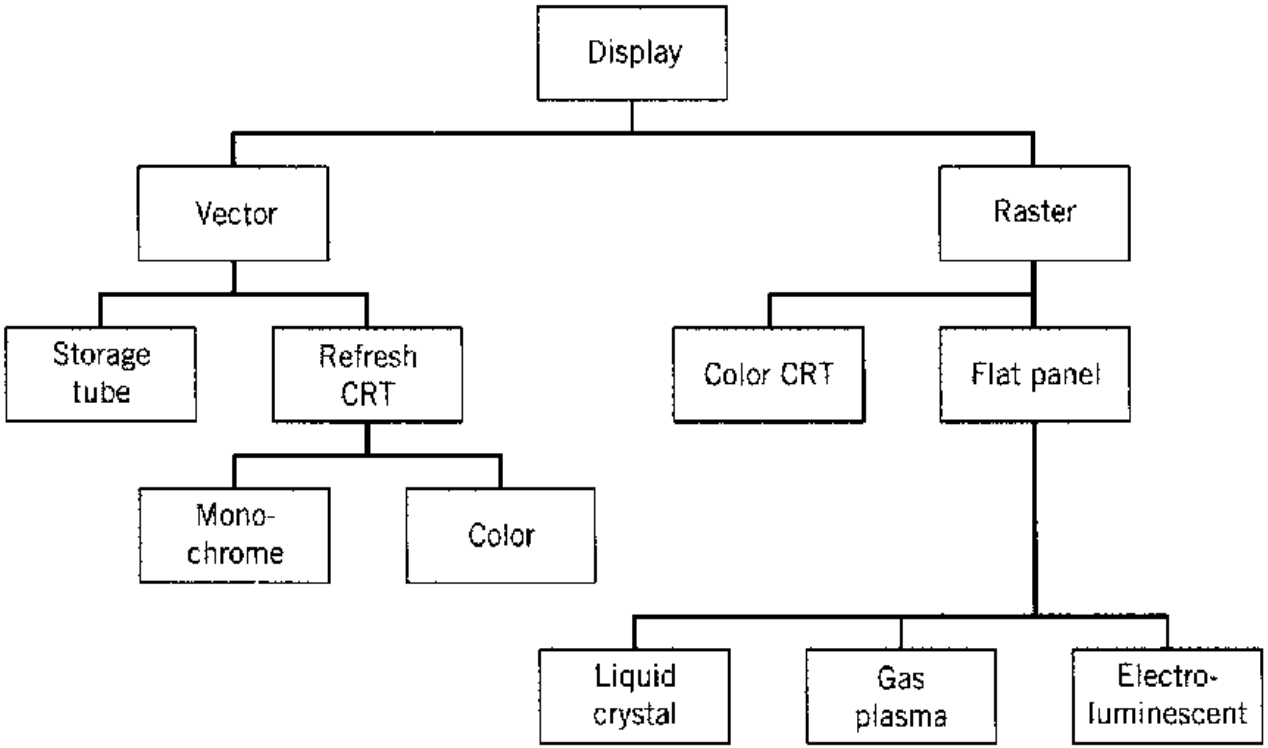
- Wide screen

I/O Devices for Virtual Reality

- Graphics display changes dynamically in response to body motion
  - Headset (provides Window), Glove
- Haptic technology
  - 컴퓨터의 기능 가운데 촉각과 힘, 운동감 등을 느끼게 하는 기술

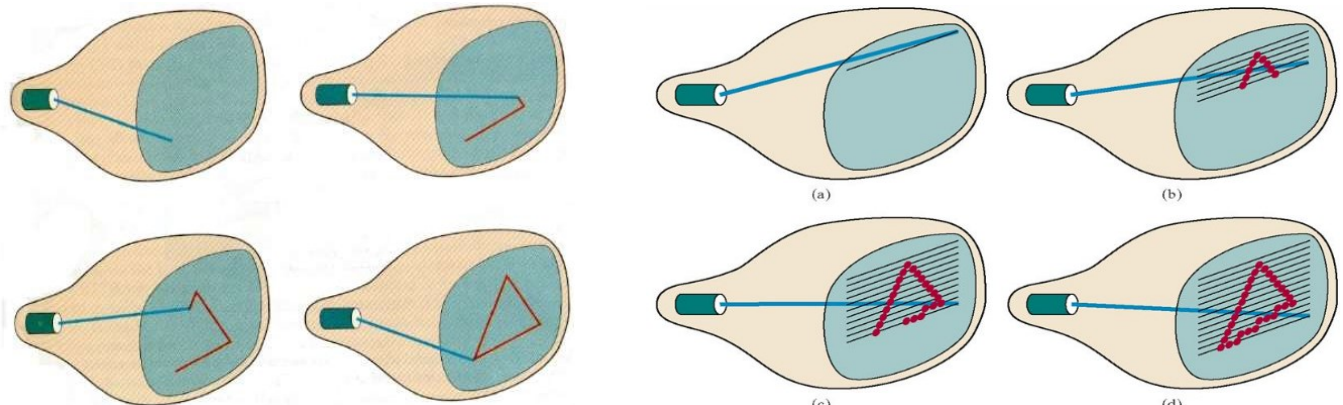
Graphics Display Devices

- Memory requirement
- Method of refresh

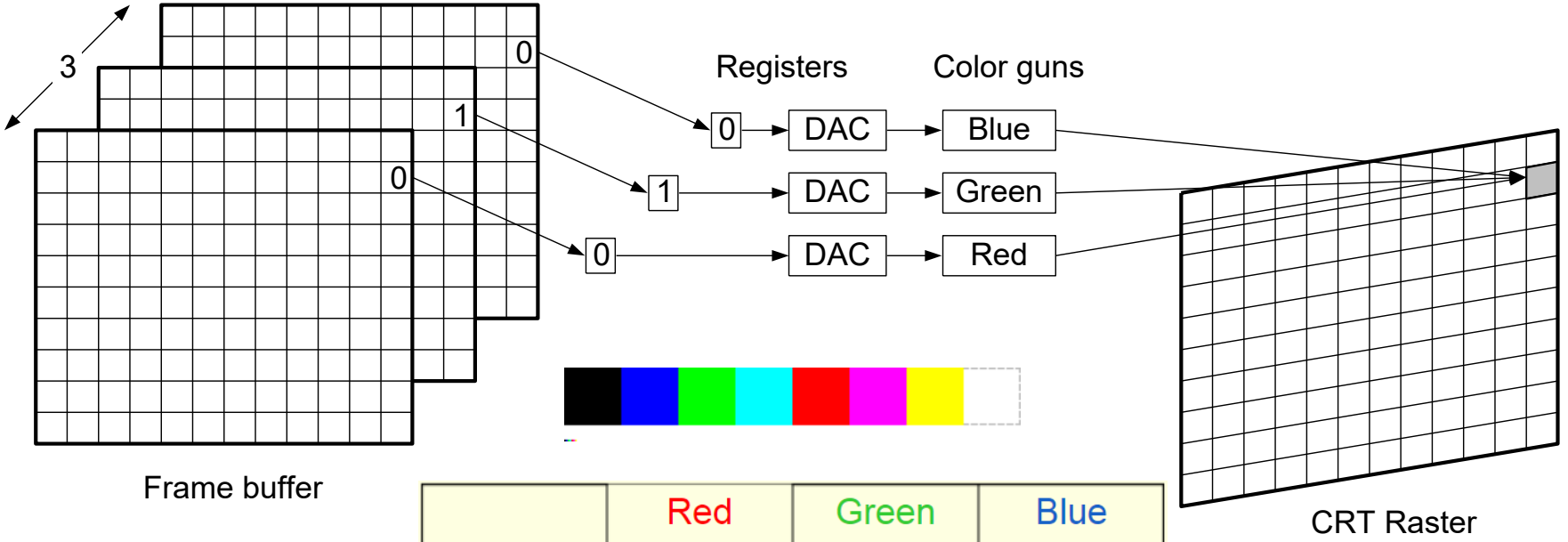


Vector vs Raster CRT (Cathode Ray Tube)

- Vector displays
  - A list of line endpoints was used to move the electron beam along some random path, so called vector scan
- Raster displays
  - (TVs etc.) drive the beam in a regular pattern called a raster scan
- Vector displays are almost extinct
- Scan conversion
  - Convert geometric primitives from vector scans description (endpoints etc.) to raster scan descriptions (Sets of pixels to turn on)



Colors of 3 Bit Planes (Frame Buffers)

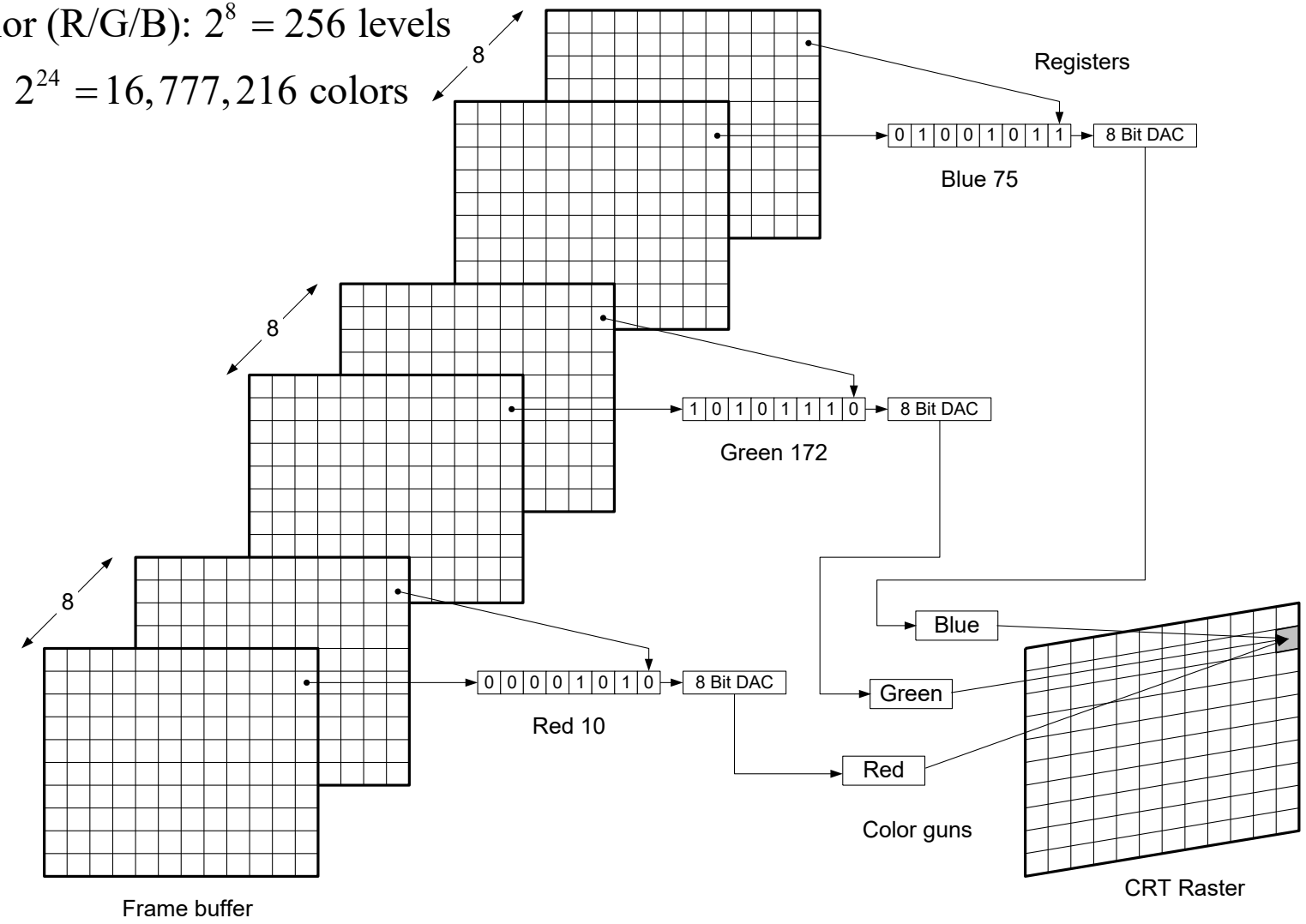


	Red	Green	Blue
Black	0	0	0
Red	1	0	0
Green	0	1	0
Blue	0	0	1
Yellow	1	1	0
Cyan	0	1	1
White	1	1	1

24 Bit Planes

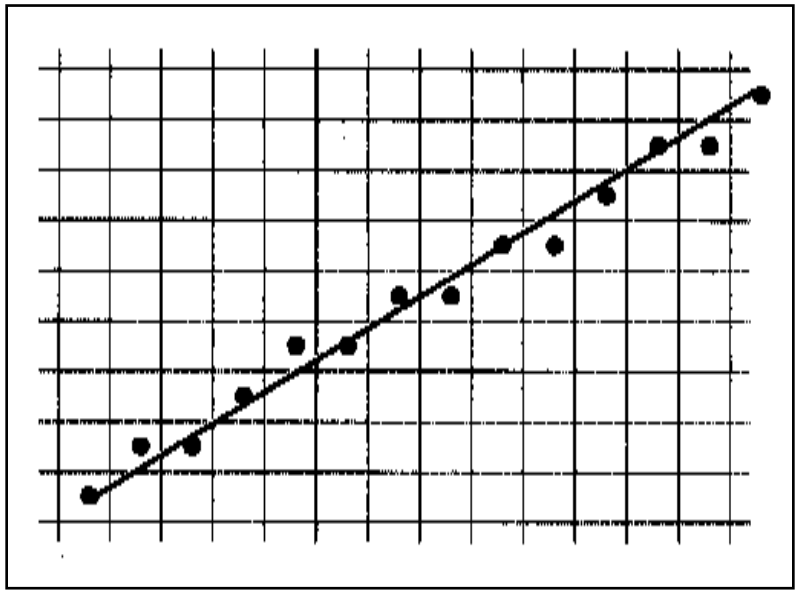
each color (R/G/B): $2^8 = 256$ levels

$\rightarrow$ total: $2^{24} = 16,777,216$ colors



Aliasing Effect

- Highlights pixels in the proximity of the line
- “Stair-stepped” appearance of diagonal lines
- Reduce the problem using various intensity levels to blend the edges of lines



Flat Panel Displays

- Emissive display (or emitters)
  - Device that convert electrical energy into light
    - Plasma Display Panel (PDP): Generates light through electrical discharge in individual cells
    - Light Emitting Diode (LED): Uses an LED matrix to produce light at each pixel
    - Organic Light Emitting Diode (OLED): Employs organic material to emit light at each pixel, offering high contrast and fast response times
- Non-Emissive display
  - Use optical effect to convert sunlight or light from some other source into graphics patterns
    - Liquid Crystal Display (LCD): Relies on external light to display images at each pixel

Image File Formats (1)

format	name	year	characteristics
BMP	Bitmap	1980s	uncompressed representation, large file sizes
TIFF	Tagged Image File Format	1986	lossless compression, popular in the printing industry
GIF	Graphics Interchange Format	1987	supports animations and transparency lossless compression that is limited to limited color palettes
EPS	Encapsulated PostScript	1987	raw and uncompressed image data directly from the camera
JPEG JPG 2000	Joint Photographic Experts Group	1992	compresses images using a lossy method and enables high quality with relatively small file sizes
PDF	Portable Document Format	1993	Adobe, versatile format that can store not only images but also texts and other elements
PNG	Portable Network Graphics	1996	lossless image format that supports transparency, graphics, logos, and images with clean lines and texts
SVG	Scalable Vector Graphics	1999	uses XML to represent images, which means they can be scaled to any size without losing quality
WebP		2010	Google, combines lossy and lossless compression, designed for the web and offers small file sizes and good image quality
HEIC	High Efficiency Image File Format		Apple, efficient compression and delivers high image quality with smaller file sizes
PSD, AI, INDD			Adobe Photoshop, Illustrator, InDesign
RAW			raw and uncompressed image data directly from the camera

Image File Formats (2)

- Scalability: Raster vs. Vector
- Compression: lossless vs. lossy
- Size: pixel, DPI(dot per inch), image size