# EP1000
Laser Cutting

Computer Controlled Cutting

- Also known as CNC (Computer Numerical Control)
- CAD provides the necessary data from design files
    - Controls cutting of material
    - Controls marking of material
- Very precise and repeatable
- Methods:
    - Laser Cutting and Engraving
    - Large format routing systems (using a mill)
    - Cardboard and paper cutting and folding
    - Plasma cutting, Waterjet
    - Vinyl Cutting

Laser cutting

Mirror

Laser beam

Lens

Air assist
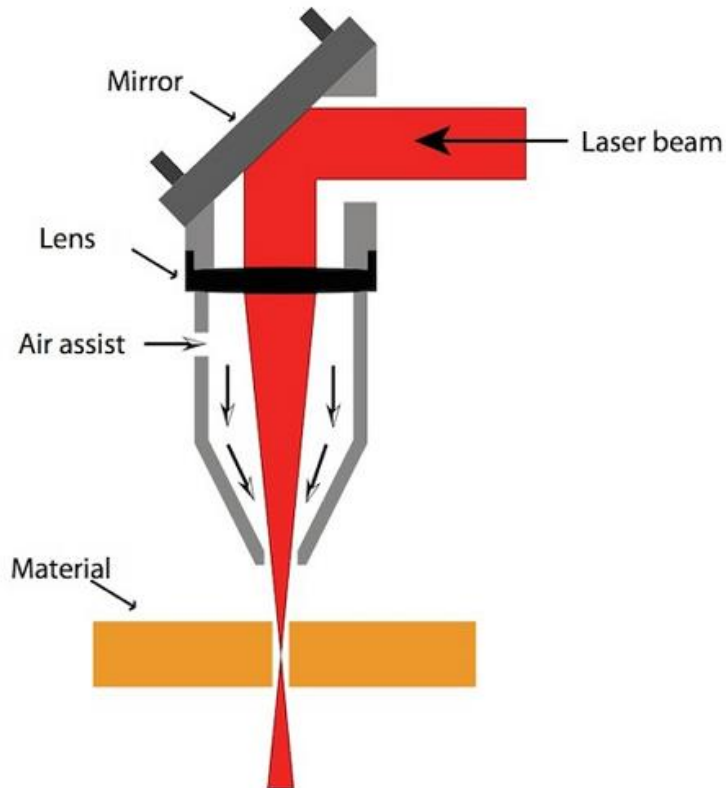
Material

- Laser is focused on the material
  - To cut through
  - To engrave / mark
- Laser ionises the material
- Air-assist removes the ionised material
- Suction removes the material and wastes to a HEPA filter
- Movement of the head by motors, controls the cutting operations

Light **A**mplification by **S**imulated **E**mission of **R**adiation

Types of Laser cutters

- CO_2 (Carbon Dioxide) Lasers
    - CO_2 gas mixture stimulated electrically
    - Suitable for non–metallic materials – wood, acrylic, glass, paper, textile, plastics, foils & films, stone

- Fiber Lasers
    - Solid state lasers which are amplified in gas fibers.
    - Suitable for cutting/marking thin metals, coated metals, plastics

- Nd:YAG, Nd:YVO (Crystal Lasers)
    - Solid state lasers
    - Suitable of cutting/marking metals, plastics, ceramics

FablabSP lasers are CO_2 lasers

Laser cutting workflow
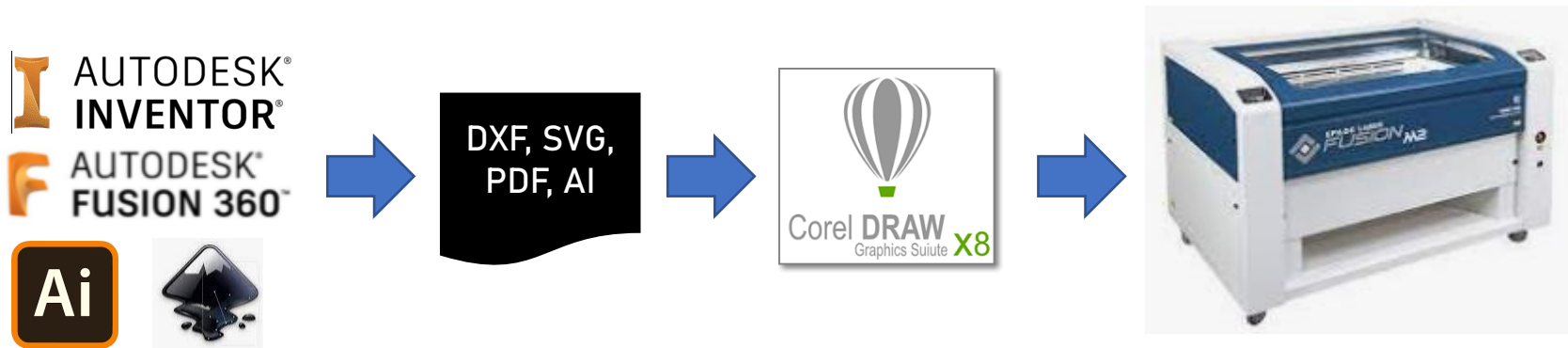
- Prepare your design using a CADD package
- Export your 2D layouts to a vector format (DXF, SVG, PDF, AI)
- Import your 2D layout into CorelDraw (or graphic editor provided with your laser cutter)
    - Confirm the necessary cut lines (hairlines)
    - Insert raster information (graphics, text) for engraving
- Send the file to the laser cutter for fabrication

CAD Process

- CAD is used to model the object
    - Provides a visual check/representation of final object
    - Able to provide tools for construction
    - Extract to obtain the 2D outline shape of construction
- Typical CAD tools
    - Fusion 360, Inventor, AutoCAD
    - Rhino
    - Blender
    - 123Make
    - Illustrator, CorelDraw, Inkscape

Vector File Formats

- Vector files are composed of a set of commands and numbers which can be used to create the CAD drawing.

- Vectors are based on formulas and scale to high resolution. E.g. a small logo can be enlarged to poster size without loss in definition or resolution.

- Vectors can be translated to machine commands which can move the cutting head of the laser to precise positions.

- Vectors are defined as "hairlines" or lines with minimal width (e.g. < 0.1mm or 0.01mm). These will be translated to cut lines.

CorelDraw

- Most Laser cutters use a Vector/Raster graphic application as the interface for laser cutter.
  - Able to translate vector hairlines into "cut" lines
  - Able to translate raster graphics into "engravings"
- Most common platform: CorelDraw
  - Imports most vector formats DXF, AI, SVG, EPS, PDF
  - Able to perform vector and raster graphics manipulations
  - Able to send cut/engrave file to the laser cutter for fabrication using a printer driver
- Control of the laser is done with the vendor's driver application.
- Alternatives: Inkscape, Adobe Illustrator

Preparing your cut/engrave file

- Import your vector file into CorelDraw
  Tip: you can arrange your cuts into a single DXF file to save time on the laser cutter pc.

- Select all cut lines and change the width to hairline.

- Add raster graphics for engraving:
    - Text
    - Graphics (e.g. photos, patterns)

- Tip: Use colors to change the engraving power of the raster

- Send the completed file to the laser cutter, configuration of the laser cutting/engraving is done by the laser cutter driver.

A Keytag with Engraving
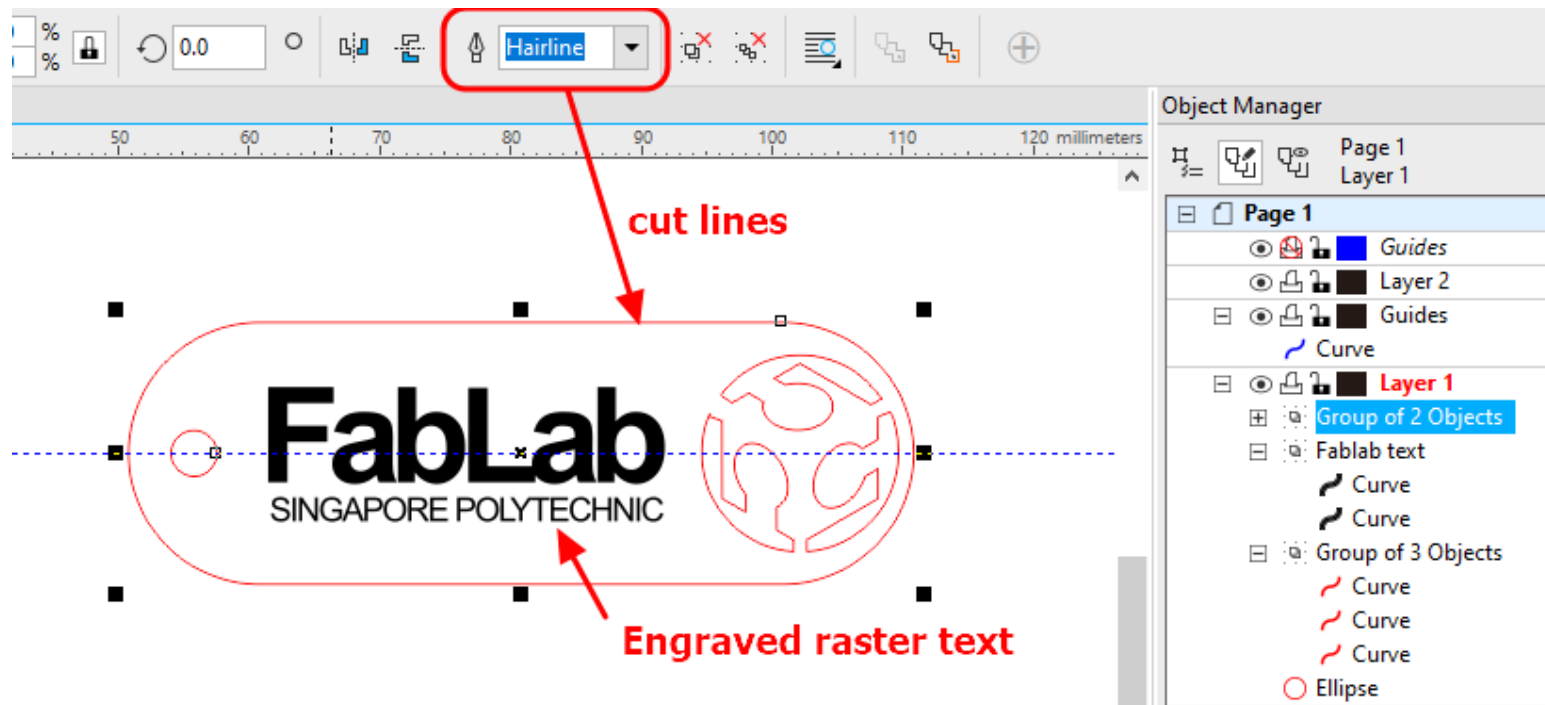
- Keytag outline was created in Fusion 360, exported as DXF and imported as 1:1 exact size.

- Fablab logo was imported as an SVG (vector) file, changed to hairline

- Fablab text was added as text and manipulated to size (raster)

Laser Safety

- Supervision at ALL times

- Class 1 with safety interlock

- Venting of fumes, adequate air flow, HEPA filtration

- Regular cleaning of optics

- Cutting of ONLY recommended materials

- In case of Hazard
  - Fires during operation
  - E-stop FIRST!
  - ASSESS situation below using fire extinguisher

The laser cutter is a potentially dangerous machine. It is very easy to start fires with the laser cutter. The laser cutter can also produce dangerous fumes (e.g., chlorine) if used with improper materials.

People **must** receive training prior to use of the laser cutter. The cutter must also remain under constant supervision while in use. This document is very partial, and does not constitute training. Please contact shop-admin@cba.mit.edu for further information.

What can happen when you leave a laser cutter unsupervised

Particular warnings:

Never cut PVC, or other chlorinated plastics (Lexan and PC board are also strongly discouraged). PVC in particular will give off chlorine gas, which is not only highly corrosive to the machine, but also dangerous for any nearby people.

Constant machine supervision really is a must. E.g., with our own machine, in the middle of a cut, I observed the laser begin etching the internal walls of the machine, and igniting the rubber rollers of the laser cutter head. It turned out that a primary mirror had fallen off, and the 100 watt laser beam was reflecting off the skewed and moving mirror. Had the machine not been under supervision, this might have resulted in a serious fire.

Materials Laserable

- Cardboard

- Wood

- Acrylic

- Delrin

- Fabric

- Ceramic

- Glass

- Flame Test: if it flames it should not be cut

Epilog: Laserable Materials

Prohibited

- PVC

- Pleather

- Moleskin

- Polycarbonate

- Polystyrene foam

- Fibreglass

- Carbon Fiber

Full Spectrum: Materials banned from laser cutting

Laser Cutter Settings

- Power
    - Higher power cuts deeper (may melt material)
    - Try not to use 100% power levels
- Speed
    - Higher speed, moves the laser head faster over material resulting in shallow cuts
    - Too low speeds may melt material
- Frequency (PPI)
    - Use higher Pulses Per Inch for dense material
    - Wood (100~300 PPI), Acrylic (700~900 PPI)

Epilog: Acrylic Recommend settings

Fusion Series Suggested Material Settings (CO2)

Material	DPI/Freq.	30 watt	40 watt	50 watt	60 watt	75 watt	120 watt
Acrylic							
Photo Engraving	300 DPI	90s 60p	90s 55p	90s 50p	90s 45p	90s 40p	90s 30p
Text/Clipart Engraving	300 DPI	90s 80p	90s 75p	90s 70p	90s 65p	90s 60p	90s 55p
Text/Clipart Engraving	600 DPI	90s 75p	90s 70p	90s 65p	90s 60p	90s 55p	90s 50p
Cutting 1/8" (3 mm)	100 f	5s 100p	6s 100p	7s 100p	8s 100p	10s 100p	12s 100p
Cutting 1/4" (6 mm)	100 f	2s* 100p	3s* 100p	1s 100p	2s 100p	3s 100p	7s 100p
Cutting 3/8" (9.5 mm)	100 f			2s* 100p	3s* 100p	1s 100p	3s 100p
Cutting 1/2" (13 mm)	100 f						1s 100p

Cutting Note: Adjusting the standard focus distance so it is closer to the lens by about .080" (2 mm) will produce better edge quality when cutting 1/4" (3mm) acrylic and thicker. Two passes can be used for cutting thicker materials. There are two types of acrylic: cast is better for engraving (it creates a frosted look when engraved) and extruded acrylic produces a much better flame polished edge.

* The Fusion has two sets of Speed control for vector cutting applications. Checking the Speed Comp selection box in the print driver will reduce the speed setting you have selected by one half. Speed Comp is most useful for speeds of 1 to 10. Example: Cut a square at 5% speed. Then repeat the job at 5% speed and also select Speed Comp. The second square will take twice as long to cut as the first square. Speed Comp gives you more slower speed setting to work with. Always use Air Assist when cutting.

Ref: [Epilog M2 Fusion Reference Manual](#)

Epilog: Wood Recommend settings

Wood					60W		
Photo Engraving	600 DPI	30s 100p	40s 100p	50s 100p	60s 100p	70s 100p	100s 100p
Clipart/Text Engraving	300 DPI	25s 100p	30s 100p	35s 100p	40s 100p	50s 100p	60s 100p
Clipart/Text Engraving	600 DPI	20s 100p	30s 100p	40s 100p	50s 100p	60s 100p	90s 100p
Deep Engraving	600 DPI	5s 100p	10s 100p	20s 100p	25s 100p	30s 100p	60s 100p
Thin Veneer (Cutting)	10 f	30s 100p	30s 80p	40s 100p	40s 100p	50s 80p	50s 60p
Cutting 1/8" (3 mm)	10 f	3s 100p	6s 100p	8s 100p	10s 100p	20s 100p	40s 100p
Cutting 1/4" (6 mm)	10 f	3s* 100p	1s 100p	2s 100p	3s 100p	5s 100p	12s 100p
Cutting 3/8" (9.5 mm)	10 f			2s* 100p	3s* 100p	1s 100p	8s 100p
Cutting 1/2" (12 mm)	10 f						3s 100p

When cutting wood, multiple passes may allow cutting of thicker materials. Using Color Mapping you can adjust the focus point between passes down to the center point of the cut for the best results.

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Epilog Settings Menu
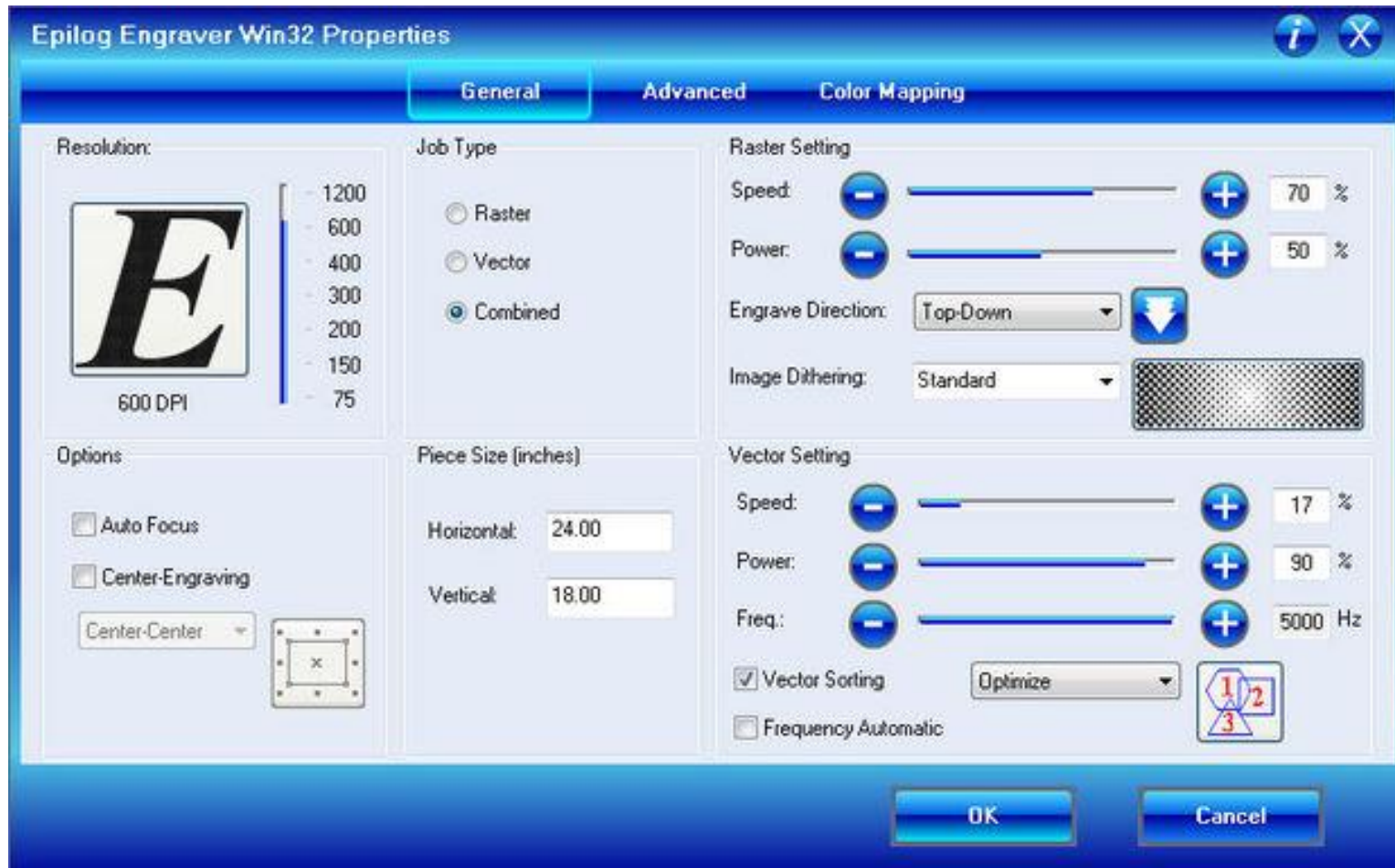
Ref: Epilog Job Manager   When in doubt, try a test cut!

EP1000
Laser
Cutting
End