# Introduction to 3D Printing

Bainbridge Artisan Resource Network

Electronic & Technical Arts Studio

# Objectives

- Learn what 3D printing is and how it works
- During class …
  - Acquire a 3D model to print
  - Prepare the model to be printed
  - Print it
- After class …
  - Be able to become certified to use BARN's 3D printing facilities on your own
  - Learn more advance techniques either through additional BARN classes or through self-guided learning (YouTube, et al.)

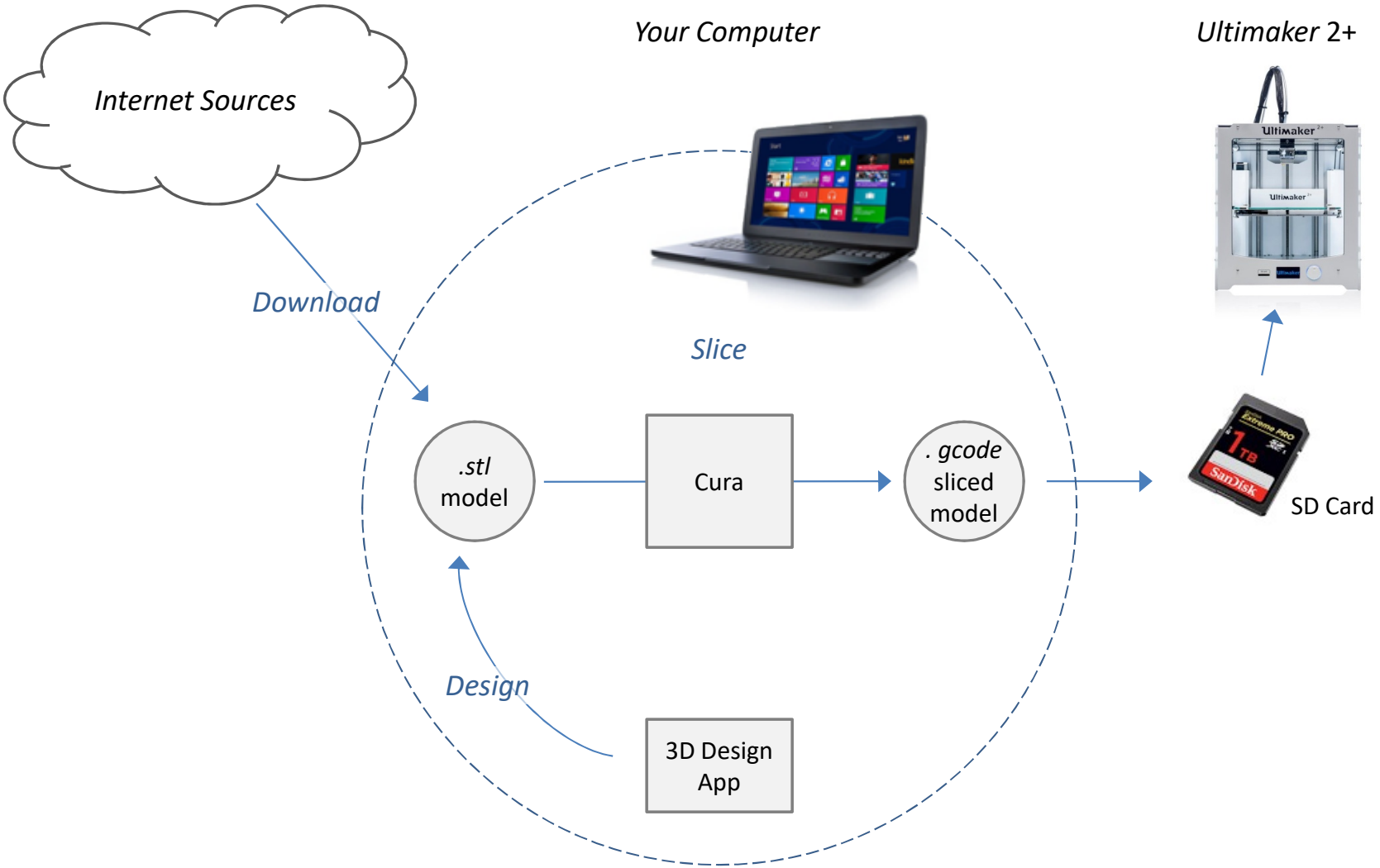
# Agenda

- 3D Printing … what it is and what it is not
- Workflow … from model to finished print
  - Preparing the model to be printed
  - Loading the file, setting-up the printer, starting the print
  - The finished results
- Additional Topics
  - Finding and downloading a model
  - Creating a model from scratch (superficially covered)

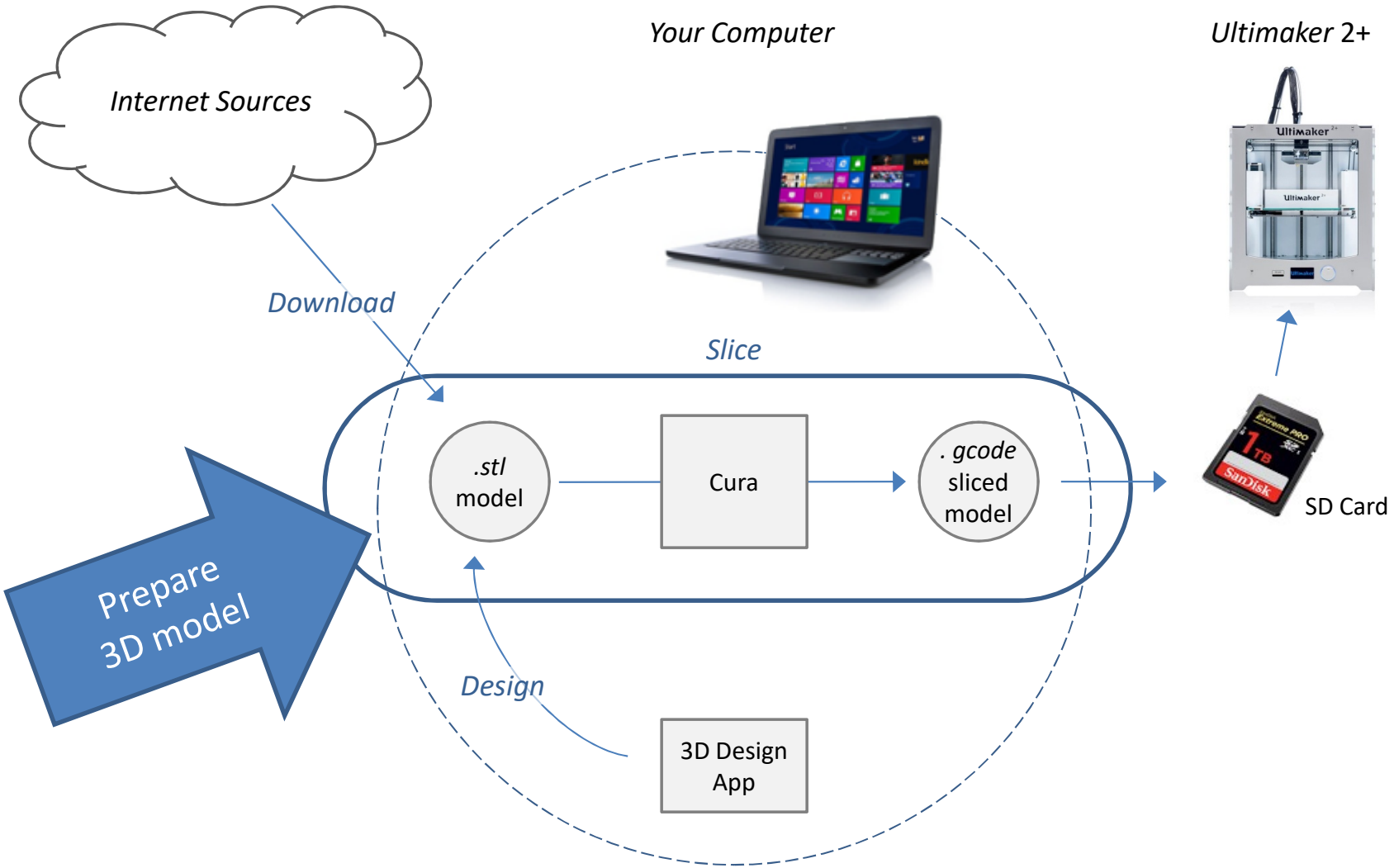
# What is 3D Printing?

- An *Additive Manufacturing* process
  - Material is added in layers
  - Wide variety of materials:  plastics, metals, glass, ceramic, food, photocurable resins, …
  - Printed through a variety of processes:  heat, lasers, ultraviolet, …
  - At the bleeding edge:  printed organs, exotic food presentation, prosthetics … limited only by imagination.
- At BARN, 3D printing is …
  - Melted plastics extruded through a heated nozzle much like a glue gun
- Misconceptions and cautions
  - You can't print everything
  - It may take some tweaking of printer settings
  - Size is limited
  - Prints can take a long time

# 3D Printer Workflow at BARN



# Prepare 3D Model for Printing



# The model file

- Computer generated file
  - ***.stl*** file type (stereolithography)
  - Almost universally used at BARN and elsewhere
- Defines the surface geometry
  - Surface is defined by linked triangles
  - Following is an *.stl* example of a sphere in different resolutions

# The Sliced Model

- Computer generated file
  - ***.gcode*** file type
  - File format supports a layer-by-layer manufacturing process
    - Originally for *subtractive manufacturing* (e.g., CNC Routing/Machining)
    - *gcode* for 3D printing is a derivative of the original gcode
- Defines how the printer should behave
  - Horizontally slices the model into layers
  - For each layer, it defines print-head movement and actions

# Slicing The Model

- A software program to convert the 3D model (.stl) into a printable model (.gcode)
- Specifies things like layer height, speeds, infill density
- There are lots of different slicer programs.
  - Cura, Slic3r, MatterControl, KISSicer
- At BARN with the Ultimaker2+, we use Cura

.stl model defines the surface geometry

Cura creates a layer-by -layer definition

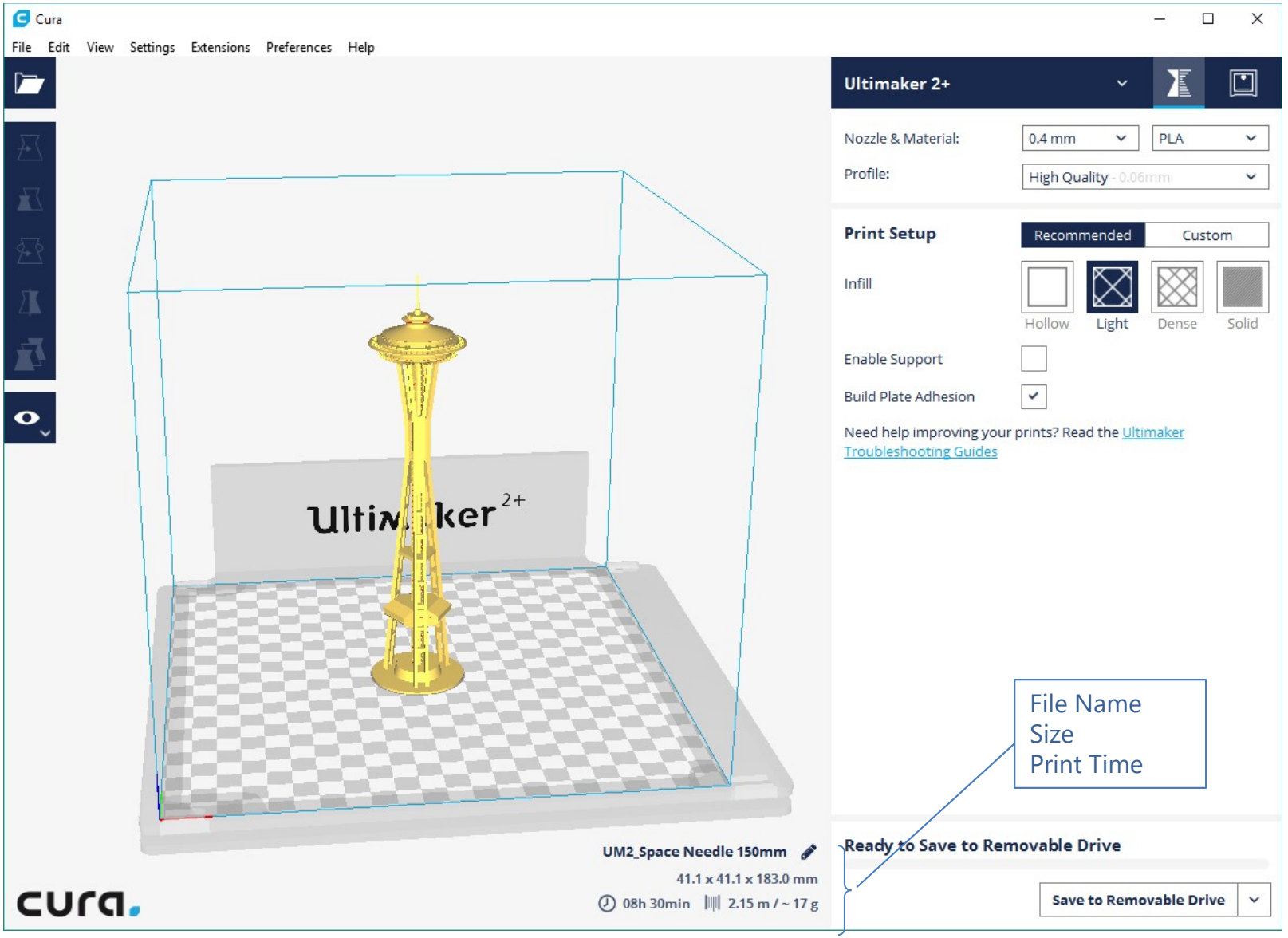
.gcode controls each level of the printing process

# Slicing The Model

- Cura needs to know about …
  - Printer and the nozzle being used
  - Material being used
- We will focus on basic settings
  - Nozzle size (0.4 mm) > preset and OK
  - Material (typically SLA) > you set
  - Profile (predefined settings) > you set
    - High Quality +++ quality print time: 3x Fast setting
    - Normal Quality ++ quality print time: 2x Fast setting
    - Fast Print + quality print time: fastest

***These settings work for the majority prints***

# Using Cura


Cura
File Edit View Settings Extensions Preferences Help
Ultimaker 2+
Nozzle & Material:
0.4 mm
PLA
Profile:
High Quality - 0.06mm
Print Setup
Recommended
Custom
Infill
Hollow
Light
Dense
Solid
Enable Support
Build Plate Adhesion
Need help improving your prints? Read the Ultimaker Troubleshooting Guides
UM2_Space Needle 150mm
41.1 x 41.1 x 183.0 mm
08h 30min
2.15 m / ~ 17 g
Ready to Save to Removable Drive
Save to Removable Drive
File Name
Size
Print Time

# Using Cura

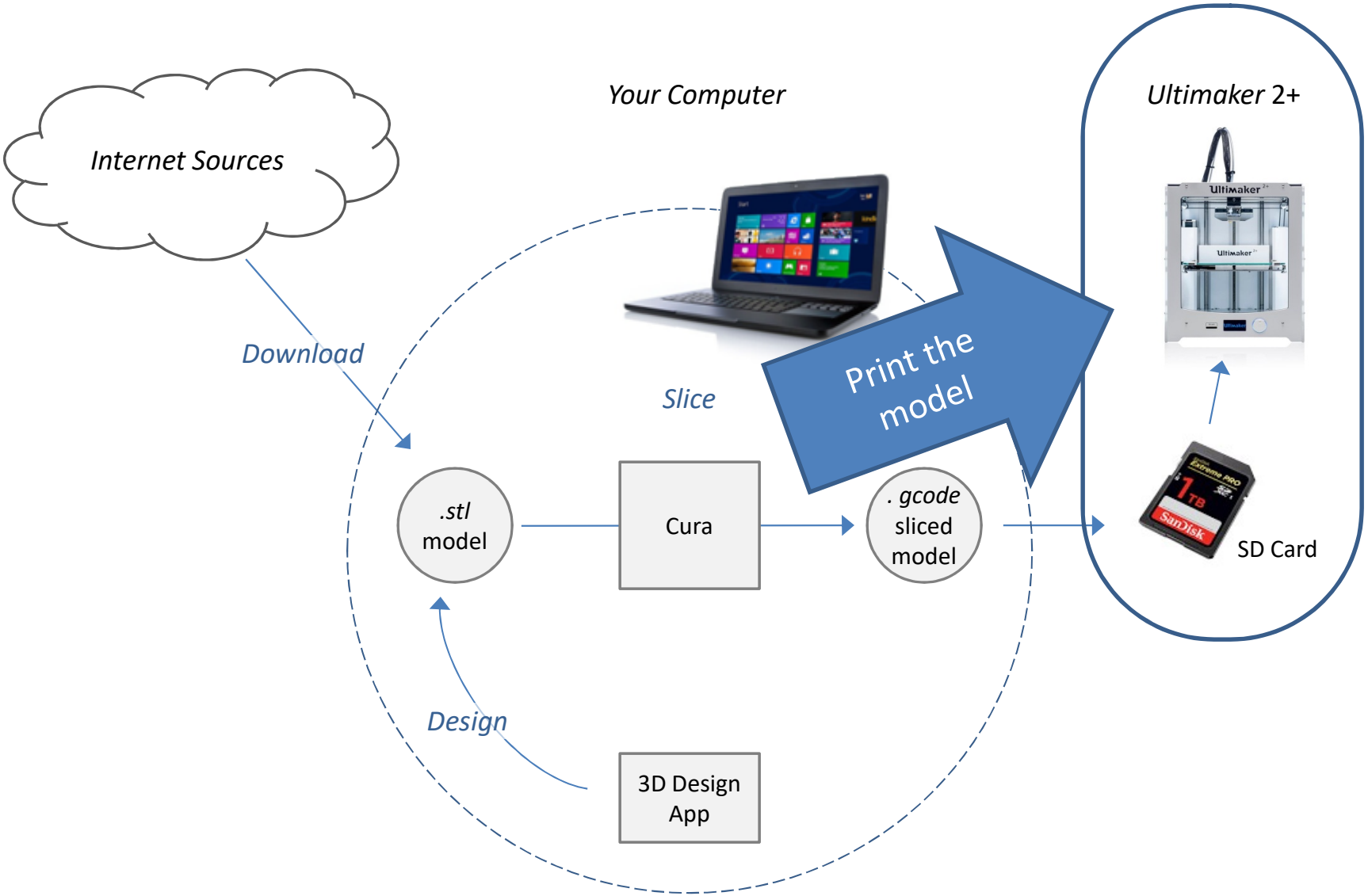
- tbd

- Model maximums
  - Maximum size is 223 x 223 x 205 mm (8.8 x 8.8 x 8.1 inches)
  - BUT the time to print this would be measured in days

- Additional resources

- Cura manual: https://ultimaker.com/en/resources/20406-installation-cura-2-1
- Cura Tutorial: https://all3dp.com/cura-tutorial-3d-printing/

# Printing the Model



# Material Used

- Material is referred to as ***Filament***
- Wide range of material types to choose from
- Three typical diameters
  - 1.75 mm, 2.85 mm, 3.0 mm
- Material type, diameter and other recommended printer settings are written on each spool

Note: The filament available for 3D printing at BARN has been provided by individual members of ETA. Unless a spool is otherwise marked, it is available to be used by a BARN member. If you plan to become active in 3D printing, please consider contributing a spool to the studio cache. You could replace a spool that is running low or add a new/novel color or material.

# Material Used

| | |
|---|---|
| PLA<br>(polylactic acid) | The most widely used; recommended for beginners. Prints fast, is safe, can be used for a broad range of models and applications. (Most commonly used at BARN). |
| Nylon<br>(polyamide) | Widely used by manufacturers for strong end-use parts and functional prototypes requiring durability and abrasion resistance. |
| ABS<br>(acrylonitrile butadiene styrene) | Frequently used. Good mechanical properties; can be used for a wide range of applications. *Requires ventilation during printing. |
| CPE<br>(co-polyester) | Chemical resistant, relatively tough material widely used for functional prototyping and modeling. |
| PVA<br>(polyvinyl alcohol) | Used to create water soluble support structures to achieve complex geometries. |
| PC<br>(polycarbonate) | Very strong and tough material used for various engineering applications. |
| TPU<br>(thermoplastic polyurethane) | Semi-flexible; used in a wide variety of engineering projects where easier and faster printing is more important than aesthetic qualities. |

More details at all3dp.com: 3D Printer Filament Guide & Comparison

# Setup Printer

- Load SD Card
  - tbd
- Load Material
  - tbd

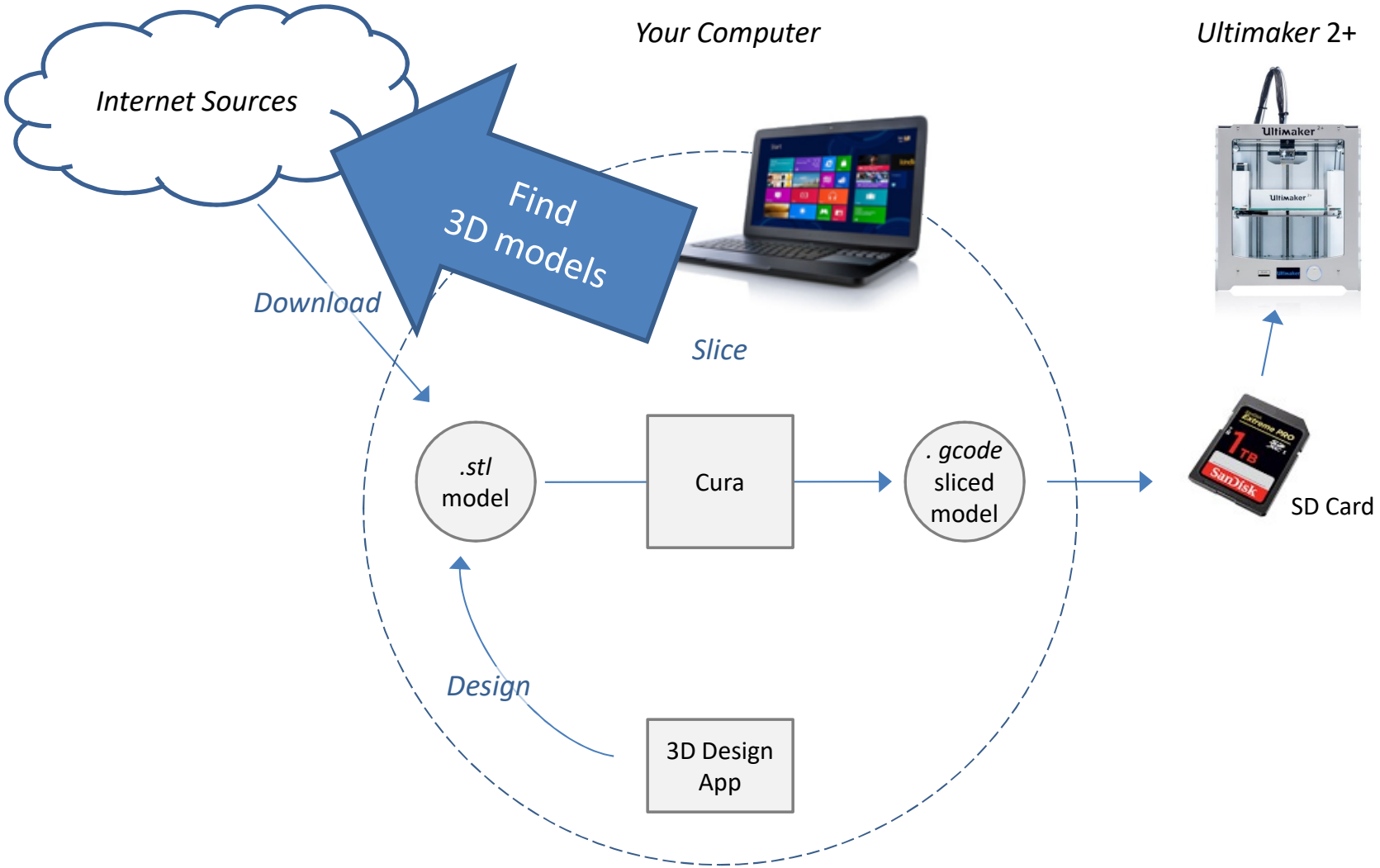
# Setup Printer (continued)

- Select and print model
  - tbd

# The Finished Print

- Tbd – discuss print fails (not in depth)

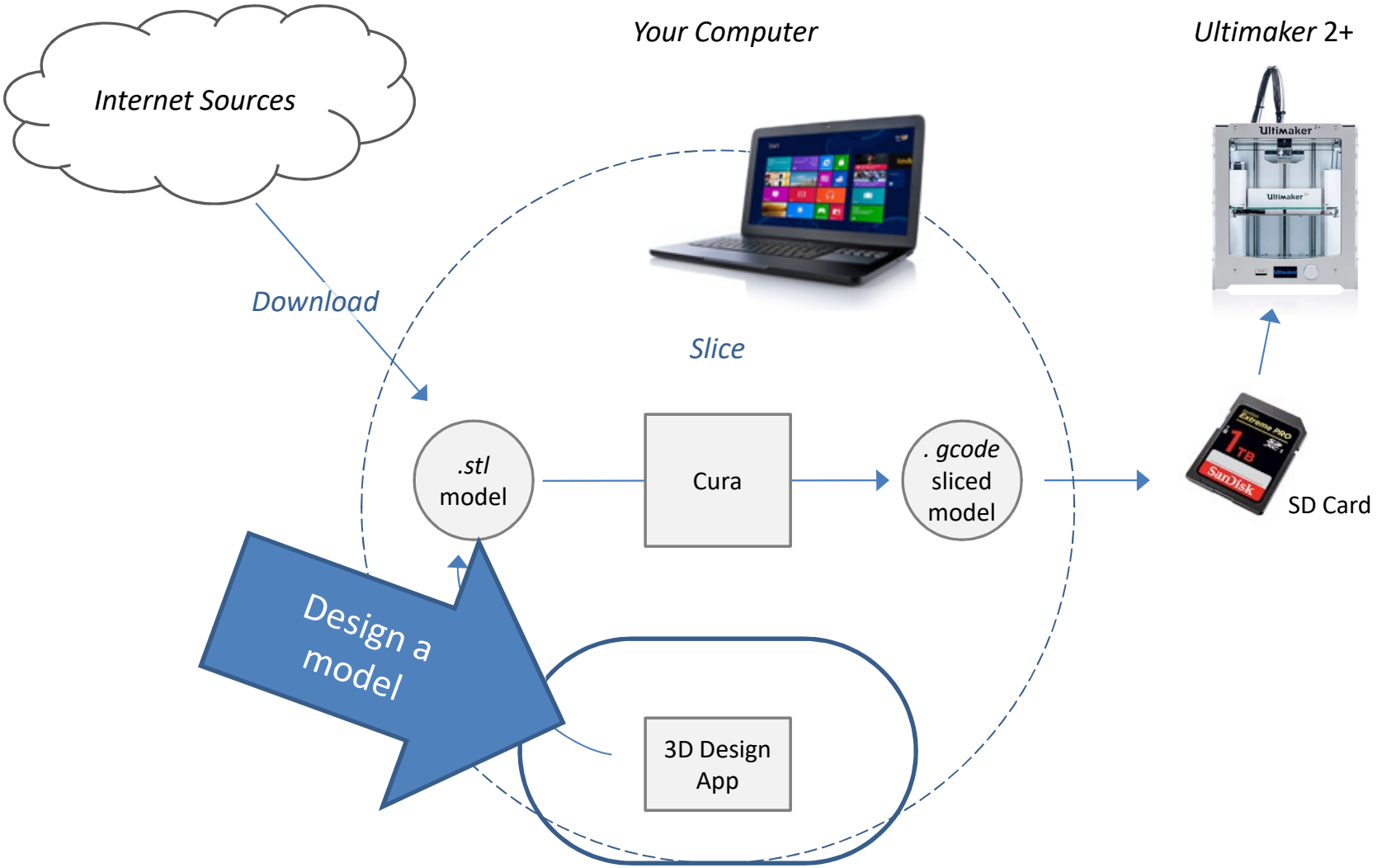
# Find Existing 3D Models



# Existing 3D Sources

- What to look for
  - Something useful
    - Household items
    - Tech items
    - Tools and gadgets
    - Storage and organization
  - Something for kids
    - Pokemon figures
    - Custom Lego blocks
    - Other toys
    - Educational items
- Then download the .stl file
- Top sites
  - thingiverse.com
  - instructables.com
  - youmagine.com
  - yeggi.com
  - Google says … "top sites for 3d models"

# Design a 3D Model



# 3D Design Apps

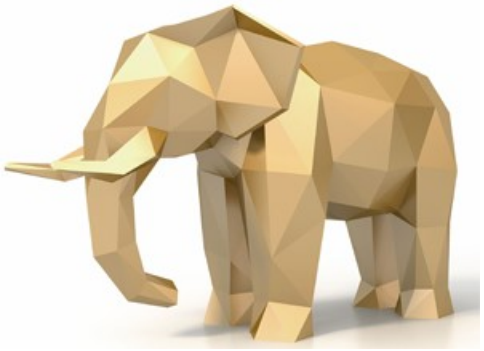
- 3D modelling software can range from fairly easy to quite difficult to learn
- Following chart is based on a post to Thingiverse, "Which 3D software for 3D printing?", and shows only free software recommended.

| App | Level | Use | Comments |
|---|---|---|---|
| TinkerCAD | Beginner, Intermediate | Precise shapes | Starting point for beginners, yet provides good capabilities |
| Fusion 360 | Intermediate, Advanced | Precise shapes | Fairly long learning curve, but many adherents |
| OpenSCAD | Intermediate | Precise shapes | 3D design through programming/scripting |
| DesignSpark Mechanical | Intermediate | Precise shapes | Current choice of this Thingiverse poster |
| Blender | Advanced | Organic designs | Most comprehensive with longest learning curve |

# Next Steps

- tbd – list of upcoming ETA classes for BARN

# Terminology



- Low-Poly
  - Models created with low polygon counts for artistic effect or speed of rendering
- Photogrammetry
  - A fully textured 3D model created from a series of photographs of a real object
- Rigged Model
  - The process of making an object ready for animation where there is an internal structure coordinated with the mesh surface that can mimic natural movements
- Voronoai Model
  - A model in which only the interconnecting edges of the surface mesh are printed

Note: Derived from more extensive glossary at http://www.brianschrank.com/2730/maya/3dglossary.pdf and elsewhere.

# Reference Summary

**General info on 3D Printing**

- all3dp.com

**Sources for exisiting 3D models**

- thingiverse.com
- instructables.com
- youmagine.com
- yeggi.com
- Google says … "top sites for 3d models"

**Cura usability info**

- Cura manual: ultimaker.com/en/resources/20406-installation-cura-2-1
- Cura Tutorial: all3dp.com/cura-tutorial-3d-printing/

**Printer filament info**

- 3D Printer Filament Guide & Comparison: all3dp.com/best-3d-printer-filament-types-pla-abs-pet-exotic-wood-metal/

**3D design software recommendations**

- Thingiverse post, "Which 3D software …": gliffy.com/go/publish/5271448"
- Google says … "best 3d modeling software for 3d printing"