

# High-Speed 3D Printing of Wireframe Prototypes

**WirePrint:** 3D Printing of Wireframe Models using Commercial Printers

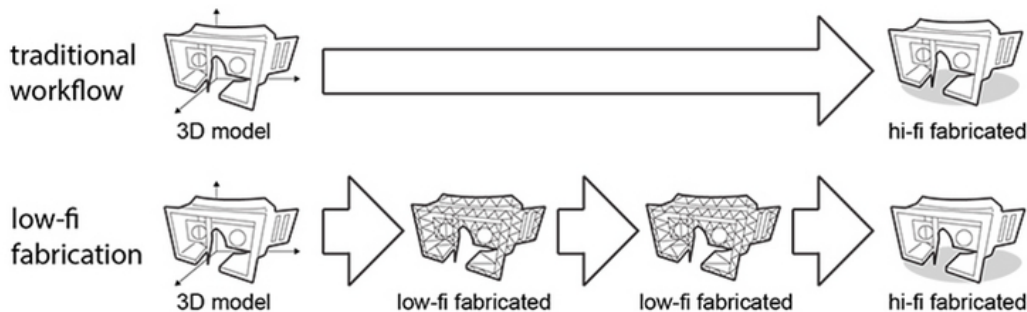
**On-The-Fly Print:** Enhanced 5-Degrees of Freedom Wireframe 3D Printer and Software

## Invention Summary

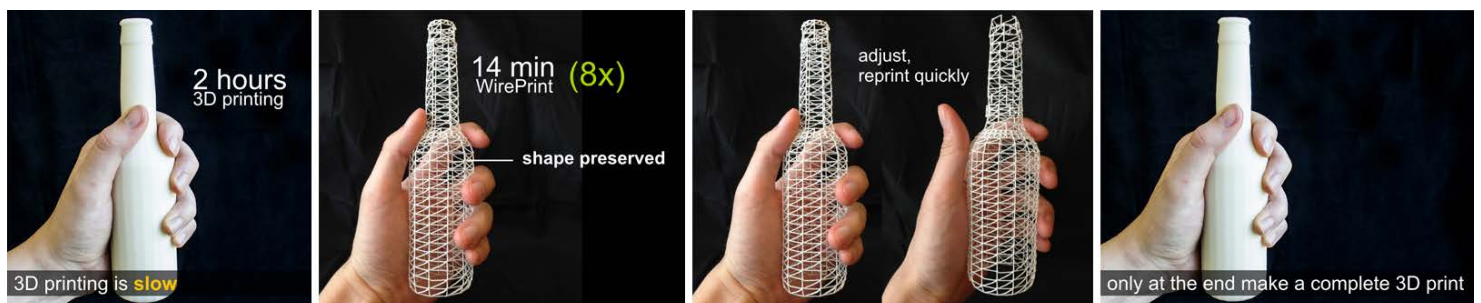
Our recently developed wireframe 3D printing system can be implemented for both traditional 3D printers (**WirePrint** Software) as well as with our enhanced printer setup having 5 degrees of freedom (**On-The-Fly Print** Software and Printer). High speed prototyping can be accomplished ~10x faster using **WirePrint** and off the shelf printers. For applications where ultra-high throughput prototyping is needed, **On-The-Fly Print** Software can boost throughput by over 30x using our 5DOF based printer enhancements and custom algorithms.

## WirePrint: Technology Overview

**WirePrint** software was developed for generating and printing low fidelity 3D wireframe previews of designed objects -- to scale and at high speed. The software is usable with most consumer-level 3D printers and allows low-cost and high-speed production of work-in-progress prototypes.



The filament is extruded directly into 3D space as opposed to traditional layer-by-layer application. This approach allows the edges of the wireframe model to be created directly, one stroke at a time, resulting in speeds up to ten times faster than traditional layer-based printing. 3D prototypes can be produced in minutes rather than hours, allowing designers to quickly see the practical results of minute changes or additions, minimizing the cost of changes in design. As an example, a bottle that would typically take about two hours with regular printing software, was printed in 14 minutes with **WirePrint**. Our software can easily transform a regular, solid design STL file into a mesh structure for rapid prototyping.



## Inventors:

Francois Guimbretiere  
 Stephen Marschner  
 Huaishu Peng  
 Rundong Wu  
 Sangha Im  
 Patrick Baudisch  
 Stefanie Mueller  
 Lisa Pfisterer  
 Serafima Gurevich  
 Alex Teibrich

## Patents:

Filed  
 WO2016040507

## Licensing Contact:

Martin Teschl  
 607-254-4454  
[mt439@cornell.edu](mailto:mt439@cornell.edu)

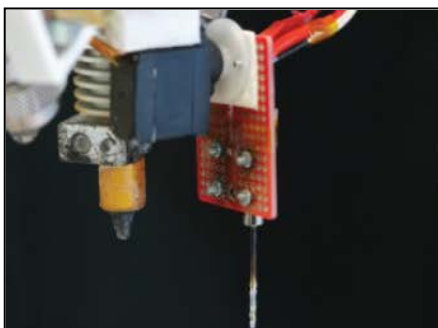
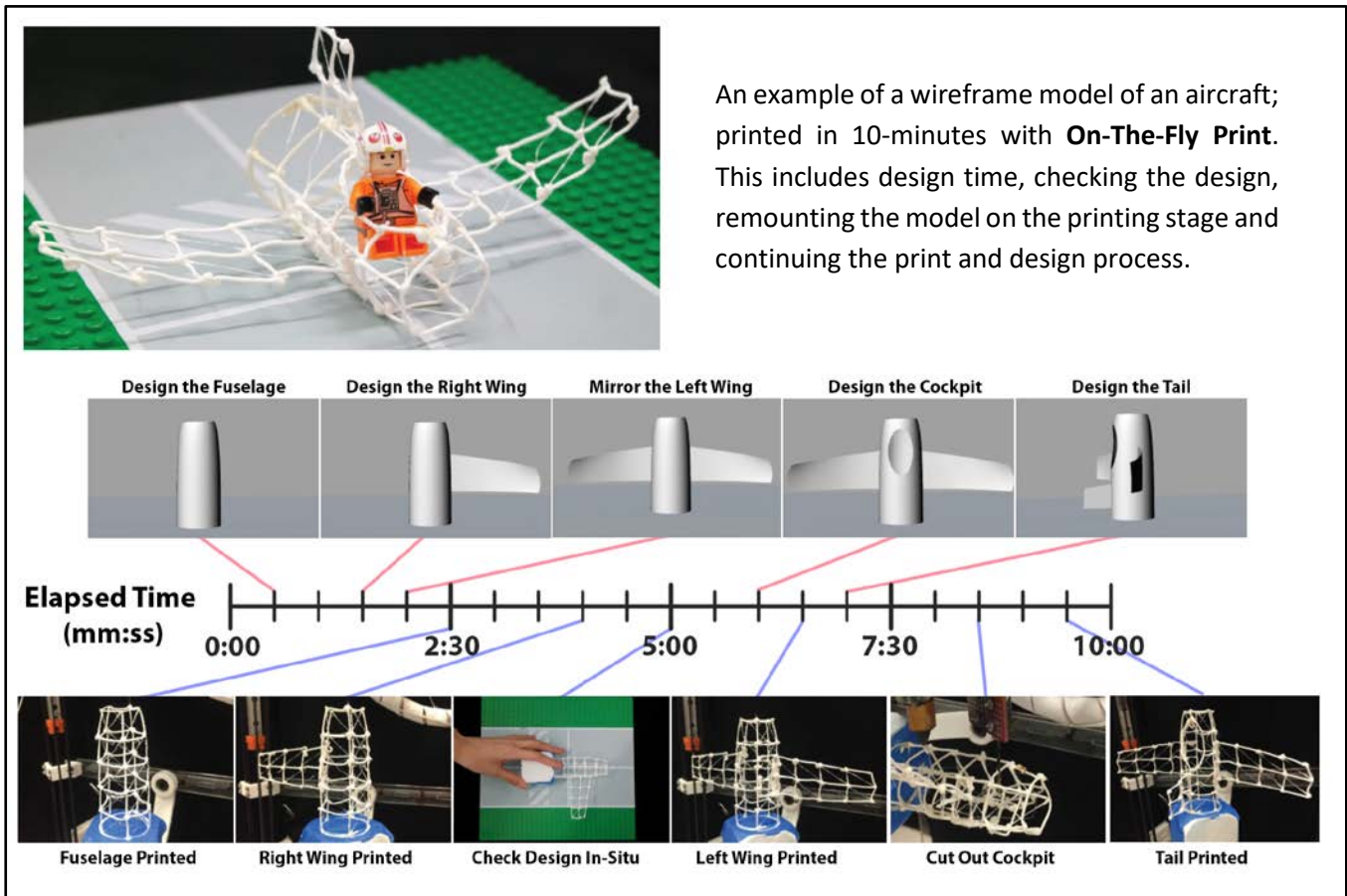
## Cornell Reference:

D7401: D6733

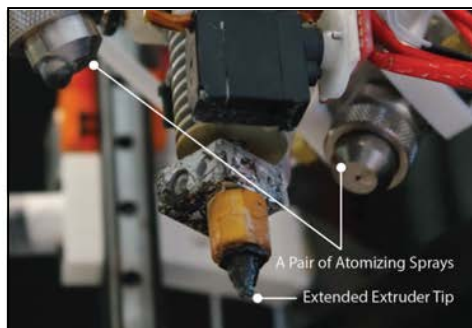
## On-The-Fly Print: Technology Overview

As an additional step up in speed and capabilities, we offer “**On-The-Fly Print**”. Cornell researchers developed a new printing system and software that takes advantage of a custom printer modification allowing for **5 degrees of freedom (5DOF)**. With two additional rotation axes, the edges of an object can be approached by the printer head from any direction, speeding up the print process and enabling printing of more versatile designs. This is combined with **custom algorithms to generate a printing plan that guarantees a smooth, collision free printing process**.

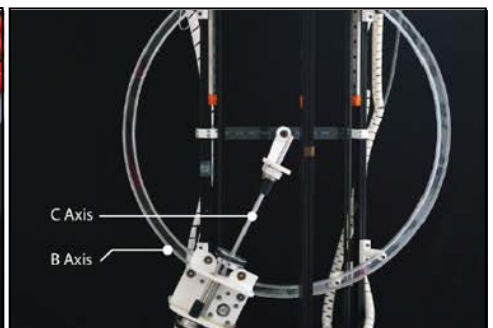
In addition, the Cornell **On-the-Fly** 3D printing system allows the user to begin **printing during the design phase as well as modify an object in real time**. The software can start printing features as they are created digitally, **a cutting tool enables automated removal/deletion of already printed parts**. If a user wants to measure or examine a printed object, they can pause the printing process and remove the object from the printer. After examination, the object can be replaced and the software will continue printing where it left off.



Retractable cutting tool



Print head design with extended extruder tip and mist cooling sprays



5DOF add-on design to an off-the-shelf Delta 3D printer

## Potential Applications

- 3D wireframe printing
- High speed prototyping
- Design tool for rapid prototyping of 3D objects, particularly suited for early prototypes and works-in-progress

## Advantages

- Saves time by printing 10-30 times faster, enabling rapid prototyping
- Wireframe structures require less material per iteration
- Flexibility to incorporate solid surfaces into the wireframe prototype
- **WirePrint** is compatible with many existing 3D printers—no hardware changes required

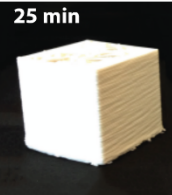
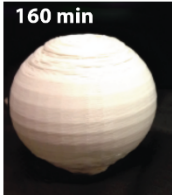


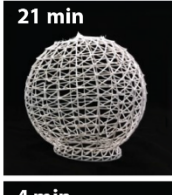

### On-The-Fly Print

- Allows for design changes during the printing process
- 5 degrees of freedom for higher speed and more versatile designs possible
- Ability for error correction and removing material
- Rapid cooling of extruded film
- Collision-free printing process

## Publications

- **On-The-Fly Printing** Video demonstration: <https://www.youtube.com/watch?v=X68cfl3igKE>
- **WirePrint** Video Demonstration: <https://youtu.be/Ea4V7kb2VsY>
- F. Guimbretiere, S. Im, P. Baudisch, S. Muller, S. Gurevich, L. Pfisterer, A. Teibrich. "System and Method for Three-Dimensional Printing" Patent Application: [WO2016040507](https://patents.google.com/patent/WO2016040507)
- Wu, Rundong, et al. "[Printing arbitrary meshes with a 5DOF wireframe printer.](#)" *ACM Transactions on Graphics (TOG) - Proceedings of ACM SIGGRAPH 2016*. 35.4 (2016)
- Peng, Huaishu, et al. "[On-The-Fly Print: Incremental Printing While Modelling.](#)" CHI '16 Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems (2016). Pages 887-896
- Alec, "[Introducing WirePrint: 3D printed wireframe previews speeds up prototyping by 10x,](#)" *3ders.org* (2014)
- Mueller, S.; Im, S.; Gurevich, S.; Teibrich, A.; Pfisterer, L.; Guimbretière, F.; and Baudisch, P., "[WirePrint: 3D Printed Previews for Fast Prototyping,](#)" *Proceedings of UIST 2014*.
- [Inventor's Website](#)

### Comparison of Printing Time

	25 min	160 min	120 min
Traditional Layer-by-Layer			
WirePrint			
On-The-Fly Print	