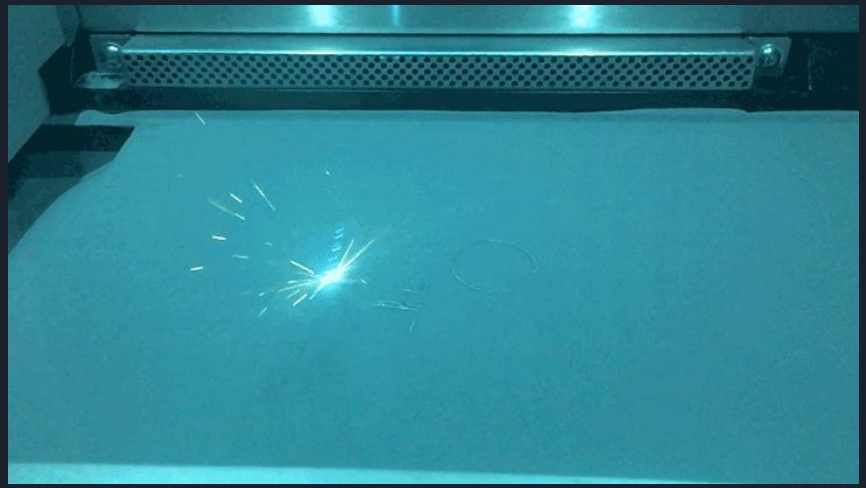
Metal Powder Bed Fusion 3D Printer

Team S18-21: Nick Engel, Ethan Rogers, Nicholas Low, Justin Lindell, Cory Voorhis

Presented by Nick Engel, Nicholas Low, and Ethan Rogers

Intro to Powder Bed Fusion

- Layer of material powder deposited on build plate (powder types: metal, plastic, glass, ceramic)
- Laser melts particles to form a layer in the shape of the part cross section
- New layer of powder is distributed over build plate
- Laser melts new layer and fuses to previous layer
- Process repeats until the part is completed

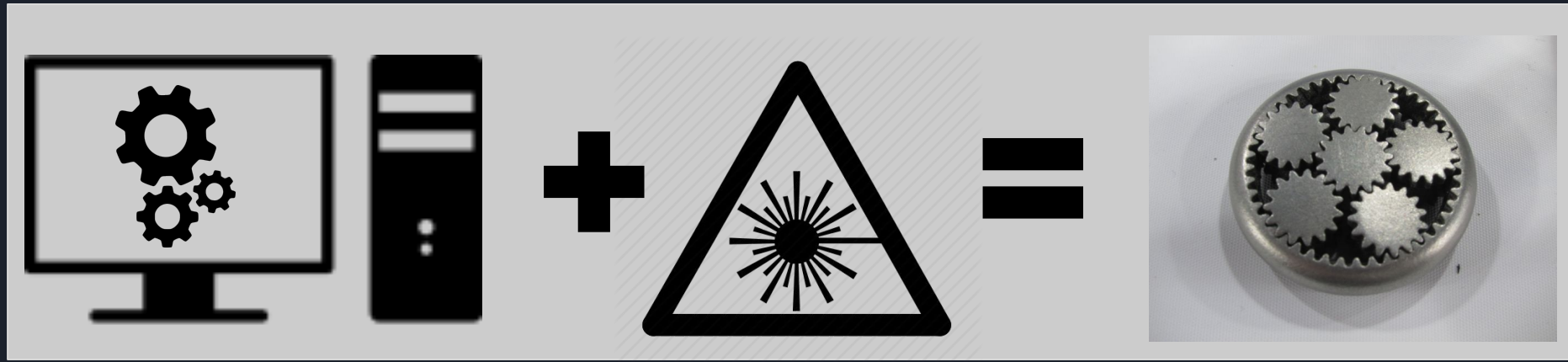


Motivations

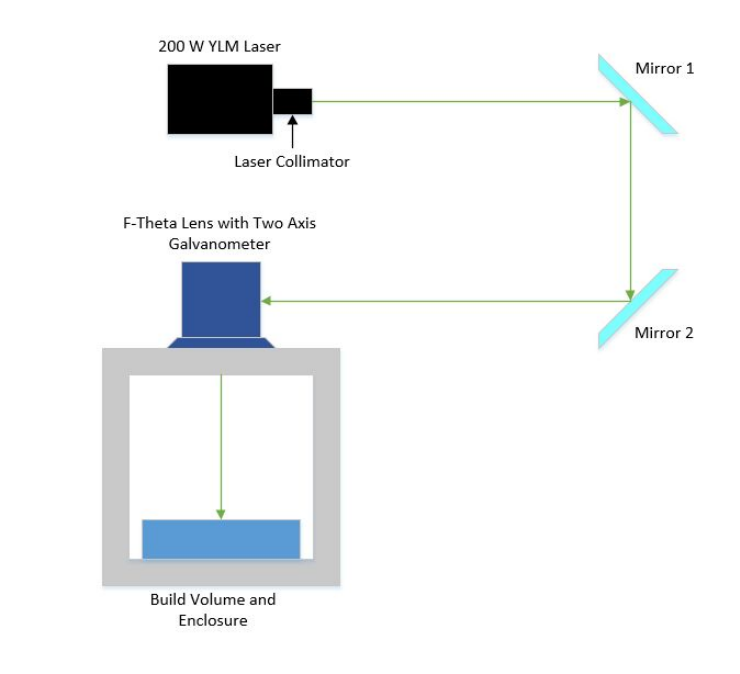
- Provide the ADAPT program at Mines with an open platform printer that:
  - Does not rely on a proprietary software tool-chain
  - Facilitates student experimentation by allowing machine parameters to be altered.
  - Includes high speed imaging to investigate how parameter changes influence the behavior of the melt pool.
- Contribute to the open source and 3D printing community.
  - Fully documented hardware and software will help others at Mines to build upon our work.
- Increase our engineering skills by tackling a highly multidisciplinary project.
- Build a tool that we'd like to use ourselves.

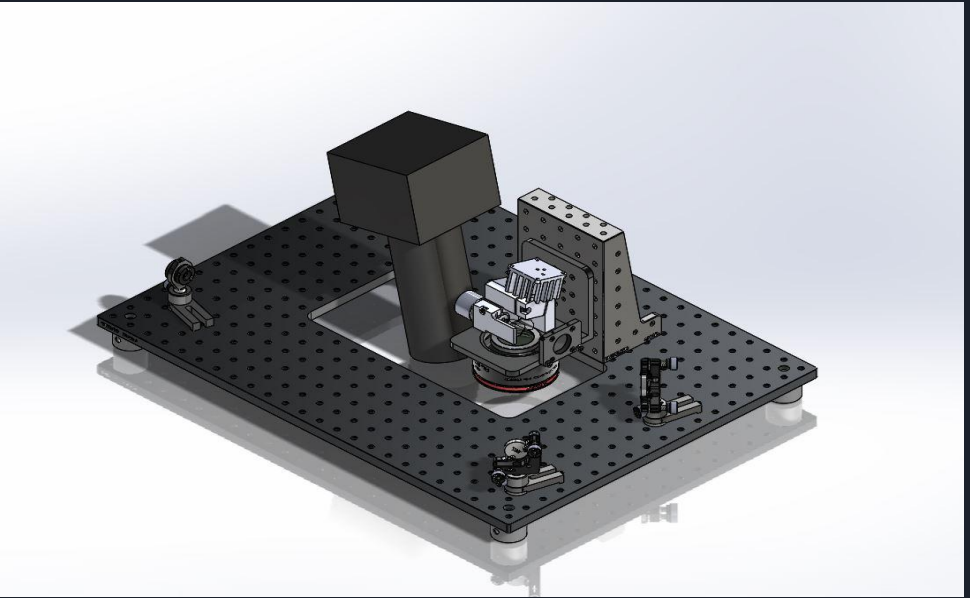
Goals

- A completed 3D printer by December 2018
- Print parts up to 100mm by 100mm by 40mm
- Ability to accept a range of particle sizes
- Flexibility to change laser spot size.
- Safe and reliable operation by students ensured by engineering and administrative control.

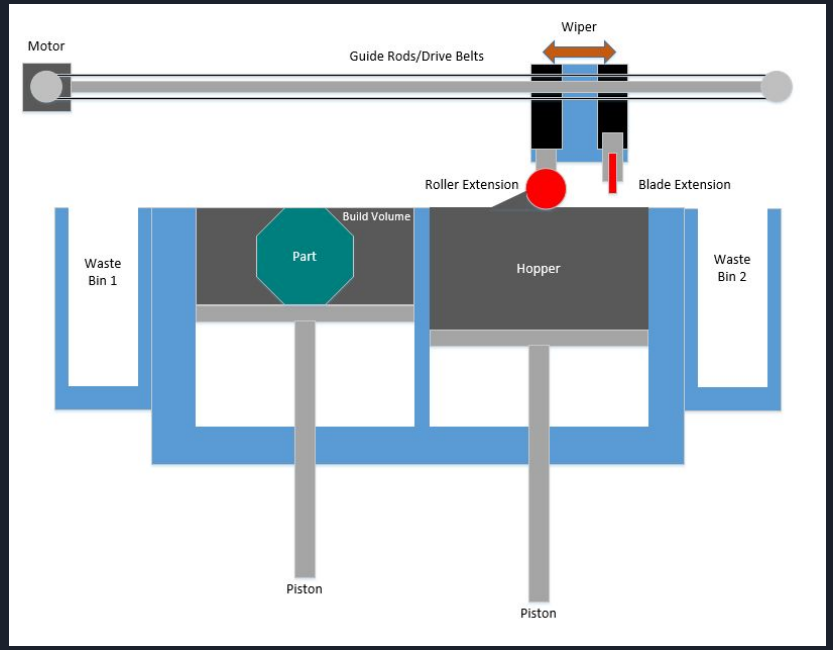


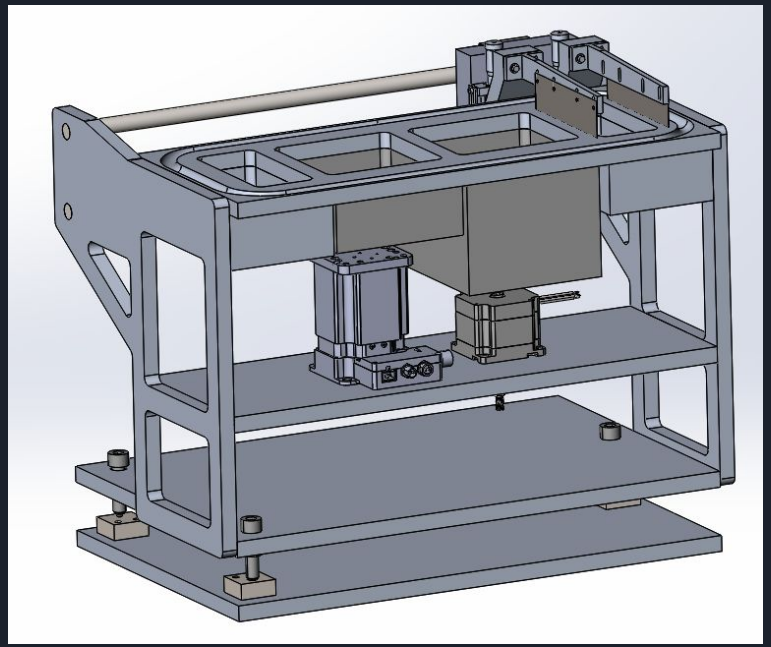
Laser -Initial Concept to Currents Designs



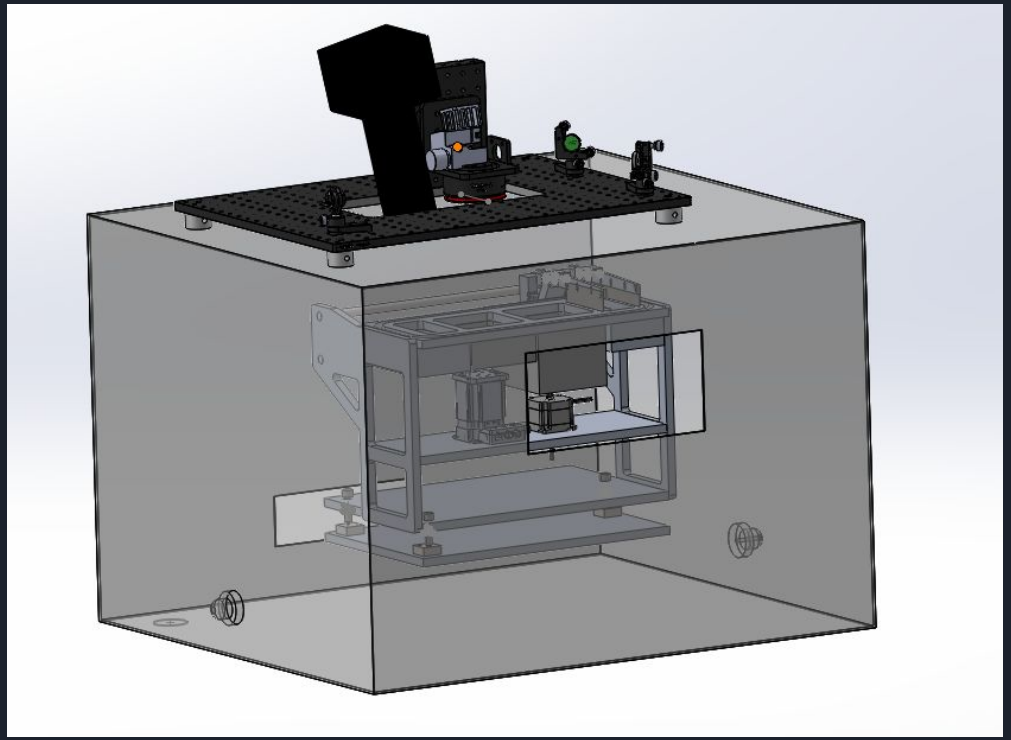


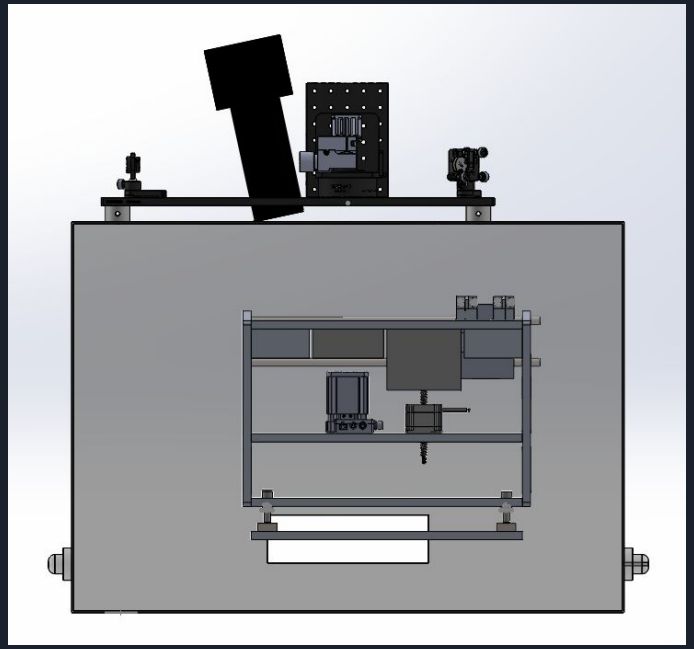
Material Delivery - Initial Concept to Current Designs





Our Current Design





Challenges and Risks

- Print Environment Requirements:
  - Inert gas recirculation
  - Environmental variables and safety interlocks must be monitored and controlled by software
- Small Particle Sizes:
  - Must be handled using appropriate PPE
- Laser safety:
  - Enclosure must be sealed with interlocks.
  - High power increases risk of personal injury and component damage.
- Software development:
  - Requires time and testing.
  - Must interface with each of the printer's subsystems.
- Lack of documentation compared to more established printing technologies.
- Large scope → Many interrelated problems
- Limited time → Few prototypes

Educational Value

- ADAPT Program
  - Introduce students to additive manufacturing
  - Hands on experience using and changing PBF processes
  - Ability to see melt pool with high speed imaging
- Mechanical Engineering
  - Ability to change and adapt all mechanical systems
  - Ability to print complex metal parts
- Computer Science
  - Ability to change and expand all programming
- Physics
  - Ability to change and adapt laser properties and scan strategies
- Electrical Engineering
  - Ability to change and adapt electrical components and wiring

Acknowledgments

Dr. Aaron Stebner

Henrik Hofvander

Dr. Jeff Squier

Dr. Branden Kappes

Elementum

3-D Systems