

# FireBreaker

Smokejumper Multi-Functional Tool

Team Members:

**Jonathan Heeter** (heeterj@tamu.edu)

**Mark Abbey** (mark6174@tamu.edu)

**Sebastian Salazar** (s\_salazar17@tamu.edu)

**Shyam Balasubramanian** (shysun@tamu.edu)

**Zach Norwood** (zach\_norwood@tamu.edu)

**Dr. Wayne N.P. Hung** (hugn@tamu.edu)

## Table of Contents

OVERVIEW	3
FUNCTIONALITY	3
DESIGN	3 - 5
MATERIAL SELECTION	5
SOCIAL AND ENVIROTMENTAL IMPACT	5
REFFERENCES	6

## Overview

Preserving and protecting the land that we treasure, the occupation of *smoke jumping* is an extreme risk job that provides an initial response to wildland fires. Smoke Jumpers are a select group of firefighters that are trained and deployed by parachute to combat wildfires; once on the ground, they must be completely self-sufficient for 48 hours and limited to 100 lbs. *Our multi-function tool provides a lightweight and compact alternative to the standard firefighter axe.*

### Functionality

Smokejumpers use a variety of tools with specific functions in which all must maintain durability during intense and high heat situations. Due to the limited pack weight, smokejumpers typically use hand tools to control wildfires. Some of the tools they use include: an axe, a McLeod, a Pulaski, and saws (Fig. 1).

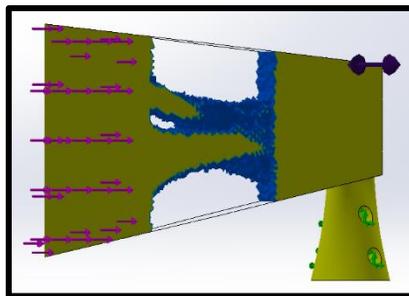
FireBreaker was designed to combine multiple smokejumper tools while reducing weight to assist in rapid wildland disaster response.

The tool includes: an axe head for chopping timber, a rake-like backhoe for creating firebreaks and breaking up topsoil, and an adjustable handle for greater leverage.

A traditional axe is a very heavy tool that occupies a significant amount of space in the smokejumper’s arsenal. When a topological optimization study was performed to identify the load carrying regions in a traditional axe, we found a lot of redundant material that provides no structural advantage. Fig. 2 illustrates what material needs to be kept (yellow) and the material that has no role in load distribution (blue or transparent).



**Fig 1:** Smokejumper Equipment



**Fig 2:** Traditional axe - Topological study.

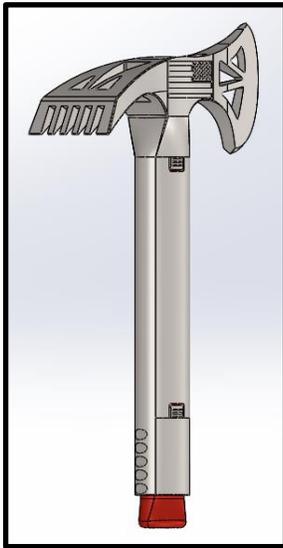


**Fig 3:** FireBreaker Axe

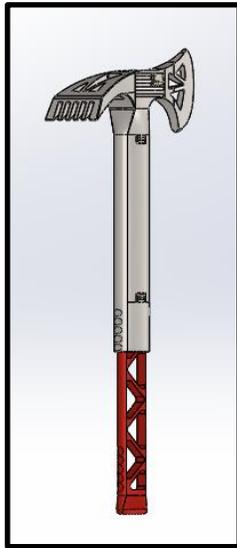
### Design

The FireBreaker design utilizes additive manufacturing to combine multiple tools that a smokejumper needs into one lightweight tool. Shown in Fig. 3, the head of the axe is designed to function as a traditional axe/hatchet head in addition to a McLeod tool located in the back. The head design also removes unnecessary material that does not undergo load when using the tool as functions. Fig. 3 and Fig. 4 illustrate the load distribution based on a topology optimization finite element analysis on the FireBreaker head when it undergoes loading in the form of a swinging cut or a dig with the plowing side of the head. The results of the study show that almost all the material in our design bears the load from the swinging cut and plowing action, and the redundant material is kept to a minimum.

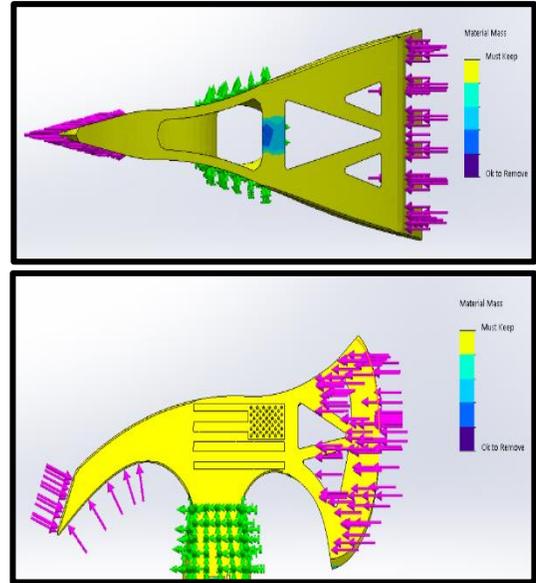
To further enhance the functionality of our axe design, the handle of the FireBreaker allows a smokejumper to utilize this tool as a hatchet (one-handed) and as an axe or plowing function (two-handed). The expansion/collapsing function of the handle is possible through a snapping tab located on the lower handle part. This will lock into an insert at either the top or bottom of the upper handle by squeezing the tabs and pushing/pulling the lower handle. Fig. 5 illustrates the tool in its collapsed form. Here, a smokejumper can yield the FireBreaker with one hand and use it as a hatchet to cut debris quickly. Fig. 6 shows the tool in its expanded form. This allows the smokejumper to swing the tool like an axe to make heavy duty cuts or as a plowing tool to dig breaks for the fires.



**Fig. 5.** Collapsed view of the axe, allows for easy transport and one-handed applications.



**Fig. 6.** Extended view of the axe allows for two handed applications



**Fig. 4.** FireBreaker Load Distribution-Topology Study

Head Characteristic Comparison		
Property	FireBreaker	Traditional Axe
Image		
Material	Titanium (Ti-6Al-4V)	Carbon Steel
Tensile Strength [ksi]	138	100
Maximum Service Temp. [°F]	662	570

**Table 1:** Comparison of FireBreaker axe head and a traditional axe head.

Summary		
Property	FireBreaker	Traditional Axe
Weight [lb]	3.5	6
Total transport length [in.]	24.44	30
Total service length	34	30

**Table 2:** Summary comparison of FireBreaker vs. Traditional Axe.

The FireBreaker Axe is designed to utilize the benefits of SLM, wherein thin hollow structures of complex shapes can be printed. The walls are thick enough to prevent warpage during SLM, but thin enough to achieve significant weight reduction. The handle also utilizes a macro-lattice structure to achieve effective load distribution and weight minimization. The FireBreaker weighs 3.5lb, which is a 72% weight reduction when compared to carrying the three traditional smokejumper tools: Axe, McLeod and a hatchet weighing a total of 13.6lb on average.

Limb Characteristic Comparison		
Property	FireBreaker	Traditional Axe
Image		
Material	PEEK	Hickory (wood)
Tensile Strength [ksi]	14.5	0.68
Service Temp. [°F]	500	~400 [charring temp.]

**Table 3:** Comparison of handles of the FireBreaker handle and a traditional wooden axe.

Summary		
Property	FireBreaker	Traditional Axe
Weight [lb]	3.5	6
Total transport length [in.]	24.44	30
Total service length	34	30
Cost	\$120	\$75.99

**Table 4:** Summary comparison of FireBreaker vs. Traditional Axe.

**Material Selection and Processes**

Part #	Item	Material	Process
1	Upper Limb <ul style="list-style-type: none"> <li>• Head</li> <li>• Outer Handle</li> </ul>	Titanium (Ti-6Al-4V)	Selective Laser Melting (SLM)
2	Lower Limb	PEEK	Fused Deposition Melting (FDM)

**Table 5:** Summary of processes.

Titanium offers high strength at low weight. It must be manufactured by SLM process because of the complex shape and the fine detailed required for the features. The handle is made of PEEK by FDM process, and we recommend it be printed in a flat (lie down) orientation to improve strength.

**Marketing**

Wildland fires endanger life across the globe and individuals who choose to put their life on the line need reliable tools. The primary audience for FireBreaker is wildland firefighters; however, outdoor enthusiasts and survivalists could also have an interest in a multi-purpose tool as it reduces pack weight.

**Social and Environmental Impact**

The growing presence of wildfires in the world is imminent. 2015 had the largest number of acres burned since 1960 with 10.13 million acres <sup>[7]</sup> and a 2017 study by NASA found that 61% of wildfires in the past 6 decades have occurred since 2000. The rapid response of a smokejumper is more vital than ever. The lightweight, multi-functional design of the FireBreaker gives each smokejumper the capabilities that now takes a team of three. The design also takes advantage of the loads the tool will undergo by removing unneeded material. This idea along with using additive manufacturing cuts down on waste material and proves to be a more energy efficient way of manufacturing.

## References

1. [https://en.wikipedia.org/wiki/Smokejumper#/media/File:Smoke\\_jumper\\_equipment.jpg](https://en.wikipedia.org/wiki/Smokejumper#/media/File:Smoke_jumper_equipment.jpg)
2. <http://www.nationalfirefighter.com/blog/hq/The-Smokejumper-s-Ultimate-Toolkit-Checklist>
3. <https://wildfiretoday.com/2011/02/26/at-what-temperature-does-a-forest-fire-burn/>
4. <https://www.craftechind.com/dont-sweat-4-high-temp-plastics-can-take-heat/>
5. <https://www.machinedesign.com/materials/plastics-and-composites/article/21812825/polyamideimide>
6. <http://www.nationalfirefighter.com/store/c/2022-Structural-Hand-Tools.aspx>
7. <https://climate.nasa.gov/blog/2830/six-trends-to-know-about-fire-season-in-the-western-us/>
8. <https://mtntactical.com/knowledge/veterans-wanted-wildland-firefighting/>
9. <http://counciltool.com/shop/fire-axesforcible-entry-toolsfire-shovels/2-75-pickhead-fire-axe-28-curved-hickory-handle/>

\*NOTE\*: The raw approximate cost to create the head and upper limb was \$57.60 and the approximate value of the lower handle is \$30.