Boeing-PBF Interruption Phase II

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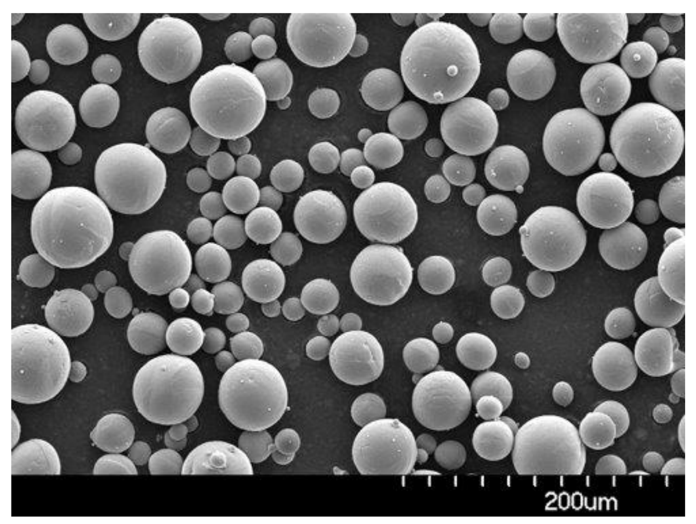
Project Summary

Build interruptions are common in additive manufacturing. Knowing the effects of a build interruption allows interrupted parts to be evaluated for use instead of disposed of.
This project compares the fatigue life of interrupted vs non interrupted additively manufactured Ti6Al4V. ASTM E466 samples are tested under cyclic loading and analyzed using various imaging techniques.

Background and Motivation

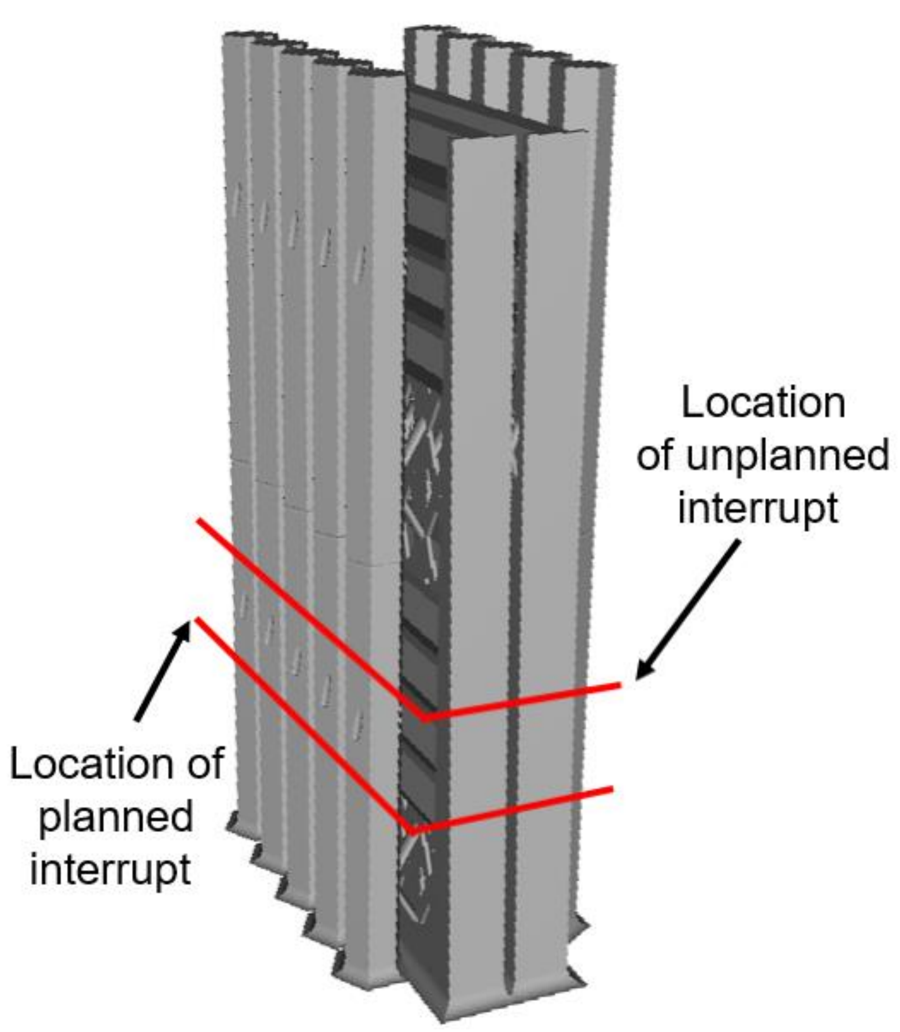
[1] EOS M290 metal 3D printer



[2] GE additive feedstock powder

During the additive manufacturing process, interruptions may occur that force the build process to stop. Durability and fatigue life of the interrupted parts is uncertain and insufficient knowledge may lead to disastrous outcomes in the event of component failure.

Goals and Objectives



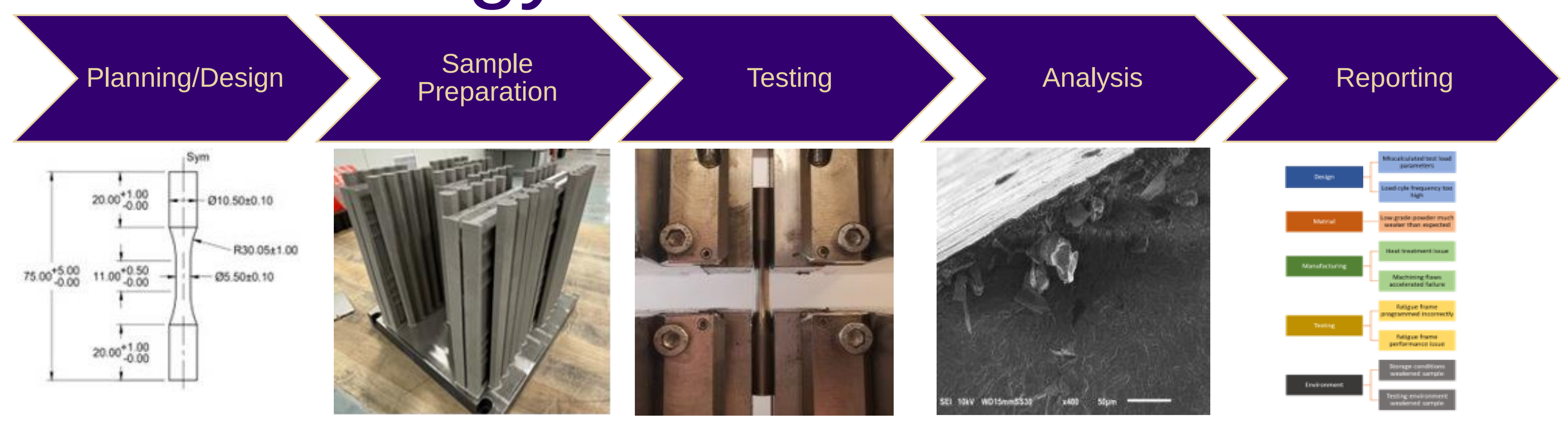
[3] LPBF Fatigue samples, as built

The goal of this project is to determine if interrupted parts can endure considerable fatigue cycles and allow acceptance of an interrupted build.

Our objective is to assess if an interrupted Ti6Al4V part has the same mechanical and material properties as a non-interrupted part.

There are interruptions in the locations of the red lines as shown in figure [3].

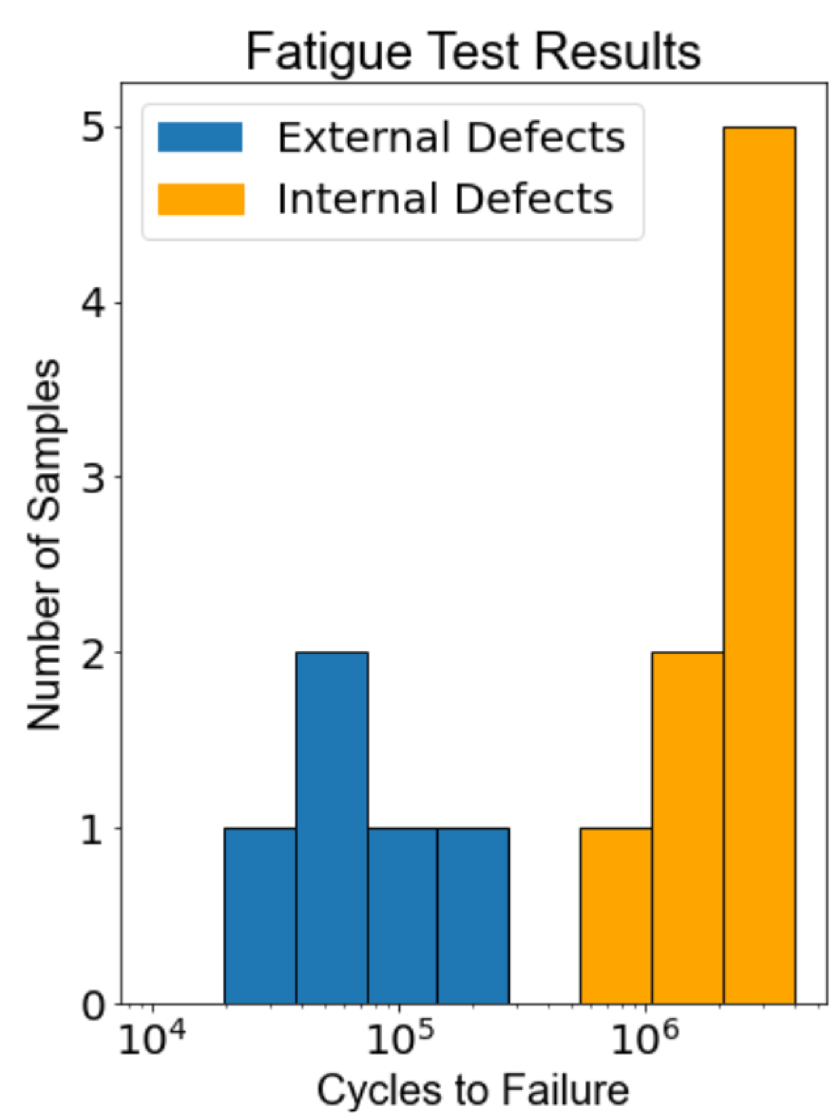
Methodology



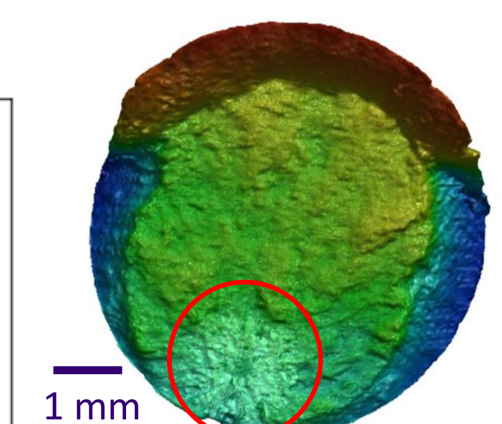
[4] Project timeline with example images

To study effects of a build interruption, we tested additively manufactured titanium samples with and without a build interruption under cyclic loading conditions. We are comparing the differences between control and interrupt builds by gathering fatigue test results and using analysis techniques.

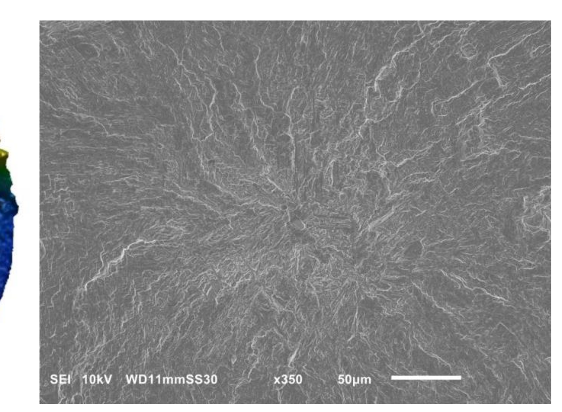
Progress and Results



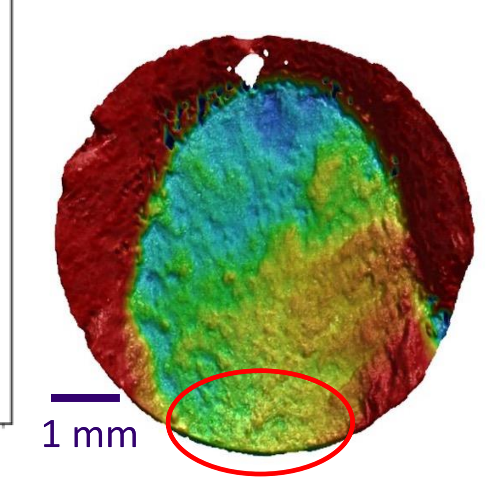
[5] Data plot on logarithmic axis



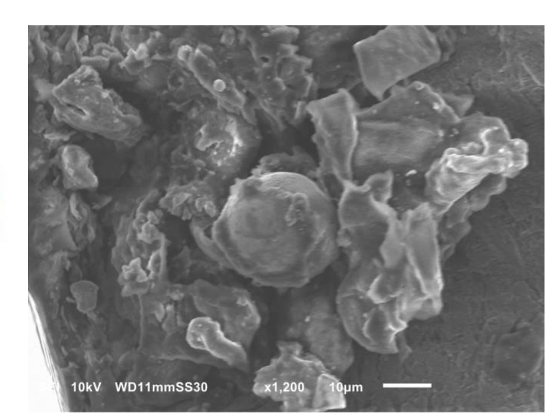
[6] Cycles to failure: 3 million



[7] Origin of internal fracture



[8] Cycles to failure: 86K



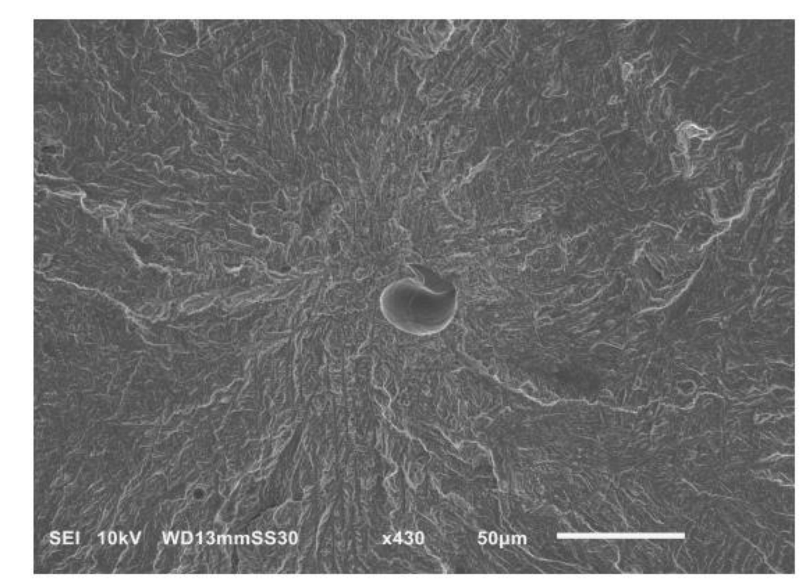
[9] Origin of surface fracture

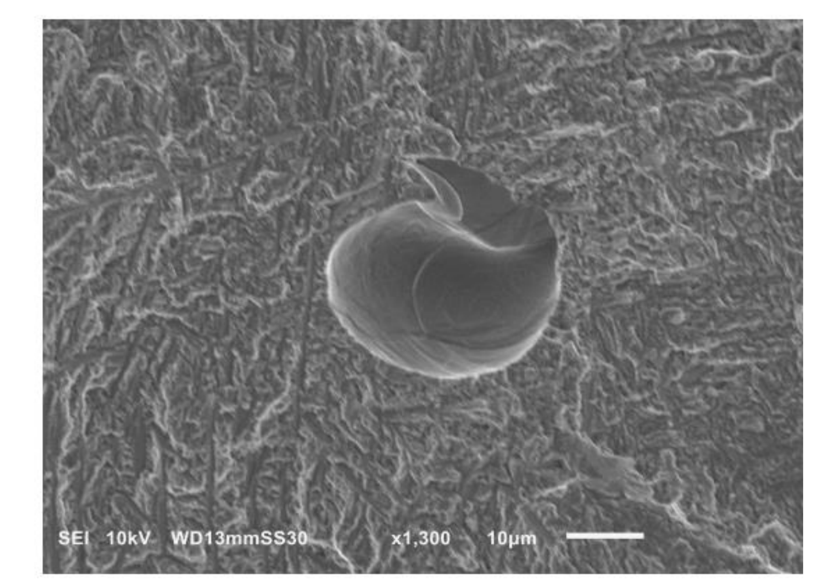
Completed testing and analysis has taught us about how the location of a defect effects the sample's lifespan. Our current results (examples of which are shown in figures [5] - [9]) have been helpful towards understanding defect location effects. Coupons with internal defects (circled in figure [6]) last much longer than surface defects (circled in figure [8]). The two types of defects form a bimodal distribution of fatigue life as seen in figure [5].

Conclusion and Future Work

The data shows that samples with internal defects fail much later than samples that have external defects. The mechanism that determines whether the sample has an internal or external defect is unknown. It should be an area of further study to quantify how the additive manufacturing process influences the fatigue life of the sample.

We are currently waiting on the interrupted titanium samples and will expect to test them soon. Delays in the project mean that the team members who are staying at UW will continue the work by testing and analyzing the interrupted samples. The interrupted samples should be categorized into two categories, internal defects vs external defects, and compared with the control build to see if the fatigue life is affected. This should give immediate answers about if continuation of interrupted builds are viable and if interruptions lead to a degradation in mechanical properties.





[10], [11] SEM images of an internal void that led to failure

Anticipated Impact

Immediate Impact: Verify that aerospace components manufactured through selective laser melting are viable for long term use in load-bearing applications.

Long Term Impact: Powder bed fusion, and additive manufacturing processes in general, can drastically reduce the waste produced in the fabrication process while offering a better buy-to-fly ratio.

Acknowledgements

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[1] "Eos M 290 EOS 3D printer," 3Dnatives, https://www.3dnatives.com/3D-compare/en/3d-printers/eos-m-290/ (accessed May 24, 2023).
[2] "Ti-6AI-4V gr. 5," Advanced Powders, https://www.advancedpowders.com/powders/titanium/ti-6al-4v-5?_ga=2.13224375.12257964.1625236864-1428637148.1625236864 (accessed May 24, 2023).