# Development of Performance Prediction and Design Methods for 3D Printed Parts under Uncertainty

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This project develops a framework which can efficiently account for micro-scale uncertain variations introduced by AM technologies in the geometry and material properties of the AM-fabricated parts. This efforts will be critical to correctly characterize mechanical properties of the printed parts so that users can accurately predict the structural performance of the parts. Specific research objectives will include: 1) Characterization of the range of geometric microstructures and internal defects that are producible via AM, as well as relating each to process variables and to their mechanical properties, 2) Improvement of the PI's stochastic multiscale modeling method by integrating a verification and validation process, 3) Demonstration of the developed framework with AM-fabricated parts provided by SHAP3D industrial partners.

In the proposed research, a new validation framework will be developed by modifying the PI's previously developed stochastic multiscale modeling method. The combination of the validation process with the multiscale modeling can significantly improve the prediction accuracy of the system's behavior. In Phase 1 (first year), three major tasks were conducted to accomplish the project goal: Task 1. The characterization of the range of geometric accuracy, defects, and surface variations that are producible in an AM-fabricated component, as well as relating each to their spatial material properties, Task 2. The creation of correlated uncertainty representation and the improvement of stochastic multiscale modeling by introducing a dimension reduction process of physical experimental data, Task 3. The development of an integrated validation framework which can handle both uncertainty and complexity in computation processes effectively, with the consideration of space and time dependent random quantities on multiscale domains.

In summary, the proposed research developed a single framework, including a new validation method and a stochastic multiscale modeling method that allows the characterization of structural properties at multiple scales. This research enables the development of very accurate, reliable models that can be used in practical 3D printed mechanical components.

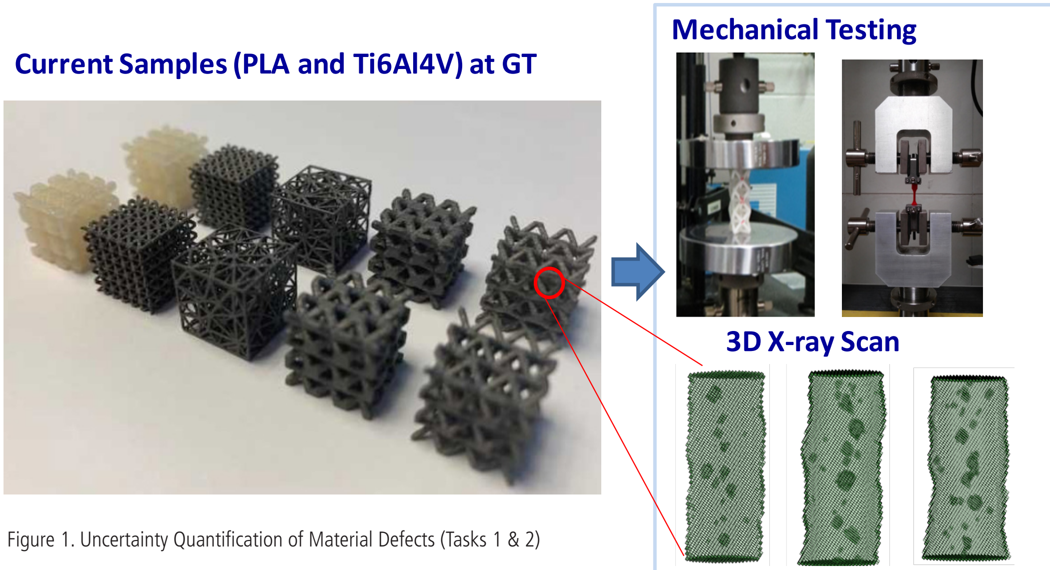


Figure 1. Uncertainty Quantification of Material Defects (Tasks 1 & 2)