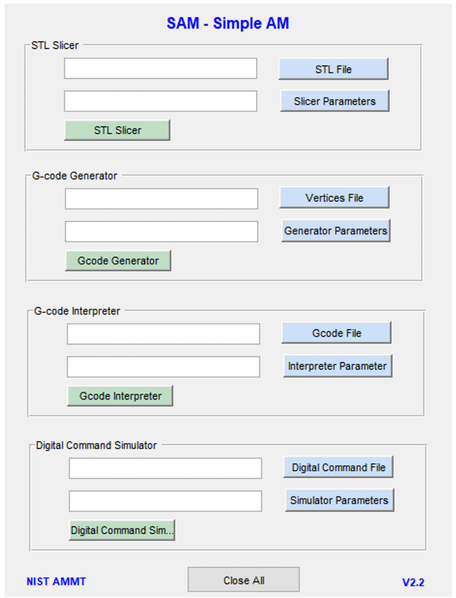
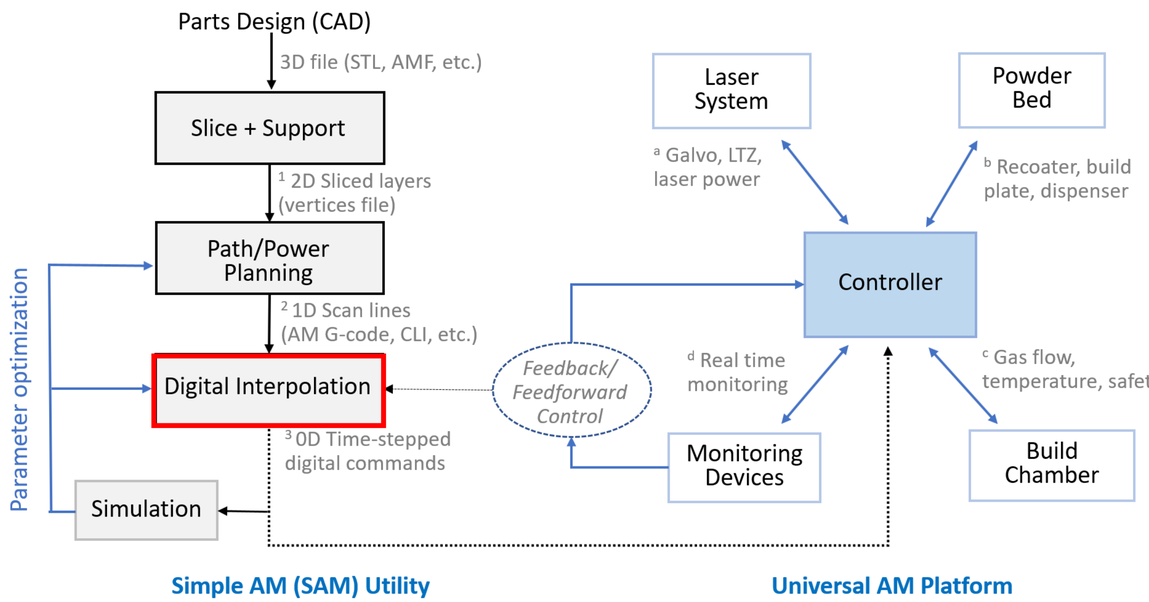
Additive Manufacturing Metrology Testbed Control

NIST ENGINEERING LABORATORY

Measurement Science for Additive Manufacturing

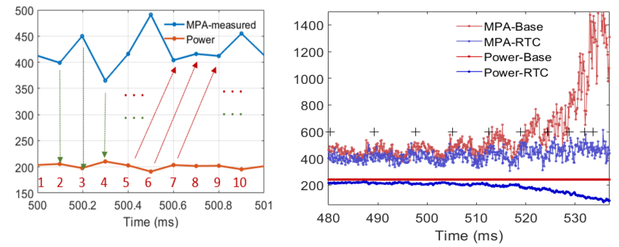
OBJECTIVE: Develop algorithms, methods, and standard protocols for Additive Manufacturing (AM) process control and implement it with software and hardware tools for open control of AM systems to enable more flexible process optimization by manufacturers.



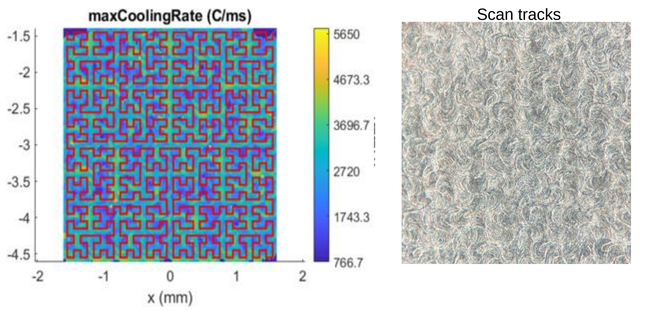


RESULTS

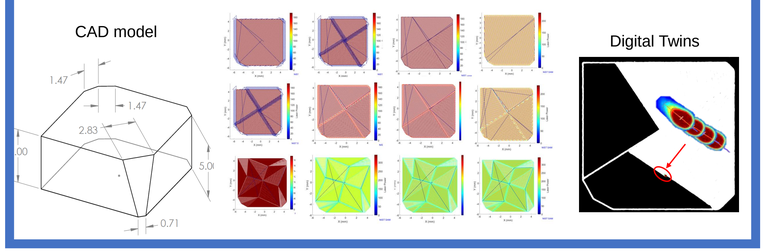
Real-time Feedback Control (100 µs response time)



Local Thermal Gradient Control (Hilbert Curve scan path)



End To End: Design - Control – Monitoring –Analysis

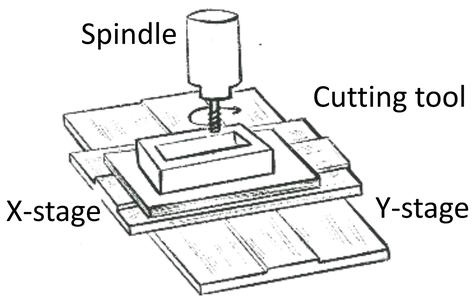


IMPACTS / CAPABILITIES:

- Developed an AM control framework with the creation of the Simple AM (SAM) utility.
- Pioneered point-wise control for Laser Powder Bed Fusion (LPBF) Additive Manufacturing.
- Enabled the first continuous laser power and speed variation scan strategy for local thermal control.
- Implemented the first real-time feedback control with a 100 µs response time for constant melt pool area AM process.
- Produced extensive high-quality datasets for AM processes, utilized both internally and externally.

TECHNICAL APPROACH:

The conventional AM machine has adapted control mechanisms from machine tools, allowing only line-wise control. It is unable to manage continuously varying local thermal conditions throughout the AM process.



The NIST approach utilized time-stepped digital commands to achieve pointwise control. AM G-code and a G-code interpreter were developed, with three path modes and three power modes defined, and jerk-limited motion control applied. This established the foundation for advanced AM control standards.