AMM
Advanced Methods for Manufacturing

DEC 2 – 3, 2020

Real Time Non-Destructive Evaluation During 3D Manufacturing of Metal Parts

Award Number: DE-SC0018743

Award Dates: 07/2018 to 08/2021

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Project Objectives

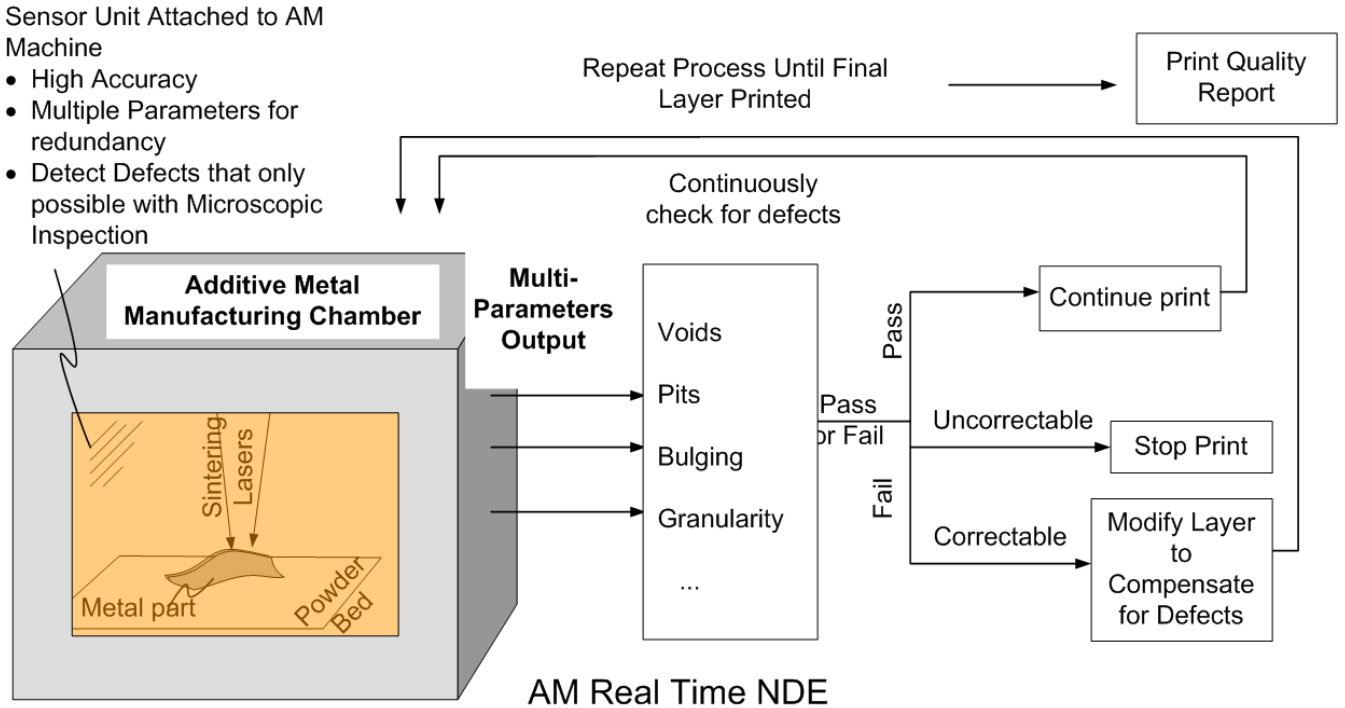
- Develop and demonstrate a **non-destructive** evaluation unit that can be added to an existing additive manufacturing (AM) tool of direct metal laser sintering (DMLS).
- LER Technologies' sensor unit will provide **real-time** information about the part quality and detect flaws as they occur.
- The information provided by this sensor unit can be used to a) **qualify** the part as it is being made and b) provide feedback to the AM tool for correction or to stop the process if the part will not meet quality requirements.
- The sensor unit will be projected to save time, energy and reduce material loss resulting in significant cost reduction.
- LER Technologies' sensor unit with advanced multi-modal optical inspection will result in a potentially higher quality AM part.

Overview

- Use a combination of multi-parameter imaging techniques.
- Each of these modalities detects different types of defects.
- The final outputs are combined to produce a defect map.
- Defects not seen by microscopic inspection can be detected by advanced optical methods

Real Time Defect Detection :

- Detection
- Correction
- Qualification



Advantage of Multi-Parameter Detection Method

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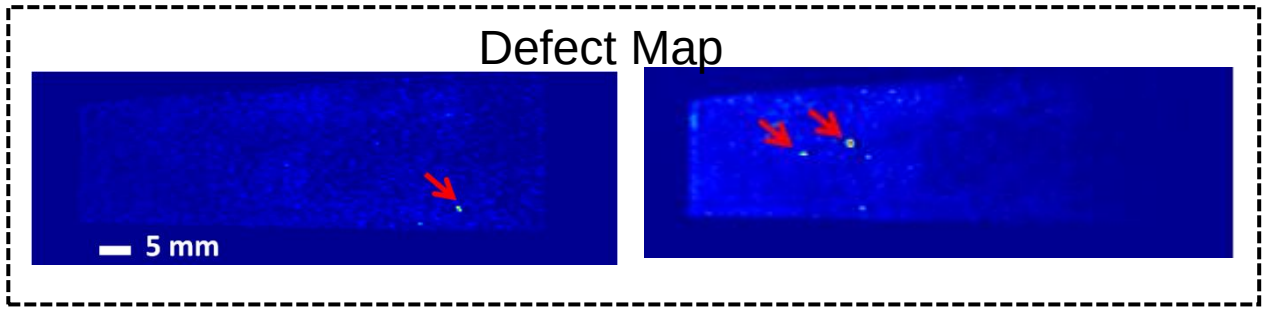
- Enables a robust real-time inspection method that ensures printed part quality.
- Provides measurement redundancy, maximizing likelihood of detecting defects that may otherwise be missed using a single parameter sensing approach.
- Avoids false readings.
- Each sensing technique sensitive to various types of defects, thus it covers a broad range of print quality issues.

Selectively Detect Various Defects



Surface Void Detection in SS 316

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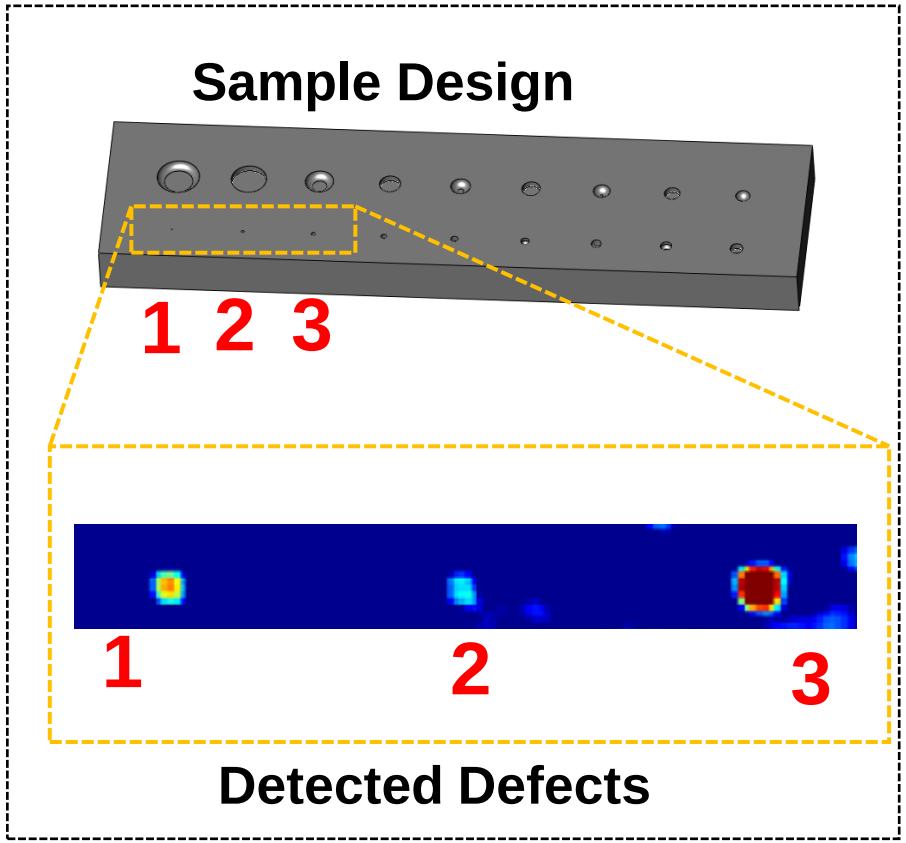

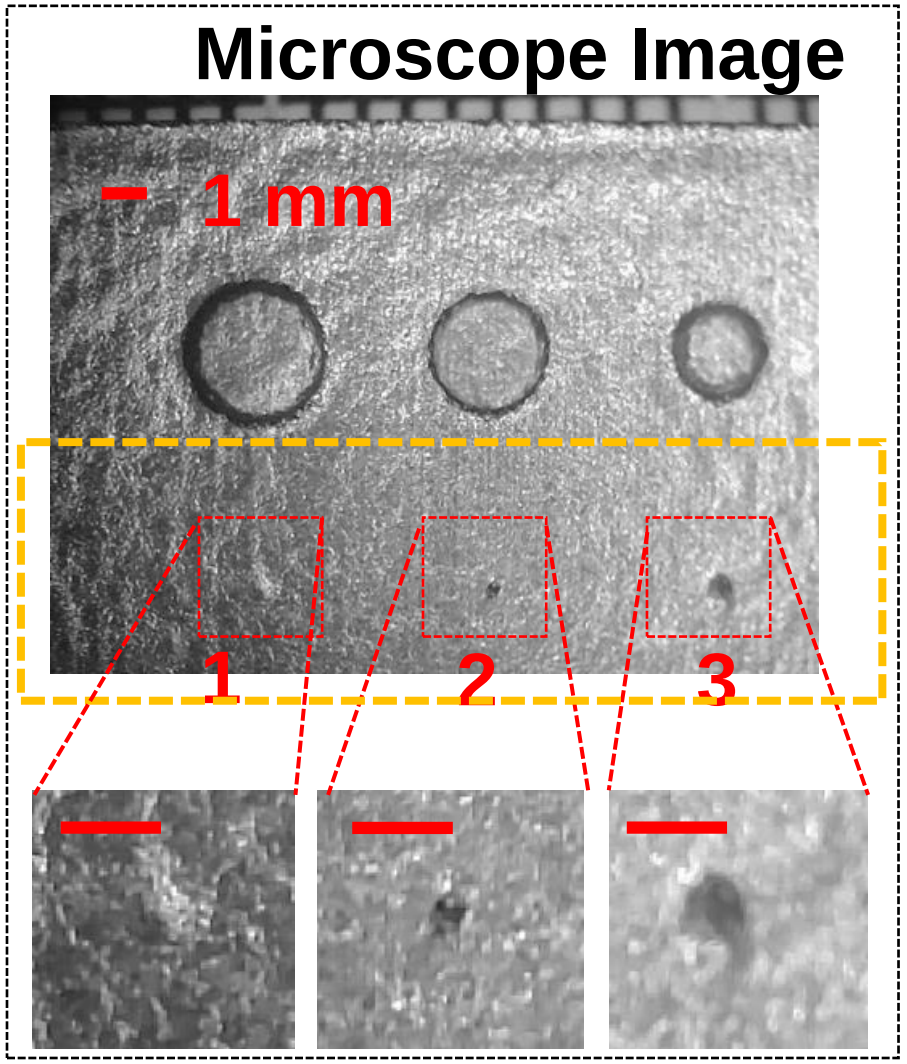

- Void depth 0.5 mm
- Smallest detected voids barely visible under a microscope.

Technical Progress/Accomplishments for FY-20

- Designed and fabricated table-top prototype capable of working with DMLS machines
- Built a chamber to mimic powder bed (DMLS) Machine(s)
- Tests with table top prototype in a realistic DMLS machine environment
- Increased the working distance and observable area suitable for DMLS Machine Operation
- Tested table-top prototype using stainless steel and Inconel samples

Table-top Prototype Tested with Simulated DMLS Chamber

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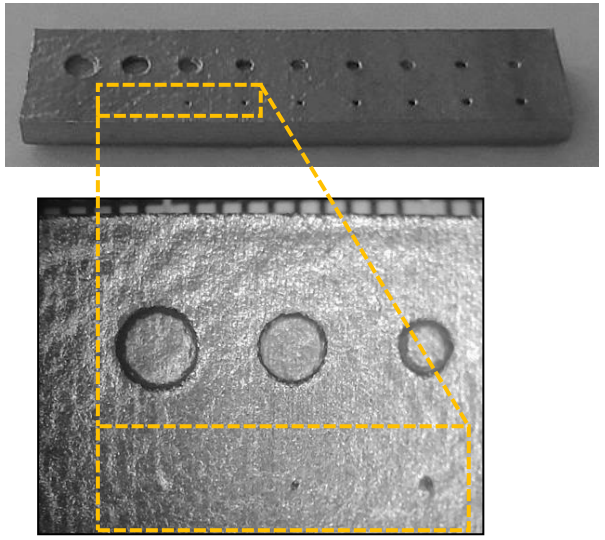
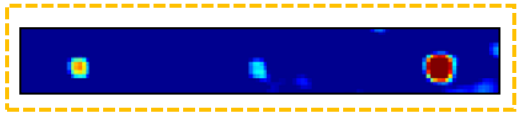
Simulated DMLS Chamber To Which Table Top Prototype Gets Attached to

Defect Sample



Microscope Images of Defect



Detected Defect

- Built a chamber to Mimic DMLS Machine(s)
- Tests with Table top Prototype
- Increased the Working Distance and Observable area Suitable for DMLS Machine Operation

Newest Data on Inconel 718 Void Detections

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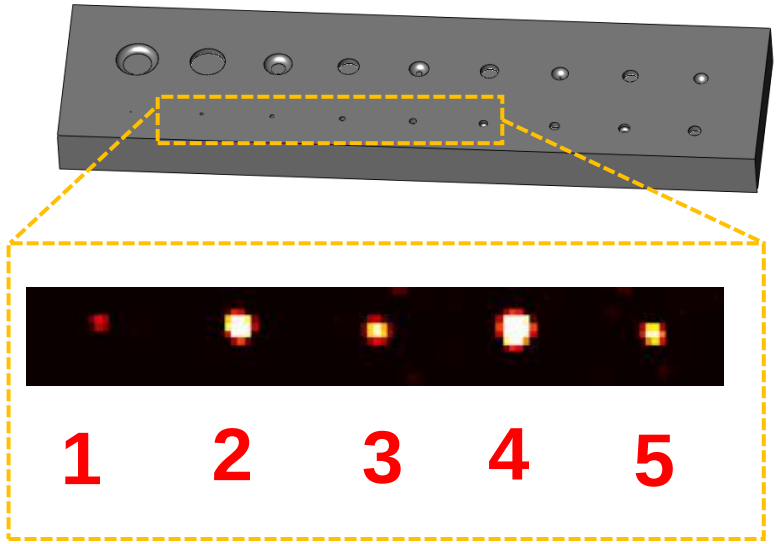
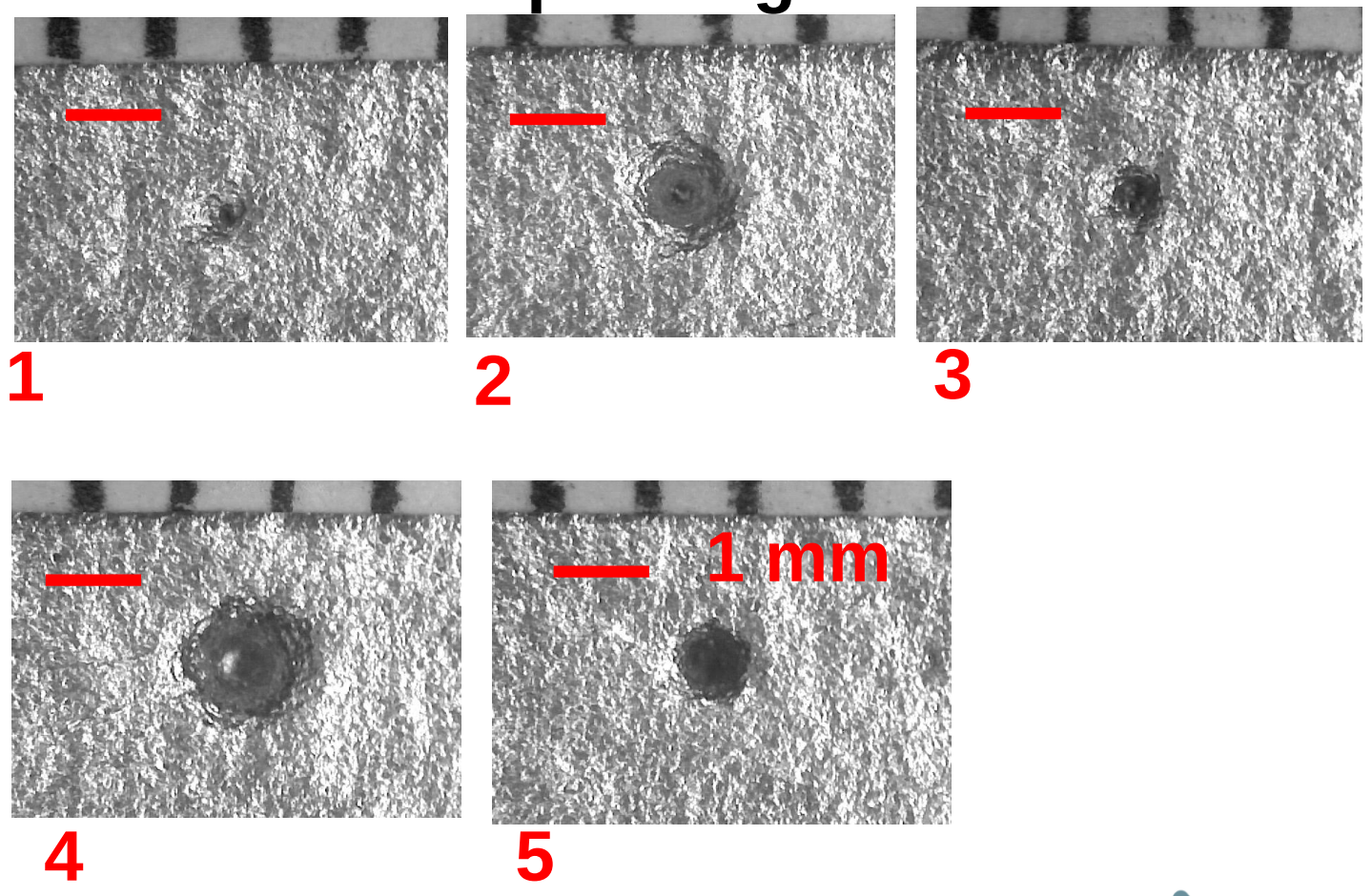
Sample Design



Detected Defects

Microscope Images



- Smallest detected voids barely visible under a microscope.
- Sensor covers large scan area as in a DMLS machine in real-time

Newest Data on Inconel 718 Surface Bulging Detection

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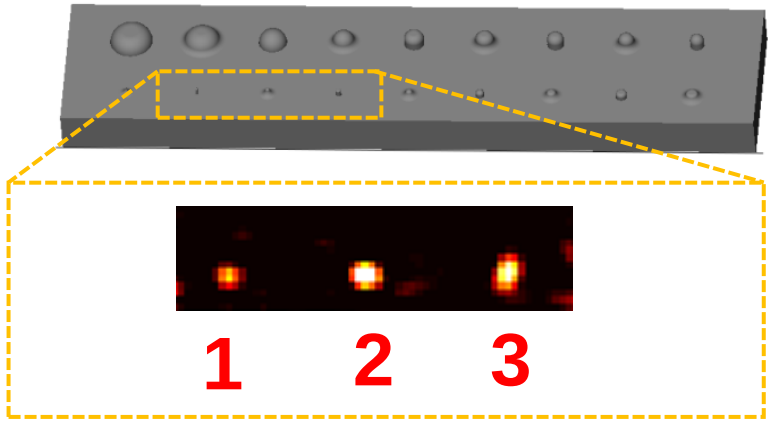
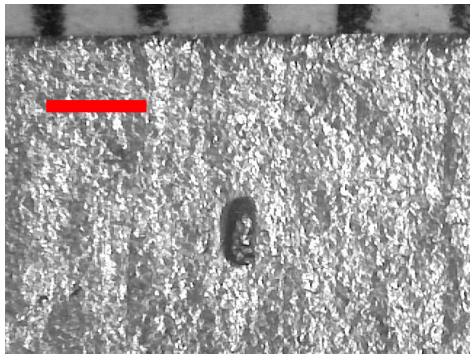
Sample Design

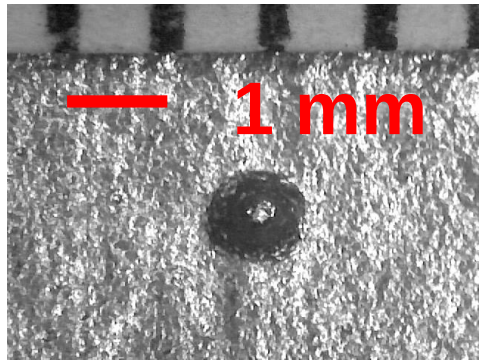


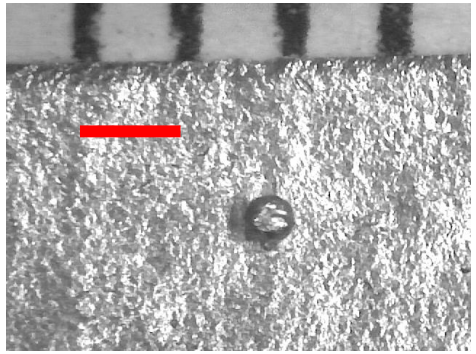
Detected Defects

- Smallest detected voids barely visible under a microscope.
- Sensor covers large scan area as in a DMLS machine in real-time

Microscope Images







Project Impacts

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Involvement :

- Meeting with various metal additive manufacturing end users and industry professionals.
- Discussion application of our sensors to their needs.
- Continue assessment of end user needs

Other/Presentations:

- Presented our work and its potential uses to AM part fabricators
- Assessed end user needs through feedback and post presentation discussion.

Impact to End User:

- Save time, energy and reduce material loss.
- Significant reduction in cost.
- Potentially higher quality 3D part due to advanced inspection

Conference Presentation:

- Submitted abstract to 2021 TMS Annual Meeting & Exhibition, Symposium: Additive Manufacturing for Energy Applications III.

Milestones and Deliverables for FY-20

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- Designed and fabricated table-top prototype capable of working with DMLS machines
- Obtained initial data from table-top prototype that validates multi-modal optical approach at identifying defects in AM metal parts
- Identified Defects of concern in DMLS on SS316 and Inconel 718 samples

Issues and Concerns

- COVID-19 impacts: Modified operations to align with current recommendations

- Despite this shift, work is performing on schedule

Milestones and Deliverables for FY-21

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- Complete final prototype sensor unit

- Test and verify prototype performance by comparing actual and detected defect values

Possible Areas/Industries/Programs (and Readiness) for Adoption

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This project aims to develop and demonstrate a non-destructive evaluation unit that can be added to an existing additive manufacturing (AM) machine.

Industry adoption will include:

- Adding the sensor unit to AM machine for real-time inspection.
- Provide volumetric defect map and information needed for part qualification.
- Enable defect correction when used in a machine feedback loop.
- It is projected to save time, energy and reduce material loss resulting in significant cost reduction.

After successful demonstration of the final prototype the estimated Technology Readiness Level will be between **TRL Levels 5 and 6**.

Questions

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