First-Year Progress Report

Metal Additive Manufacturing: Design, Materials, and Applications in Steel

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Reporting Period: Fall 2025 to Summer 2026

1. Project Overview and Year-One Summary

Metal additive manufacturing (AM) is reshaping how the aerospace, automotive, energy, and structural sectors design, fabricate, and repair high-performance steel components. Yet, the US workforce trained to span both metallurgy and layer-by-layer fabrication remains scarce. The current global metal AM market is valued at approximately $7 billion and projected to grow rapidly, underscoring the scale of the opportunity. To close this skills gap, the PI is developing an interdisciplinary Metal AM course at Arizona State University (ASU) that trains the next generation of engineers to employ steel in creative ways across structural, mechanical, and aerospace applications. The three-year effort (Fall 2025-Summer 2028) advances through four phases: content development, piloting, full-semester launch, and institutionalization. This report covers the first year of the project (Fall 2025 to Summer 2026), during which all proposed tasks and milestones were completed on schedule. Specifically, the PI (1) formed the course advisory team and finalized a course outline, (2) developed all nine instructional modules together with assignments, term-project statements, and grading rubrics, and (3) collected feedback from some students and faculty colleagues and revised the content accordingly. These activities were carried out within the $10,000 first-year budget, which supports 0.5 month of summer salary for the PI and the procurement of instructional materials.

2. Curriculum Development Activities and Milestones Achieved

In Fall 2025, the PI and team finalized and approved a detailed course outline, satisfying the two Fall 2025 milestones: 1) course outline approved and 2) partners confirmed. Content development began immediately on the first three modules: applied metallurgy (phase diagrams, grain-size measurement, structure-property relationships, and the high-temperature behavior of structural steels), AM processes for metals (directed energy deposition, powder bed fusion, binder jetting, ultrasonic- and friction-stir-assisted methods, and hybrid AM), and feedstocks for metal AM (powder production and characteristics, recycling, and wire and sheet feedstock). Initial laboratory concepts were drafted in parallel to support experiential, steel-focused learning.

In Spring 2026, the PI completed modules four through six: heat transfer in metal AM, microstructure and its control, and the mechanical properties of AM steel parts; each delivered as lecture slides, lecture notes, curated readings, and steel-specific case studies. Concurrently, the PI built the assessment infrastructure: assignments and a term-project framework centered on metallography and mechanical testing, together with their grading rubrics. Coordination with ASU laboratory facilities and partners secured access to AM demonstrations and to printing steel specimens, thereby satisfying the Spring-2026 milestone requiring that laboratory exercises and assignments be finalized. During Summer 2026, the PI completed the final three modules: common defects and their characterization, residual stresses and distortion, and the safety, sustainability, and economic dimensions of metal AM, bringing all nine modules to a fully drafted state. The PI

then gathered feedback through internal peer review and from graduate students, and revised the lecture content, instructional materials, and laboratory exercises accordingly. These activities met the two Summer-2026 milestones: all course content drafted and revisions documented. Throughout the year, every module was framed around steel applications and examples, sharpening the course's focus on steel's role in modern additive manufacturing while retaining all planned topics and learning outcomes.

3. Deliverables, Outcomes, and Next Steps

As of the close of Year One, the project has produced a complete, peer-reviewed instructional package: nine fully drafted modules spanning applied metallurgy through sustainability and economics, a bank of assignments and term-project statements emphasizing metallography and mechanical testing, and the corresponding grading rubrics, aligning with the four course objectives and four learning outcomes defined in the original proposal. All seven Year-One milestones across the three terms were achieved on schedule and within the $10,000 first-year budget. To this end, the course is now positioned to transition from development to delivery. In Fall 2026, the PI will pilot-test the material with a small cohort through an independent-study format and document student learning outcomes to guide refinement. The pilot will be followed by the first full-semester offering in Spring 2027, with a target enrollment of 20-30 students; a field visit to the CMC micro-mill in Mesa, Arizona, the world's first steel micro-mill; and guest lectures from steel-industry partners. Overall, the first-year results indicate that the project is on schedule to deliver a permanent, replicable Metal AM course that strengthens ASU's ties to the steel industry and supplies a workforce fluent in both traditional steel engineering and additive manufacturing.