Building an Interdisciplinary Additive Manufacturing Ecosystem: A Case Study of TUM.Additive

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Abstract: Additive manufacturing (AM) is an intrinsically interdisciplinary technology, spanning materials science, process and mechanical engineering, and design, with applications from construction and aerospace to medicine and the life sciences. Its industrial relevance depends on combining innovative process technologies with strong application potential, yet this is frequently constrained by fragmented expertise across materials, design, and application disciplines. Research entities such as universities tend to reproduce this fragmentation because resources, incentives, and reputation are organised around individual chairs, professorships and departments. This paper asks how an interdisciplinary AM ecosystem is built and coordinated within a university, and which mechanisms enable and constrain that process. We address the question through a single, revelatory case study of TUM.Additive, a mission network at the Technical University of Munich uniting thirty-five chairs and professorships from seven TUM schools and over one hundred researchers, spanning all seven DIN EN ISO/ASTM 52900 process categories and five material groups. We read the case through a triple helix lens, complemented by entrepreneurial ecosystem theory, and analyse it using the network's three coordination mechanisms: Connect, Collaborate, and Communicate. This study highlights that intra-university ecosystem building depends on the active, coordinated operation of these three mechanisms to overcome institutional friction. It contributes to the triple helix and entrepreneurial ecosystem literatures by extending them to the underexamined intra-university level, offering a transferable framework for research-network builders.

Keywords: Entrepreneurial ecosystems, Triple helix, Additive manufacturing, Interdisciplinarity, University innovation, Research-network coordination

1. Introduction

Additive manufacturing has moved, over the past two decades, from a rapid-prototyping niche to a strategically significant field of industrial and academic activity (Ngo et al., 2018). Its defining characteristic as a research object is that it cannot be owned by any single discipline: a metal lattice, a bioresorbable implant, and a 3D-printed concrete structure each require the simultaneous engagement of materials scientists, engineers, clinicians, and designers. AM becomes relevant only when innovative process technologies meet strong application potential, yet that combination is repeatedly hindered by fragmented expertise across the disciplines involved.

This fragmentation is reinforced by the university's organisational reality, which allocates people, budgets, and reputation to individual chairs, professorships, or departments. The result is a coordination problem: the technology pulls towards integration while the institution pushes towards fragmentation. Bridging the two is a precondition not only for coherent research but for translation, that is, for moving AM-powered innovations towards industrialisation with a genuine application focus.

Much of the innovation-studies literature that speaks to this problem operates at the regional or national scale: clusters, regional innovation systems, and entrepreneurial ecosystems are typically theorised as geographies rather than as intra-organisational arrangements. Comparatively little attention was paid to how an ecosystem is deliberately constructed within a single university, across its internal boundaries, and alongside its engagement with industry and government. Yet this is precisely the arena in which many emerging technologies are first assembled into a coherent research and translation agenda.

This paper examines that arena through the case of TUM.Additive, the additive manufacturing mission network at the Technical University of Munich (TUM). It asks a single guiding question: how is an interdisciplinary AM ecosystem built and coordinated within a research university, and what mechanisms enable and constrain that process? We approach the case through the triple helix model of university, industry, and government relations, complemented by entrepreneurial ecosystem theory, and operationalise the analysis using the network's own framework of three coordination mechanisms: Connect, Collaborate, and Communicate.

The contribution is threefold. First, we extend ecosystem and triple helix thinking to the intra-university level, treating the university not merely as one node in a larger helix but as a miniature ecosystem in its own right that must be actively integrated. Second, we offer an empirically grounded account of the coordination work, much of it relational and communicative rather than technical, that holds such an ecosystem together. Third, we propose a transferable framework that other research-network builders can apply.

2. Theoretical Background

2.1 The Triple Helix and the Entrepreneurial University

This paper reads TUM.Additive as a triple helix configuration operating within and around a single university, and so requires the model theorising how value arises between institutional spheres. The triple helix model conceptualises innovation as emerging from the overlapping, increasingly reciprocal relations among university, industry, and government rather than from any one sphere alone (Etzkowitz and Leydesdorff 2000). A central claim is that the university assumes an entrepreneurial role, adding a third mission to teaching and research: economic and social development (Etzkowitz 2003; Gibbons et al. 1994). While the model is usually applied to relations between distinct institutional spheres, its underlying logic, that value is created in the overlaps, hybrids, and boundary organisations forming between them (Cai and Etzkowitz, 2020), can be extended inward to the overlaps between disciplinary units inside a single university, while industry and government remain present as the outer spheres of the ecosystem.

2.2 Entrepreneurial and Innovation Ecosystems

This paper's concern, how an innovation ecosystem is deliberately built and held together inside a single university, makes the entrepreneurial and innovation ecosystem literature relevant. Ecosystem approaches shift attention from linear pipelines to the interdependent actors, resources, and relationships that jointly produce innovative and entrepreneurial outcomes (Isenberg 2010; Stam 2015; Spigel 2017). Two features are relevant to TUM.Additive as a built and maintained ecosystem. First, ecosystems are held together less by hierarchy than by relational and informational ties, making coordination and orchestration central. Second, they are increasingly recognised as requiring active orchestration by identifiable actors rather than emerging spontaneously (Harima et al. 2024). This study builds directly on both features and asks what orchestration looks like when the ecosystem is bounded by a single institution.

2.3 Interdisciplinarity and Additive Manufacturing as a Boundary Technology

The coordination demands this paper explains are rooted in additive manufacturing itself. AM is usefully understood as a boundary technology: an object whose development recruits multiple communities of practice and, because it sits between them, continually generates coordination demands. The concept of the boundary object originates with Star and Griesemer (1989) and was extended to the technologies of the Fourth Industrial Revolution, including additive manufacturing (Krafft et al., 2020). The interdisciplinarity literature has long noted that cross-disciplinary work is impeded by differences in vocabulary, epistemic standards, publication norms, and incentive structures (Klein, 1990; Jacobs and Frickel, 2009). At the university, the chair system amplifies these frictions by rewarding disciplinary prestige over integration. Consequently, an intra-university AM ecosystem must work directly against this institutional gradient.

2.4 Research gap

Together, the triple helix, ecosystem, and interdisciplinarity literatures leave a gap: the former focus on inter-organisational dynamics rather than internal university ecosystems, while the latter details frictions without specifying network-wide coordination mechanisms. The aim of this paper is therefore to identify and characterise the coordination mechanisms through which an interdisciplinary ecosystem is built and sustained within a single university, together with the tensions that constrain that process, and to establish how these mechanisms extend triple helix and ecosystem theory to the intra-university level.

3. Research Context and Methodology

3.1 Research Design and Case Selection

The coordination problem set out in Sections 1 and 2, that AM generates integrative demands a chair-based university is not structured to meet, calls for a design that traces how coordination is accomplished in practice. This paper therefore uses a single-case study design, examining TUM.Additive in depth rather than comparing many cases. This approach suits "how" questions about contemporary phenomena the researcher cannot

manipulate (Yin 2018) and matches this paper's question directly. TUM.Additive is a university-wide AM network at the Technical University of Munich, uniting thirty-five chairs and professorships across all seven TUM schools under a dedicated coordination function (Section 4). It is selected not as a representative or typical case but as a *revelatory* one: a deliberately constructed, formally governed, university-wide AM network that makes visible coordination dynamics which are usually tacit or dispersed. Single revelatory cases are valued for the analytical depth and theoretical insight they afford, with generalisation understood as analytic (to theory) rather than statistical (to a population) (Eisenhardt 1989; Yin 2018).

Case context and data sources

The evidence base draws on multiple sources. First, the network's public and institutional documentation: its mission statement and community listing, its curated publication records, and its strategic and communication materials, including the network's image and pitch presentations. The network's representation of member research is compiled from the chairs' public websites, and the equipment listed for collaboration is verified by email with each chair's point of contact before publication, making both traceable to verifiable sources. Second, records of recurring activities like PhD seminars, the AMeetUp series, and trade fairs. Third, first-author participant observation as network coordinator, providing direct insight into daily ecosystem maintenance. Documentary sources and participant-observation notes were analysed thematically, using the Connect, Collaborate, and Communicate framework set out in Section 3.2 as the coding structure. Each item was coded against the three mechanisms to group and compare recurring practices. Multi-mechanism activities were double-coded to trace interactions. Triangulating documents with direct observation filtered out one-off events and reduced single-source bias.

3.2 Analytical Framework: The Three Coordination Mechanisms (Connect, Collaborate, Communicate)

To structure the analysis, we use the network's own framework of three coordination mechanisms. *Connect* is the relational work of linking previously unconnected units and sustaining those links. *Collaborate* is the conversion of connection into joint output and translation, through co-initiated projects, consortia, and start-up and industry engagement. *Communicate* makes the network's research and its shared resources visible and accessible, rendering dispersed activity legible and actively enabling collaboration. We treat these three mechanisms analytically as the means by which intra-university and university-to-industry overlaps are actively produced rather than assumed, and we map each onto the triple helix relations it primarily serves.

3.3 Reflexivity and Limitations

The first author holds the science-management role within TUM.Additive. This insider position affords access and interpretive depth but also potential bias; we treat it reflexively, distinguishing observed mechanisms from advocacy and triangulating observation against documentary evidence where possible. As a single case, the study makes no claim to statistical generalisation. Its contribution is analytic: to sharpen and extend theory about intra-university ecosystem building, and to offer a framework that future comparative work can test.

4. The Case: TUM.Additive

4.1 Mission, Structure, and Scope

TUM.Additive is a mission network at the Technical University of Munich that unites the university's additive manufacturing expertise into an integrative, interdisciplinary research ecosystem. Founded in 2022, its defining feature is breadth. Rather than sitting within a single faculty, the network bundles AM activity from thirty-five chairs and professorships and over one hundred researchers, spanning all seven schools of TUM and covering fields from materials science, mechanical, process, and civil engineering, and design, to chemistry, medicine, the life sciences, informatics, and the economics of innovation. Its research covers all seven DIN EN ISO/ASTM 52900 process categories and five material groups, supported by a large installed base of AM systems giving near-complete in-house coverage of established and emerging methods, and complemented by more than fifty lectures across its departments. This breadth is the network's central asset and its central coordination challenge: it assembles the full disciplinary range that AM demands, while inheriting the full heterogeneity of incentives and cultures that the chair system produces.

4.2 Governance and Coordination

The network is academically co-led by two scientific coordinators from complementary domains: laser-based additive manufacturing, within the Department of Mechanical Engineering, and materials engineering of additive manufacturing, within the Department of Materials Engineering. This pairing itself embodies the

interdisciplinary logic of the enterprise. Day-to-day coordination is carried out by a dedicated science-management function that performs the connective, collaborative, and communicative work analysed in this paper. This central function is complemented by a distributed structure in which each chair provides a single point of contact, giving the network a hub-and-spoke architecture: one central coordinator linked to one liaison in every member chair. Governance is soft rather than hierarchical: the coordination function holds no formal authority over the chairs and cannot direct their resources, so decisions about joint activity are reached by convening, proposing, and securing voluntary commitment. The network therefore governs through consent and persuasion rather than command. This separation between academic leadership and operational coordination is analytically important: it locates much of the ecosystem-orchestration work in identifiable roles rather than leaving it to emerge spontaneously from the chairs. The network's autonomy is limited in a specific way. Embedded in and funded by the university, it holds no independent budget or authority, yet it also stands outside the chairs' own command structures, coordinating actors it cannot direct. This produces a distinctive autonomy paradox: the network depends on the university for its existence but relies on persuasion, not hierarchy, to act. Its independence lies not in freedom from university governance but in the operational latitude to broker coordination the formal structure does not provide.

4.3 The Ecosystem and its Industry Node

Beyond its internal breadth, TUM.Additive presents itself as a four-part ecosystem spanning science, entrepreneurship, industry-on-campus, and industry partners, making the triple helix concrete within and around a single university. Science is the academic core. Industry-on-campus is embodied in the TUM-Oerlikon Advanced Manufacturing Institute, a boundary organisation linking the university and the industrial partner Oerlikon. The entrepreneurship strand, anchored by TUM Venture Labs AM supporting start-ups, represents the capitalisation of knowledge emphasised in the entrepreneurial-university literature. The industry-partner strand connects to government through Bavaria Makes, Bavaria's High-Tech Alliance for the Manufacturing of the Future, an association supported by the Free State that unites companies, universities, and research institutions to industrialise additive manufacturing. Bavaria Makes participates directly in the network's activities, from its PhD seminars to the joint presence at Formnext, so that government is not a distant funder but an active convenor of university and industry actors, completing the triple helix depicted in Figure 1.

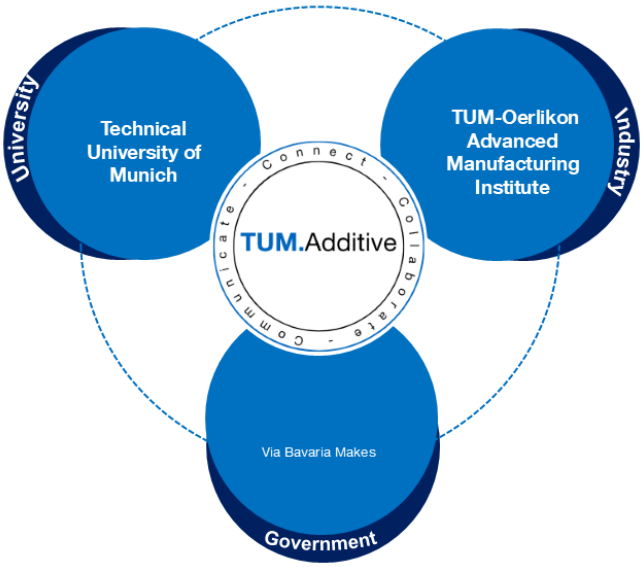


Figure 1: TUM.Additive as a coordinating hub, applying Connect, Collaborate, and Communicate to link the university (Technical University of Munich), industry (TUM-Oerlikon Advanced Manufacturing Institute), and government (reached through the Bavaria Makes alliance) spheres of the triple helix

5. Findings

TUM.Additive operates as one coordinating activity within the broader additive manufacturing environment of the Technical University of Munich, linked outward to the university's industry and government partners through the TUM-Oerlikon Advanced Manufacturing Institute and the Bavaria Makes initiative described in Section 4. The findings that follow concentrate on the layer that this paper takes as its contribution: the internal, intra-

university work of building and holding the ecosystem together across the chairs. We organise these findings around the network's three coordination mechanisms, in the order in which they operate, Connect, then Collaborate, then Communicate, and then draw out the enablers and tensions that cut across them. Each mechanism is read as a way of actively producing the overlaps on which the ecosystem depends, while the external partnerships of Section 4 remain the outer frame. Table 1 summarises the mechanisms and their principal activities, each examined in turn below.

Table 1: The three coordination mechanisms and their principal activities in TUM.Additive

Mechanism	What it does	Activities in TUM.Additive
Connect	Brings chairs and researchers together to foster interdisciplinary projects	PhD Seminar Series; Chair Visits; Ameet Series; Know Our Members series on LinkedIn
Collaborate	Converts connections into joint projects, consortia, and start-up and industry engagement	Formnext (joint booth); EuroTeQ Collider mentoring; AMI Monthly Minds
Communicate	Makes research outputs and shared resources visible and accessible	AM Publication database; Paper Spotlight on LinkedIn; Facilities Wiki

5.1 Connect: Boundary-spanning as the Primary Building Act

The first finding is that the ecosystem is built, above all, through sustained connective work. Because the constituent chairs have no structural obligation to cooperate, links between them must be actively created and maintained rather than assumed. Much of this work is concentrated in the science-management function, which spans the internal boundaries of the university, identifies complementary capabilities across chairs, and convenes them around shared opportunities. This work is made durable by a network of designated points of contact, one per chair, giving the central function a reliable channel into every member unit and turning an informal web of relationships into a maintainable structure. It is sustained through recurring formats that give members regular, low-cost occasions to discover one another's work and to connect beyond the university: the PhD seminar series institutionalises encounters among early-career researchers, chair visits build direct relationships between the coordination function and individual units, the AMeetUp networking series, organised with TUM Venture Labs AM, connects researchers with the start-up community, and the Know Our Members series on LinkedIn makes individual members and their expertise visible across the network. In triple helix terms, the value the model locates in the overlaps between spheres has an intra-university counterpart: the overlaps between disciplines do not pre-exist but must be actively created, and this connective work is how they are brought into being.

5.2 Collaborate: Converting Ties Into Joint Output and Translation

The second finding is that connection is validated by collaboration: the joint proposals, co-initiated projects, consortia, and start-up and industry engagements through which the ecosystem produces value that no single chair could produce alone. This is where the network's interdisciplinary premise is tested and, when successful, borne out, and the conversion operates through several channels. The joint booth at Formnext, the sector's principal international trade fair, gives members a shared platform to present their work to industry and to initiate contact with potential partners. EuroTeQ Collider mentoring brings researchers together as volunteer mentors to support student teams on a common annual challenge, drawing their expertise into joint work around a shared problem. The AMI Monthly Minds meetings bring the TUM-Oerlikon Advanced Manufacturing Institute's researchers together to share findings and develop project proposals, converting shared presence into proposal-stage collaboration. Together, these channels reach across the network's internal, entrepreneurial, and industry boundaries.

A concrete instance shows how the mechanisms feed one another. The Chair of Materials Science approached TUM.Additive for specific equipment; using the Facilities Wiki (Section 5.3), the science-management function identified a match and connected it to the Chair of Carbon Composites, and the two now intend to co-author a paper. Though no output has yet resulted, the sequence, from resource enquiry, through brokered connection, to intended joint publication, shows connective and communicative work converting into collaboration in progress. At a larger scale, a proposal is currently being developed for a bilateral workshop under the Indo-German Science & Technology Centre (IGSTC), bringing together three chairs, the Bavaria Makes initiative, and industry partners, and thereby spanning the university, government, and industry spheres.

5.3 Communicate: Visibility and Shared Access to Resources

The third finding is that a shared communication infrastructure is not a cosmetic add-on but a core coordination mechanism. It operates in two complementary ways, delivered through three connected instruments. First, it showcases AM research and publications within the ecosystem, rendering a set of parallel activities into a recognisable collective actor. The monthly Paper Spotlight on LinkedIn surfaces an individual member's publication to the wider network, giving dispersed research a regular, shared point of visibility. The AM Publication database extends this from the individual to the collective: a consolidated, year-by-year record that brings together more than 270 publications between 2022 and 2025, drawn from chairs across all seven schools, into a single visible list. The network maintains this record across both of TUM's publication databases, the established MediaTUM and the newly introduced TUMFIS platform, which it adopted as soon as it became available, illustrating the ongoing work of keeping the network's output visible. Second, and less obviously, it creates a commonly accessible platform that makes the network's resources open for collaboration, namely its facilities, materials, machines, and manufacturing capabilities, transparent and easy to locate. This is the function of the Facilities Wiki, a maintained inventory of the equipment members make available to one another, currently listing over 150 items across four categories: 96 AM printers, 10 simulation tools, 24 analysis devices, and 29 further pieces of equipment. Crucially, this inventory is not assumed but verified: each entry is confirmed by email with the relevant chair's point of contact before publication, so the platform functions as a trustworthy and maintained resource rather than a static snapshot, and the same points of contact that enable connection keep it current.

Together, these instruments turn communication into an enabler of collaboration rather than a mere record of it. A dispersed network is, by default, invisible to its members, the wider university, and external partners; by making both its outputs and resources visible, it lowers the barriers to the collaborations described in Section 5.2, as the equipment enquiry linking the Chair of Materials Science to the Chair of Carbon Composites illustrates.

5.4 Enablers and Tensions

Across the three mechanisms, two enablers recur. The first is dual, cross-domain academic leadership that legitimises interdisciplinary effort from the top; the second is a dedicated operational coordination function that supplies the connective, collaborative, and communicative labour from the middle. Two external anchors reinforce these: a boundary institute linking the university and industry, and a venture-lab route to entrepreneurship, which together give the internal network durable external partners. Two tensions also recur, and together they constitute the principal barriers to synergy in the network's cooperative mode. The first is chair-level autonomy: because chairs retain control over their own resources and priorities, participation is largely voluntary and must be continually re-earned. The second is incentive misalignment: academic reward systems still privilege disciplinary output, so the network's integrative work competes with individually rational disciplinary strategies. The coordination mechanisms mitigate these tensions by lowering the cost of cooperation and raising its payoff, but do not dissolve them.

6. Discussion

These findings speak back to the literature reviewed in Section 2. For the triple helix theory, the case suggests that the model's core intuition, that value is produced in the overlaps between spheres, applies not only between the university, industry, and government, but also within the university, between its own disciplinary spheres. TUM.Additive's four-part ecosystem suggests that the helix operates at two levels at once: an internal helix of disciplines and an external helix of science, industry, and public funding, joined by boundary organisations and an entrepreneurship route. The university is therefore not simply one node in the helix; it is itself a site, where helical, overlap-producing dynamics must be actively cultivated before the external helix can be effectively engaged.

For ecosystem theory, the case underscores the centrality of orchestration: the ecosystem does not emerge spontaneously from the co-presence of chairs but is built and sustained by identifiable coordinating actors, showing what stewardship concretely involves at the intra-organisational scale.

For practice, the framework offers research-network builders a compact diagnostic: weakness in any one mechanism predicts a characteristic failure mode, whether isolated chairs, activity without shared results, or an invisible network whose resources no one can find. Although the case concerns additive manufacturing, the same three mechanisms plausibly apply to any emerging, boundary-crossing technology, which is where the framework's broader relevance lies.

7. Conclusion

This paper asked how an interdisciplinary additive manufacturing ecosystem is built and coordinated within a research university. Its central argument is that such ecosystems do not emerge on their own but must be actively orchestrated across disciplinary and institutional boundaries. The study approached this through a revelatory case study of TUM.Additive, examined not as a triple helix in itself but as the university actor within a wider triple helix of university, industry, and government, and analysed using the network's own three coordination mechanisms. The analysis showed that such ecosystems are built through sustained connective work, made productive through collaboration that converts ties into joint, translation-oriented output, and made durable through communication that renders the network visible and opens its resources for collaboration, all against the institutional gradient of a chair-based university and supported by external boundary organisations and an entrepreneurship route.

The study's contribution is to extend triple helix and entrepreneurial-ecosystem thinking to the intra-university scale, to specify the coordination work it demands, and to offer a transferable framework for research-network builders. Its principal limitation is the single case; it invites comparative work across universities and technologies to test the claims advanced here. As additive manufacturing and other boundary technologies continue to demand integration that institutions are not naturally built to provide, understanding how such ecosystems are deliberately assembled becomes a question of both scholarly and practical consequence.

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AI Declaration: During the preparation of this manuscript, the authors used Grammarly and Claude (Anthropic) for language editing and paraphrasing. All research, data collection, analysis, structure, interpretations, and conclusions were carried out by the authors, who take full responsibility for the final text.

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