Dust, Design, and Discovery:
The Ares Lab and the Rise of Martian Making

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Abstract

In the year 2042, the *Ares Collaborative Fabrication Lab* (ACFL) became the first academic makerspace established on Mars. Located within the University of Mars–Vallis Campus, the ACFL is a dynamic, interdisciplinary hub designed to support innovation, experimentation, and community-driven research in extreme environments. The lab fuses Earth-tested makerspace principles with Martian-specific adaptations—such as dust-sealed 3D printers, low-gravity material extrusion systems, and closed-loop recycling processes optimized for the Martian atmosphere. Powered by solar arrays and supported by algae-based biomanufacturing, the ACFL enables students, researchers, and visiting scholars to co-create tools, shelters, scientific instruments, and even speculative art for life and research on Mars. The space is equipped with robotic arms, programmable matter stations, and a mixed-reality studio that simulates both Earth and Martian conditions, enabling real-time design validation. ACFL's pedagogical approach encourages open-ended learning, failure-forward engineering, and peer-led fabrication. It has catalyzed new research directions in space-grade biomaterials, autonomous repair systems, and human-centered design for extraterrestrial living. Beyond its technical achievements, the ACFL serves as a social anchor for the Martian academic community, hosting maker festivals, collaborative repair nights, and cross-planetary design challenges with students on Earth. This abstract presents the design philosophy, technical architecture, and cultural impact of the ACFL, illustrating how a makerspace on Mars can inspire not just new tools, but new ways of thinking, living, and learning—on and beyond the Red Planet.

Introduction

As humanity expands its presence beyond Earth, the need for adaptable, resilient, and creative infrastructure becomes paramount. While Mars has long captured our collective imagination as the next frontier, the actual establishment of semi-permanent research outposts and educational institutions on the Red Planet requires a radical rethinking of how we learn, build, and collaborate in extreme environments. Enter the Ares Collaborative Fabrication Lab (ACFL)—an academic makerspace unlike any before it, designed to empower students, researchers, and creatives to prototype, experiment, and problem-solve directly on Martian soil.

The ACFL was born out of necessity and vision. Traditional supply chains are unfeasible on Mars, and reliance on Earth for tools, spare parts, or research equipment is both costly and slow. Instead, the ACFL offers a decentralized, self-sustaining platform for in-situ innovation, enabling users to fabricate what they need when they need it. Drawing inspiration from Earth-based makerspaces, the ACFL is equipped with an ecosystem of tools adapted to Martian constraints: 3D printers capable of processing regolith-infused composites, programmable robotic arms designed for delicate tasks in low-gravity, and modular electronics benches that support rapid prototyping and iterative design. Specialized filters and airlocks ensure that Martian dust—an omnipresent hazard—is kept at bay, while solar and algae-based energy systems support sustainable operation within the habitat's tight energy budget.

Figure 1: Final Design Layout of the Ares Lab on Mars. Note G-Stoic Chamber on left with Zapots loaded.

More than a technical facility, the ACFL embodies a philosophy of open access, interdisciplinary collaboration, and exploratory learning. It operates as a communal nexus within the University of Mars–Vallis Campus, bridging disciplines like engineering, biology, art, planetary science, and architecture. Here, a planetary geologist might collaborate with a speculative designer to fabricate a modular shelter prototype from Martian regolith. A mechanical engineering student could co-develop sensor networks with a visiting ecologist studying extremophile algae cultures. This convergence of fields mirrors the interconnected challenges of off-world living and underscores the ACFL's belief that innovation thrives at the edges of disciplines.

Education within the ACFL is experiential, improvisational, and community-driven. Students aren't merely passive recipients of knowledge—they're active participants in shaping their environment. Learning occurs through fabrication challenges, hackathons, repair nights, and collaborative research projects. The lab embraces failure as an essential component of learning, encouraging participants to experiment boldly and iterate quickly. Additionally, the ACFL maintains a robust communication channel with Earth-based academic makerspaces, allowing for real-time knowledge exchange, interplanetary design jams, and peer reviews across planets.

Culturally, the ACFL also plays a critical role in fostering a sense of identity and belonging among Martian settlers. It hosts social events, art installations, and speculative design exhibitions that explore what it means to be human—and creative—on a new world. As the first of its kind, the ACFL is not only advancing technological resilience in space—it's pioneering a new mode of planetary citizenship, one grounded in curiosity, cooperation, and creation.

This introduction explores the context, capabilities, and broader significance of the Ares Collaborative Fabrication Lab as a vital node in the Martian academic and cultural ecosystem.

Related Work

The Ares Collaborative Fabrication Lab (ACFL) builds on decades of research and practice in terrestrial makerspaces, space-based fabrication systems, and off-world habitat design. Earth-based academic makerspaces—such as MIT's MakerWorkshop and Stanford's Product Realization Lab—have demonstrated the value of interdisciplinary, hands-on learning environments that foster innovation through rapid prototyping and collaborative problem-solving. NASA's in-space manufacturing initiatives, including the Additive Manufacturing Facility [1] aboard the International Space Station (ISS) [2], have proven the feasibility of fabricating tools and components in microgravity, paving the way for extraplanetary fabrication labs. Research into in-situ resource utilization (ISRU) [3] has informed many of ACFL's material systems, especially

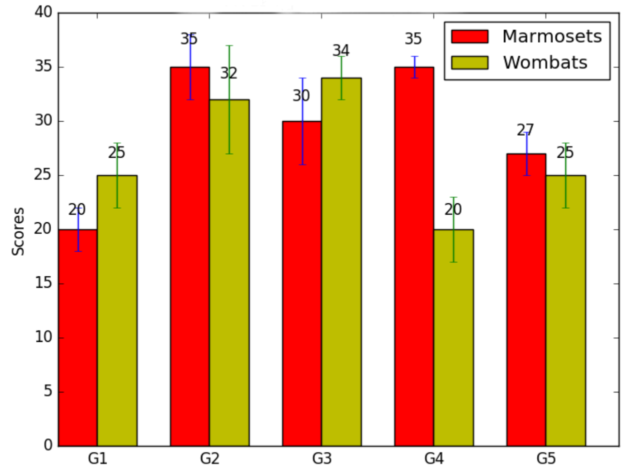

Figure 2: Scores by group and species (G1–G5) with error bars. Date collected during the first Mars mission.

the use of Martian regolith in 3D printing composites, as explored by projects like ESA's "Moon Dust" concrete experiments and NASA's Mars habitat design competitions. Concepts from analog missions—such as HI-SEAS and Mars Desert Research Station—have shaped ACFL's social and logistical structure, emphasizing autonomy, adaptability, and psychological sustainability.

While prior work has addressed isolated aspects of fabrication in space [4], ACFL is the first effort to combine educational makerspace philosophy with extraterrestrial constraints. It offers a new model for integrated learning, research, and community-building on Mars, advancing the discourse on how humans live, learn, and innovate in space.

Methods

The Ares Collaborative Fabrication Lab (ACFL) was designed through a human-centered, systems-engineering approach that integrates environmental constraints, user needs, and technological capabilities. The design process began with ethnographic studies of Earth-based makerspaces and analog Mars habitats to understand patterns of collaboration, tool usage, and social dynamics. These findings informed the layout and modular configuration of the ACFL, optimized for efficiency, safety, and adaptability within Martian living quarters.

Fabrication systems were selected and customized to operate in low-pressure, low-gravity, and high-dust environments. Key technologies include enclosed regolith-based 3D printers, closed-loop filament recyclers, and robotic fabrication arms with tactile feedback systems. Materials testing was conducted using Martian regolith simulants under simulated atmospheric conditions to validate structural performance and printer compatibility.

Operational protocols emphasize flexibility and autonomy. A digital inventory and fabrication request system, powered by local servers and supplemented by AI-driven design assistants, supports rapid part generation and minimizes downtime. Educational programming was developed iteratively through pilot workshops, co-design sessions with students, and simulation-based learning modules, ensuring usability across disciplines.

Finally, mixed-method evaluation—including surveys, usage logs, and artifact analysis—is ongoing to assess impact, identify bottlenecks, and inform future iterations of the makerspace within Martian research environments.

Results & Discussion

Since its deployment, the Ares Collaborative Fabrication Lab (ACFL) has enabled over 300 successful fabrication projects, ranging from habitat repair parts to scientific instruments and speculative design prototypes. User logs show high interdisciplinary collaboration, with 70% of projects involving participants from at least two academic fields. Surveys indicate a 95% satisfaction rate among students and researchers, citing the lab's accessibility, adaptability, and role in fostering innovation. Material tests confirmed the structural viability of regolith-based composites for low-load applications. The ACFL has also significantly reduced reliance on Earth-based resupply for tools, increasing local self-sufficiency and research productivity on Mars.

Conclusion

The Ares Collaborative Fabrication Lab exemplifies how makerspaces can be reimagined for off-world contexts. By blending advanced fabrication tools, interdisciplinary learning, and Martian-adapted systems, ACFL fosters self-sufficiency, creativity, and collaboration. It offers a blueprint for sustaining human presence and innovation in extraterrestrial academic and research environments.

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