

## **FormFree Concrete for FreeForm Retrofit Components**

*A Robotic Manufacturing Ecosystem for Precast Building Envelopes*

**Overview** // Our multi-disciplinary team is developing a holistic design through manufacturing system for overcladding of commercial building envelopes made from insulated, composite concrete panels. Our approach leverages the prefabrication capacity of the architectural precast industry, while introducing an innovative, moldless process to manufacture concrete components. This formfree approach relies on a combination of robotic and 3D Printing technologies targeted to address existing innovation gaps in precast concrete factories.

The system has three primary components:

1. 3D scanning for performance driven panel layout and design tools. (Mapping, Phase II)
2. **Overcladding system of composite concrete panels manufactured with robotic finishing (Retrofit Tools, Primary Focus Phase I).**
3. Certification of finish quality using computer vision (Sensing & Inspection, Phase I)

**Challenges** // Overcladding is a minimally invasive retrofit approach that can simultaneously address the varied challenges plaguing US Commercial building stock. These buildings currently consume 19% of the nation's total energy; have a median age of 32 years; often lack insulation; have unwanted air/moisture penetration; and are overdue for exterior repairs. In addition, retrofitting buildings that span centuries of architectural styles, and whose façades are seldom flat, requires added design flexibility. There are few straight lines or true corners in old buildings, thus parts must be dimensionally unique and geometrically imperfect.

**Impact** // Our approach maintains the resilience and modularity of traditional precast panels, but introduces a highly customizable manufacturing alternative that is better suited to the geometric complexities of overcladding. In addition, greater design freedoms enable improved performance - in this case tunable insulation, optimized strength to weight ratio, and airtight component integration. Lastly we prioritize in-factory productivity, consolidating the number of on-site trades to minimize occupancy disruptions and simplify installation.

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**Industry Partners and Technology Transfer Mentors**

[ExOne](#), a global leader in binder jet 3D printing technologies and applications

[FANUC](#), industrial robot manufacturing, automation technologies, and integration experts

[Michael Brothers Hauling & Recycling](#), exploring new markets for demolition waste streams

[CMU Scott Energy Institute](#), strategic partnerships and mentoring, Program Connector

[CMU CTTEC](#), university resource for technology transfer and enterprise creation

[Idea Foundry](#), non-profit economic development focused on tech transfer, Program Connector