Agile Dwelling Units for an Aging Population

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Keywords: Aging in Place, Accessory Dwelling Units, Integrated Health-Centered Design Approach & Design-build Studio

As the number of older adults continues to grow rapidly, the need for personalized, innovative, and responsive housing solutions is critical to support individuals' social, emotional, financial, and physical needs. This research deploys an outcomes-based design approach to explore ways in which Agile Dwelling Units (AgDUs) with integrated Information and Communication Technologies (ICTs) can be used to prolong older adults' ability to live independently and age in place. A multidisciplinary team of industry experts, design practitioners, and scholars, worked collaboratively across three focus areas— human factors, health technologies, and design — to model a process that supports the contextual understanding, exploration, and deployment of AgDUs for an aging population. Using Dallas, Texas as a case study, developed methodology and research was applied to a one-semester academic studio course, in which architecture students designed initial prototypes to create healthy and flexible living spaces that adapt to the ever-changing needs of one's lifespan. This project models an integrated process between designers and non-designers that is necessary when addressing complex urban systems. Shared knowledge synthesis and innovation generated in collaborative practice with allied disciplines is equally as important in architectural education as it is in practice, to prepare students to be socially responsive and relevant professionals.

HOUSING AN AGING POPULATION

The older adult population in the United States has doubled since 2012. By 2030, one in five Americans will be 65 years or older, outnumbering children for the first time in US history[1]. As part of the aging process, many older adults require some level of specialized care to address the physical and psychosocial changes they are experiencing, ranging from advanced chronic disease to declining physical and cognitive capacities. For many, these changes can transform previously simple tasks, things like cleaning the home and managing medications, into challenging barriers to sustain one's level of independence. Older adults' homes and living situations are essential to maintaining high individual autonomy and quality of life. Research shows that the holistic well-being of older adults is prolonged when people maintain their independence, familiar daily routines, and social connections within their community. This is reinforced by the strong preference of older adults (75% of those 50 years and older) to remain in their current home and community for as long as possible[2]. For many however, aging in place presents difficulties due to an increased need for assistance over time, inaccessible housing design, lack of access to health and transportation services and escalating costs of living.

Low-income individuals on a fixed income are especially challenged, as adapting one's existing home to accommodate specialized care and greater accessibility is financially out of reach. A 2022 study by the National Association of Home Builders found that the average price for aging in place remodels, excluding the need for major improvements, totaled $9,500. For homes that require more intensive interventions, including renovated bathrooms, structurally widened hallways, and countertop height adjustments, that number quickly inflates to over $75,000 on average, well above the $14,000 one-time payment for those who qualify for Medicaid's Home Modifications Funding[3].

To support aging in place, communities require a range of affordable housing options that include accessible features that link housing more directly to healthcare. This work explores the use of a single residential housing typology, accessory dwelling units (ADUs), to support staging in place to accommodate users of different abilities and phases of life. ADUs have grown in popularity over the last few decades as sources of secondary income, residences for aging relatives, and even primary homes for those seeking a minimalistic lifestyle. There are many benefits to building and residing in an ADU, such as increasing residential density, flexibility in site location, and the simplicity of spaces without loss of function. However, current ADU design and construction trends often create units that are rigid in terms of use and form and cost more than most people can afford. This work explores design strategies that inform AgDU prototypes for a wide range of users. For the purposes of this research, AgDUs are defined as affordable, technology-enabled dwelling units that can be adapted to individual needs while supporting independent, secure, and engaged healthy

living. They offer a unique opportunity to flexibly adapt one's existing property to minimize the displacement of older adults in single-family zoned neighborhoods.

> Many adults (49%) are open to alternative housing options that would better enable them to age independently. Around 60% of adults would consider options like accessory dwelling units (ADUs) or "in-law cottages" to be able to live near someone but maintain their own space, save money, or get help with daily activities.
>
> —AARP, *Where We Live, Where We Age*

METHODOLOGY

Regardless of the word used, interdisciplinary, cross-disciplinary, or multidisciplinary work has been commonplace in academia in the 21st century to elevate research relevance and secure more robust funding. This work historically came out of the hard science disciplines, propelled by funding agencies such as the National Institute of Health, that focus on complex problems using teams of experts with different backgrounds[4]. Architectural faculty embedded in interdisciplinary research is most frequently associated with the correlated social impacts of architecture through process-driven research rather than the practice of design and building. In recent years, we have seen a shift in architectural research from academia to professional practice with a heightened interest in measurable outcomes for public audiences. This is exemplified by large international firms such as Gensler, HKS, and ARUP creating dedicated research institutions in the 2000s to address output-driven research. A 2022 report on the drivers of architectural research concluded that more collaboration between academic and professional practitioners is needed to drive rigorous research with social, cultural, and commercial value[5]. These principles apply to design studio learning and are further enhanced when a broad spectrum of disciplines is actively engaged in research.

To merge process and output-driven research, this study was conducted by a multidisciplinary team of experts, faculties, and students from the Center for Advanced Design Research and Evaluation (CADRE), architecture firm HKS' Health and Senior Living Practice, and the University of Texas at Arlington's (UTA) College of Architecture Planning and Public Affairs and Multi-Interprofessional Center for Health Informatics (MICHI). It is divided into three phases: (1) research to identify the gaps and challenges in designing technology-integrated dwelling units for aging in place, (2) initial design development of agile dwelling units, and (3) high-fidelity prototype deployment and evaluation. The scope of this article describes phase 2 and how literature research, discovery interviews, roundtable discussions with experts, and frameworks from phase 1 informed student design approaches. The aim is to provide perspectives for more holistic AgDU development that recognizes the need for cross-disciplinary integration in the residential market to support successful staging in place.

HUMAN FACTORS, HEALTH TECHNOLOGY, AND DESIGN FOR AGDUS

Three main lenses are used to inform a health-centered design approach for agile dwelling units including human factors, health technology, and design. Information collected across these lenses was converted into easy-to-use tools or worksheets designed to orient and introduce architecture students to design contexts, potential health indicators of end users, optimal design outcomes, and a design strategy framework.

Human Factors: A human factors approach focuses on identifying individuals' abilities, needs, and limitations to inform the development of design, tools, and technology to optimize user outcomes[6]. Older adults comprise a diverse population group with a wide range of ever-evolving physical, emotional, behavioral, educational, economic, and socio-cultural capabilities, limitations, and preferences. It is important to consider people's current position on the spectrum of needs and where they are projected to be in the future to inform the type of support needed to maintain independence at different stages of life. Autonomy for older adults is dependent upon one's ability to engage in everyday life activities. These can be categorized into three groups, (1) the activities of daily living (ADLs) that are essential for basic health and survival, ie: going to the bathroom and transferring, (2) the instrumental activities of daily living (IADLs) that are necessary for independence but are beyond primary self-care, ie: housekeeping and cooking, and (3) enhanced activities of daily living (EADLs) that contribute to a sense of fulfillment and well-being, ie: playing games and exercising. Although diagraming various human factors is seemingly simplistic, identifying nuanced resident needs and associated outcome-based design strategies to address them can be challenging. Further research and post-occupancy studies are needed to articulate the scale of impact that networked design strategies can have on older adults. Understanding the spectrum of human factors allows designers to identify specific AgDU design strategies that can be implemented to optimize desirable physical/digital, sensory, cognitive, and social outcomes based on user needs and preferences. For adults that require significant support, AgDUs designed to facilitate independent living may not be an appropriate housing choice.

Design Considerations:

- *Cater design to the ever-evolving individual needs and capacities of users*
- *Support physical and mental health including cognitive, social, and independent functions*
- Create useful, usable, affordable, and desirable units

Health Technology: Older adults' dependence on technology, specifically health technologies, has risen in recent years in

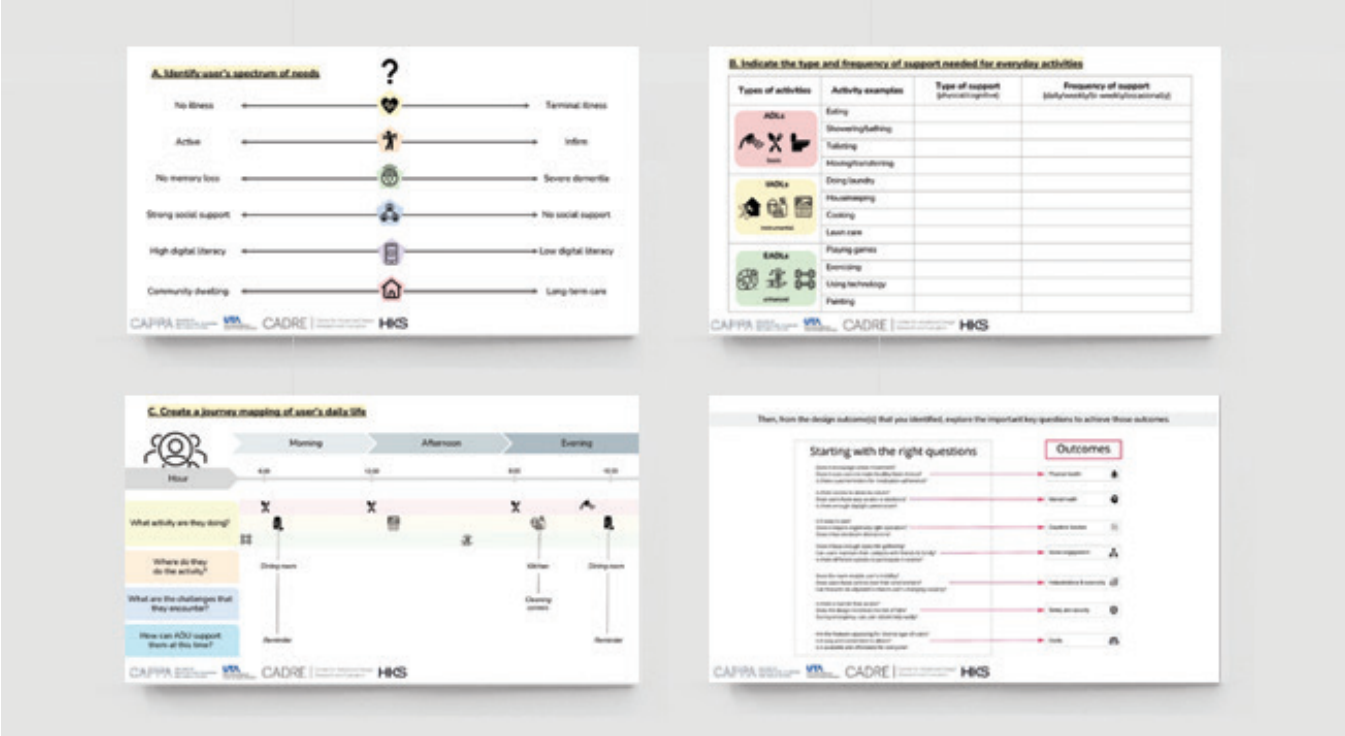


Figure 1. Research based design tools for AgDU design by CADRE.

response to the lack of available health services relative to increased demand and the expansion of telehealth options[7]. Health technology is particularly critical for health monitoring and management for older populations and can be used in residential settings to support independent living activities like housekeeping and cooking[8]. Technologies, whether categorized as attached, detached, passive or active, should be deployed to anticipate dynamic changes in one's environmental and behavioral life to support staging in place[9]. Although the development of ICTs has progressed, concerns remain about their accessibility and design for use by older adults. Studies show that training in digital competency and technology operations is needed for the integration of active technologies that require direct user interaction whether incorporated into the residence (attached) or not (detached). In contrast, passive technologies that do not require direct interaction, like Real Time Location System (RTLS) used to remotely track room use show potential as a preventative monitoring strategy for older adults when the technology is reliable and advanced enough for residential use. The categorization of ICTs allows designers to identify and map the types of technology that are most appropriate for specific users.

Design Considerations:

- *Customize ICTs to users' lifelong needs*
- *Optimize technology to minimize costs and maintenance through design*
- *Minimize compliance gaps through technology training*

Design: ADUs as a residential housing type are not a new concept. In many places, ADUs have a history dating back to the early 1900s when back houses were used as worker housing. ADUs are typically defined as a secondary smaller unit concerning a larger primary structure. There are three main types of ADUs - attached units, detached units, and clustered units (detached units grouped to form small communities, some with shared amenities or communal space to foster social connections). For this research, ADUs are designed to adapt to the changing needs of older adults over time, however, ADUs can also be used to house family members or caregivers to support aging individuals in maintaining independence. In municipalities, building codes limit what can or cannot be built. States like Washington and California have progressive zoning policies that allow ADUs by right and have put together pre-permitted catalogs of construction documents and contractors to help streamline the process; other areas prohibit ADUs altogether. Across the country, the average cost of an ADU is $150,000 or $250/square foot[10]. In many places, this is out to reach for medium to low-income wage earners and is more than the cost of some homes. Prefabrication construction methods including modular, flat pack, kit-of-parts, and additive manufacturing show promise in minimizing labor costs and improving product quality but continue to present cost challenges at low production volumes. In addition to cost, the health impact and life cycle of materials and systems need to be carefully weighed and considered. Strategies should extend beyond universal design principles to address health indicators and aid

Figure 2. Typical Dallas block patterns and proposed AgDU typologies.

specific activities unique to visual impairments, memory loss, declining mobility, etc.

Design Considerations:

- Utilize prefabrication construction methods to minimize site construction time and costs at scale
- Incorporate sustainable design strategies to promote holistic health and well-being
- Create flexible spaces that can adapt to accommodate changing user needs over time

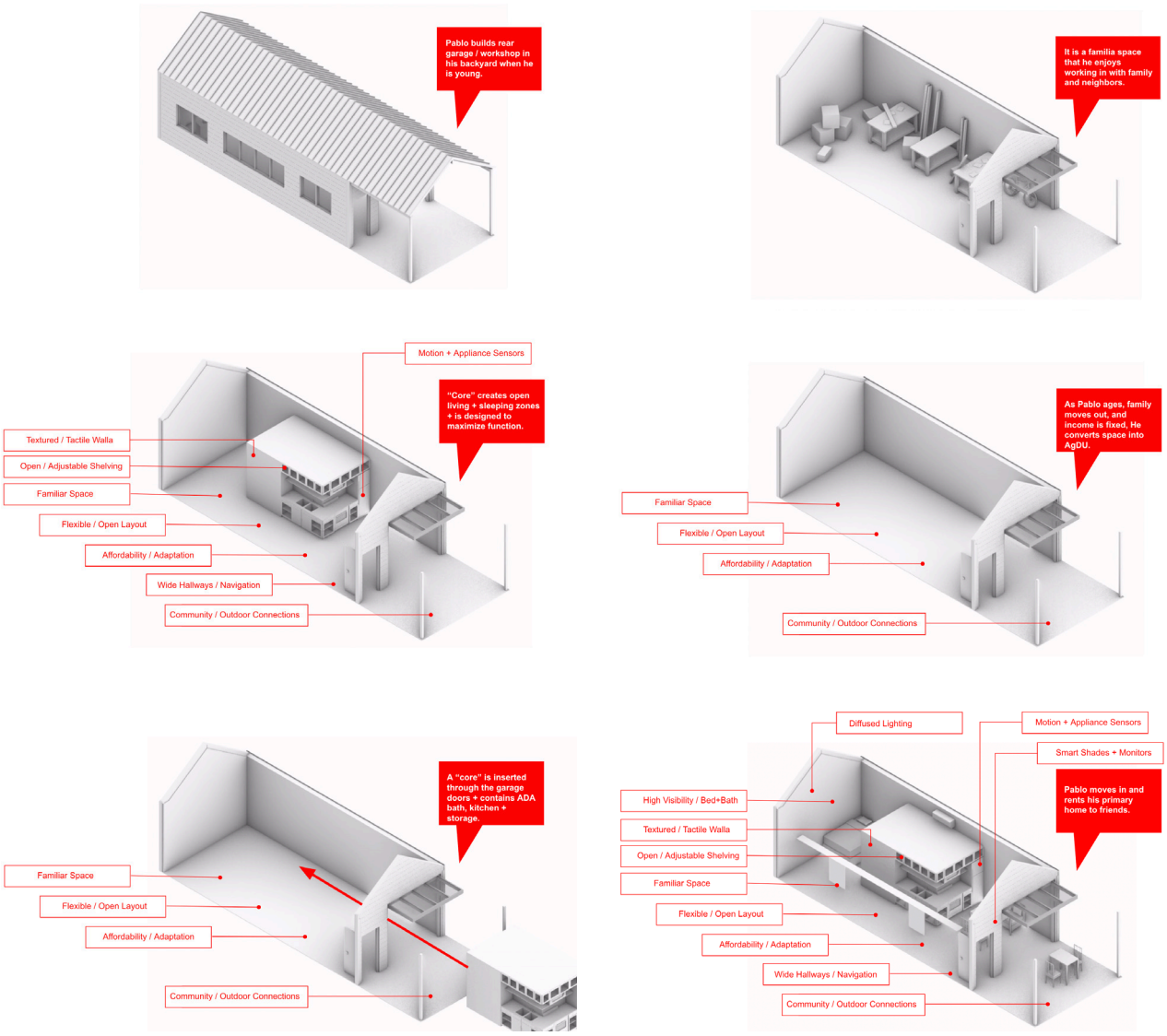
HUMAN FACTORS, HEALTH TECHNOLOGY, AND DESIGN FOR AGDUS

Three AgDU design seeks to address the universal issue of aging. Human factors, health technology, and design research were used by fourth-year undergraduate architecture students to orient and shape AgDU design priorities while working across issues of context, economics, and constructability. The research uses Dallas, Texas as a model case study city for both suburban and metro area AgDU design and deployment to testing its broader applications.

As one of the fastest growing regions in the United States, the Dallas Fort Worth area experienced the second largest domestic migration gains in 2021, second only to Phoenix, Arizona. Dallas exemplifies many post-war suburban patterned cities comprised of land predominantly used for housing (75%) of which 65% is zoned for single-family use. Like other US cities, many Dallas neighborhoods have resisted denser housing development patterns and new dwelling typologies in exclusively residential areas. To ground this work in context, students began looking at Dallas demographic and single-family land use patterns with a specific focus on geographies with a high concentration of low-income and aging residents with relatively low life expectancy (those households making less than $40,000 annually, are 65 and older, and have a life expectance of 77 years or less). This population tends to have fewer housing choices as they age and are more likely to be negatively impacted by escalating housing costs.

The four study neighborhoods identified were developed between the 1920s and the early 2000s, and exhibit typical development patterns for their era. The two early postwar neighborhoods developed in the 1920s – 1950s have a strong presence of backyard structures that were built later than the primary house. The two more recent neighborhoods developed in the 1970s-2000s have homes with integrated garages. These differences are not surprising based on housing trends and serve as a good sampling of how different block patterns present different opportunities. Students generated specific AgDU approaches for each of the four block patterns - additive modules for long-thin lots, core conversions for lots with existing rear structures, cluster community for lots with shared rear alleyways, and freestanding units for wide shallow-depth lots. Developed typologies using prefabrication construction techniques including modular, panelized, and kit-of-part assembly appropriate to neighborhood context and considered lot and public right-of-way access. Models were diagrammed, tested, and revised on numerous sites throughout the city.

Housing intended to support aging in place should respond to context while also addressing human factors and ICTs. Using the spectrum of needs and journey-mapping activities developed by the research team, students defined representative,



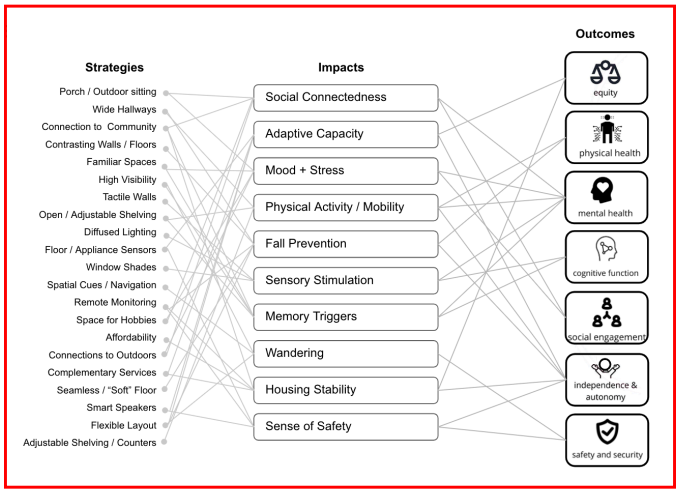


Figure 3. Outcomes-based design framework and conceptual AgDU design. Project by Mikel Cardiel, Jennifer Jett, and Daniel Mora.

neighborhood clients that were informed by health research, stakeholder interviews, and personal experience. Developed personas ranged from older adults with cognitive to physical impairments possessing various degrees of illness, activity level, memory loss, social support, digital literacy, and residential independence in both current and future life stages. Health trajectories, level and type of required assistance, and daily routines were used to identify and map design strategies specific to desired health impacts unique to individuals that can potentially lead to long-term health benefits outcomes. This was not a perfect process but began to lay out a catalog of site and building strategies that can be applied to AgDUs more universally.

Taking a closer look at one group's project, students created an AgDU for their client Pablo. Pablo owns a home in the gentrifying neighborhood of Mount Auburn. He is a retired woodworker who lives on a fixed income. He enjoys spending time in his garage and wood shop space behind his current house. When he began experiencing mild symptoms of memory loss, he began the process of clearing out his garage to prepare for an AgDU conversion. Once completed, he rented the primary structure on his property to generate additional income that would allow Pablo to continue to live in his neighborhood while eliminating the financial stresses of home ownership and daily expenses. The familiarity of the space, yard, and neighbors are natural memory simulators as he continues to age. Using the garage door for access, a prefabricated "core" consisting of an ADA bathroom, kitchen, and storage space is installed and connects to the main home's electricity and sewer lines by sleeves installed in the wall. The "core" contains a smart sensor, passive technology, sensory stimulation, and adaptive millwork that supports changes in physical and cognitive ability at various stages of aging. Pablo rented the core as a medical device through his healthcare provider and paid for it with home modification funding. It will be picked up and removed when it is no longer needed, thus converting the garage for the moment into a living unit with both communal and sleeping areas.

Similar explorations were completed for the remaining three groups' AgDU projects. Full-scale section models constructed of each design were used to better understand materiality, connection details, and function. These shed light on future opportunities for further research and development and teach students the value of iterative design and making.

CONCLUSION

In recent years innovation in human factors, health technology, and ADU design and construction practices have increased overall in their respective fields. Further collaboration between users, architects, healthcare, and technology providers is needed to ensure successful integration into the residential units and care plans while providing adaptable, healthy, and reliable environments to support their health and well-being. Residential units designed with the integration of ICTs in mind offer a viable solution for older adults to stage in place. With the variety of health conditions, physical capacities, and availability of social support, a technology-integrated residential unit like AgDU can facilitate users in adapting to the changes throughout their life course. This study is an early ideation stage of an AgDU. While several early prototypes have been designed and developed by the University of Texas at Arlington students, there is a need to expand this work to study and test the AgDU concept in the community. Involving government agencies and industry partners is a critical next step to further developing AgDU design strategies, development, and deployment.

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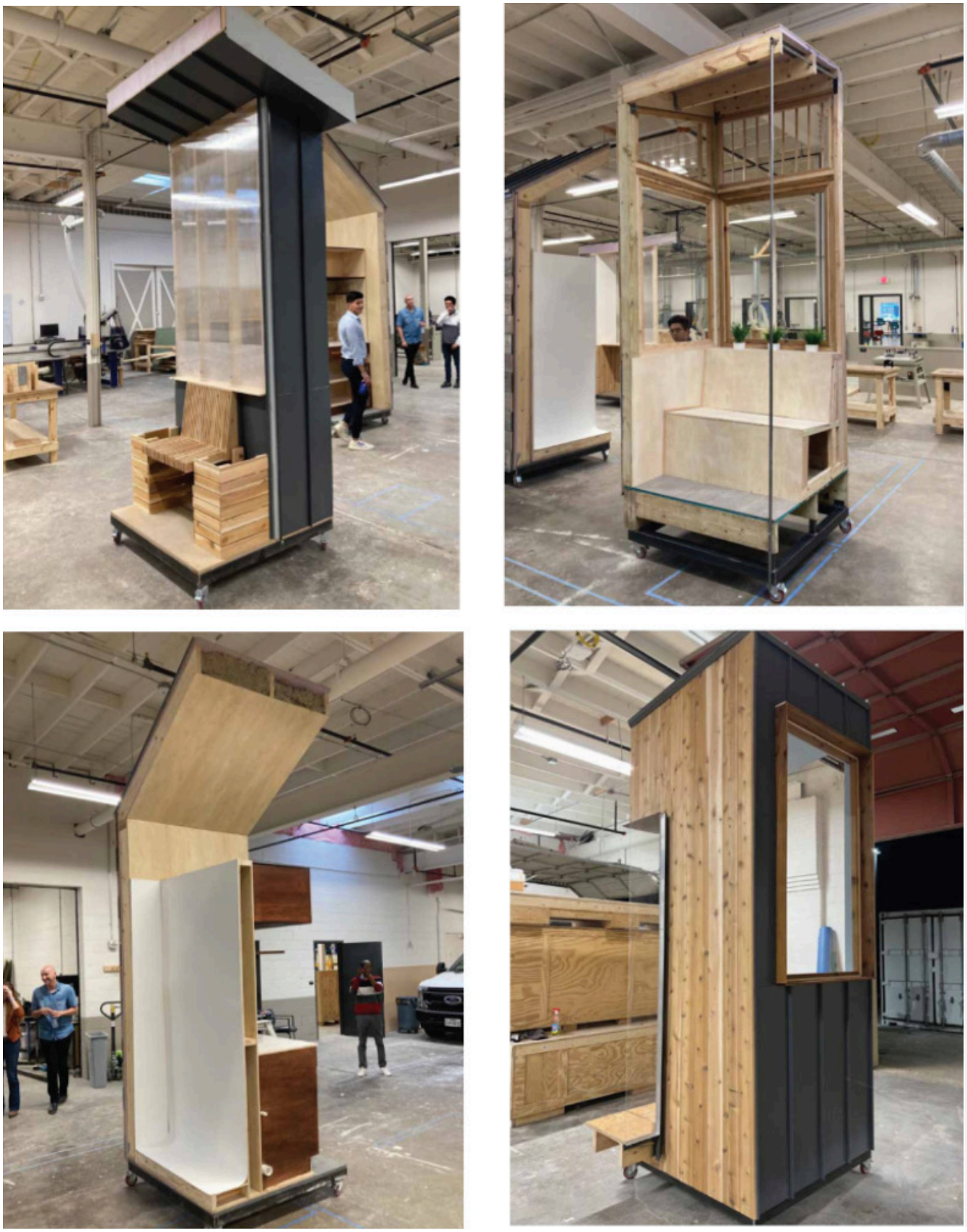

Figure 4. Prototype AgDU section models.

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