ISO-Fold

A Method for Delivering Small Homes to Rural Alaska Using Foldable, Container-Packable Housing

Research and Development Program Outline

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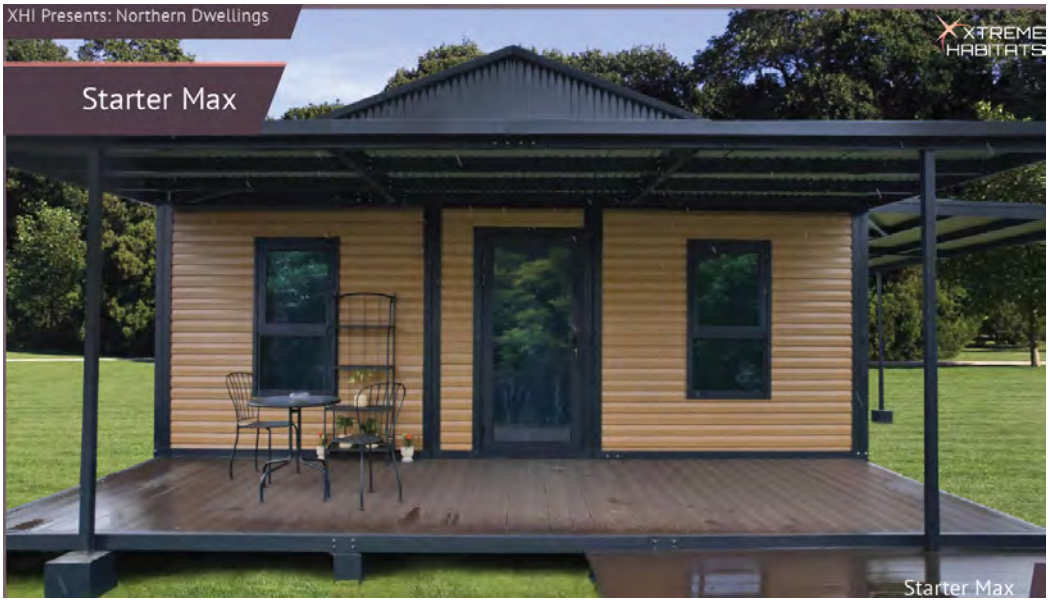

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Executive Summary

ISO-Fold is an XHI research and development program that began with initial research in 2023, advanced through design planning in 2024, and culminated in the construction of first prototypes in 2025. In December 2025, the program achieved a major milestone with the delivery of the first four sample units in Anchorage, Alaska.

The program's goal is to create a repeatable end-to-end method for delivering small homes to rural Alaska by aligning foldable housing with standardized intermodal freight workflows. The commercial outputs of this effort are **Polar Tough Homes** models that can be shipped efficiently and deployed rapidly on-site with limited labor and tools.

Figure 1: ISO-Fold units prepared for deployment.

Problem

Rural Alaska communities face acute housing constraints driven by high logistics costs, short construction seasons, limited local labor and equipment, and extreme environmental loads. Conventional construction amplifies schedule and cost risk at each transfer point (port handling, barge transport, lightering/beach landings, staging, and on-site assembly).

ISO-Fold Method

ISO-Fold formalizes two compliant shipping pathways to maximize route flexibility and reduce special handling:

Pathway	Description
Path A: Container-Packable	The home (or defined kit boundary) ships *inside* an ISO container (CONEX). The container is the unit of handling.
Path B: Container-Equivalent	The home folds into a shipping article that can be lifted, secured, and stacked *like* an ISO container; the folded home becomes the unit of handling.

Design Specifications

The ISO-Fold prototypes developed in 2024-2025 are designed to meet the following dimensional requirements:

- **Deployed exterior dimensions:** $24' \times 20'$ (480 sq. ft. exterior footprint)
- **Minimum useable interior space:** 430 sq. ft.
- **Minimum interior height:** 8 feet

These specifications ensure that the units provide functional living space for two-bedroom configurations while maintaining compatibility with Alaska's extreme insulation requirements.

Program Timeline and Milestones

Development Timeline

2023	**Initial Research Phase** Problem definition, stakeholder engagement, and logistics analysis. Space precedent translation from ISS deployment methods.
2024	**Design Planning Phase** Path A vs Path B trade studies. Selection of Path B for near-term two-bedroom units. Design of insulation bulk management and thermal continuity.
2025	**Prototype Construction Phase** Fabrication of full-scale $24' \times 20'$ Path B prototypes. Comprehensive testing (stack-load, racking, weather sealing).
Dec 2025	**Delivery Milestone** Delivery of first four sample units in Anchorage, Alaska. Validation of Path B handling.
Future	**Field Demonstration & Scaling** Pilot shipments through representative Alaska routes, manufacturing scaling, and development of Path A optimization.

Figure 2: Early research context: Experiments with Container Homes

Near-Term Design Direction

Design work completed through 2024 and validated in the 2025 prototypes indicates **Path B** is the most practical near-term pathway for an Alaska-ready two-bedroom unit due to:

- **Insulation bulk:** Alaska insulation packages add thickness. The $24' \times 20'$ envelope accommodates this while keeping 430 sq. ft. of usable interior space.
- **Interior height:** ISO-Fold prioritizes a minimum interior height of 8 feet, which is difficult to achieve in container-fit designs.
- **Thermal continuity:** The architecture avoids hinged wall assemblies where feasible to minimize thermal breaks.

ISO-Fold Program Outline

1. Purpose and Problem Statement

Problem: Remote Alaska housing delivery is constrained by high logistics costs, short construction seasons, limited equipment, and extreme environmental exposure.

Program Goal: Develop and validate a repeatable delivery method that reduces landed cost and execution risk by aligning foldable housing with standardized intermodal freight workflows.

Program Outcome:

- *Research outcome:* Documented method (requirements, packaging, SOPs, QA).
- *Product outcome:* Implementation-ready Polar Tough Homes designs.

2. What "ISO" Means and Why CONEX-Style Containers Matter

ISO and Standardization: ISO refers to the global system of standardized container dimensions and handling interfaces. **Relevance to Alaska:** Alaska relies heavily on marine freight. Designing housing that is container-compatible reduces special handling and increases route flexibility for rural communities.

3. Research Objectives and Key Questions

Objectives:

- Define ISO-Fold packaging and handling rules.
- Develop foldable housing architectures compatible with intermodal freight.
- Validate performance through representative scenarios (port, barge, beach landing).

Key Questions:

- What architecture balances shipping ruggedness with Alaska performance?
- What does "container-equivalent" mean in measurable engineering terms?
- How can the $24' \times 20'$ dimension efficiently fold while preserving interior space?

4. Space Precedents for ISO-Fold

The International Space Station (ISS) provides a relevant analog for delivering habitable infrastructure through a difficult last mile.

- **Standardized Units:** ISO-Fold standardizes major subsystems (wet-wall, electrical, HVAC) as protected modules.

- **Controlled Mating:** Deployment is a controlled procedure: structure locked first, weather sealing second, utilities third.

Figure 3: Prototype unit demonstrating structural integration.

5. ISO-Fold Shipping Pathways

Path A (Container-Packable): The home ships inside an ISO container. **Path B (Container-Equivalent):** The home folds into a stackable shipping article.

Note: Path B was prioritized in 2024-2025 for two-bedroom units to accommodate insulation bulk and interior height requirements. Path A remains a secondary optimization track.

6. Alaska Performance Requirements

- **Dimensions:** $24' \times 20'$ footprint, 430 sq. ft. usable interior, $8'$ height.
- **Loads:** Extreme wind, snow, and ice loads.
- **Thermal:** Meet Alaska energy standards with continuous insulation strategies.
- **Moisture:** Robust ventilation and condensation control.

7. Concept Development

Path B concepts implemented in 2025 include structural shipping exoskeletons and core-plus-deployable-bays. Downselect criteria focused on achieving the dimensional targets, thermal continuity, and shipping readiness.

8. Prototyping, Testing, and Validation

Acceptance Gates:

1. **Shipping Readiness Certification:** Confirm Path A packing or Path B stacking requirements.

2. **Habitation Commissioning:** Confirm deployed dimensions, weather-tightness, and utility function.

2025 Test Regimen: Included stack-load testing, lift and securement validation, shipping-mode weather sealing, and transformation reliability trials.

9. Regulatory and Implementation Pathway

The program is defining product classification (modular vs. manufactured), factory QA/QC regimes, and documentation packages for repeatable deployment.

10. Economics and Scale Strategy

Future work includes landed-cost modeling comparing Path A and Path B, defining manufacturing strategies, and developing training programs.

11. Milestones

- **Phase 0-2 (Completed):** Requirements, design, prototyping, and Dec 2025 delivery.
- **Phase 3 (Planned):** Path B field demonstration through representative Alaska routes.
- **Phase 4-5 (Planned):** Scale package and Path A optimization.

12. Risk Register

Key risks include complexity creep, transformation reliability, and moisture ingress. Mitigations include gate-based certification, non-hinged wall strategies, and rigorous time-in-folded-state conditioning tests.

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