# Open Source Connectivity Standards
# for the **US Offsite Construction Industry**

February 2024

Accelerating the adoption of offsite construction practices (and productized housing elements) by standardizing the connections between buildings and modules, and between modules.

Working to unlock the power of collaboration to *both* address the US affordable housing crisis *and* speed commercial office space conversions.

*(Paper summary as a slide presentation, here.)*


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## PROBLEM

The current case-by-case design of *US module utility interfaces* are internally managed (through vertical integration) by highly-centralized actors:

- vertically-integrated **design-build modular** conglomerations (i.e. VCB, FullStack, RESIA, etc.),
- multinational **hospitality** corporations (i.e. builders serving Marriott, Hilton, etc.),
- multinational **healthcare** corporations (i.e. builders serving HCA Healthcare, Community Health Systems, etc.)

These actors are the largest consumer of US modules ("pods"), functioning like Tier 1 manufacturers, defining gross demand.

However, without an *open connectivity standard*, Tier 2 module manufacturers (i.e. SurePods, DuraPods, Capsule, TatemTek, etc.) cannot reliably make products to serve other customers (or importantly: traditional general contractors willing to experiment with offsite construction methods).

This bespoke, per-customer service erases each Tier 2 manufacturing organizations' ability to build a catalog and deliver with effective, coherent mass-production principles. **It is a product catalog that signals true manufacturing efficiencies.**

Today's *Tier 1 led* case-by-case offsite construction workflow is inefficient, requiring prohibitive overhead with:

- modified design (adjusted layouts of fixtures, access, etc.),
- updated engineering (adjusting calculations of shipping forces, code clearances, etc.), and,
- re-organized manufacturing set-up with each run (adjusting procurement, inventory, tooling, etc).

This internal industry friction is clearly visible. **Note how (currently) every major US bathroom module manufacturer features a "Design" stage as part of their delivery process** (FIG 01 through FIG 04).

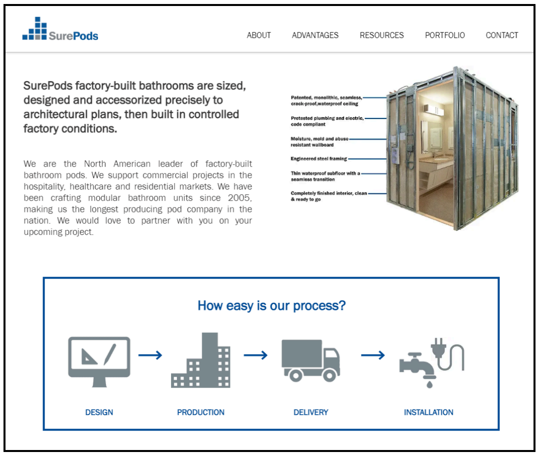


FIG 01: Screenshot of **SurePods** (Orlando, FL) website landing page. (www.surepods.com)

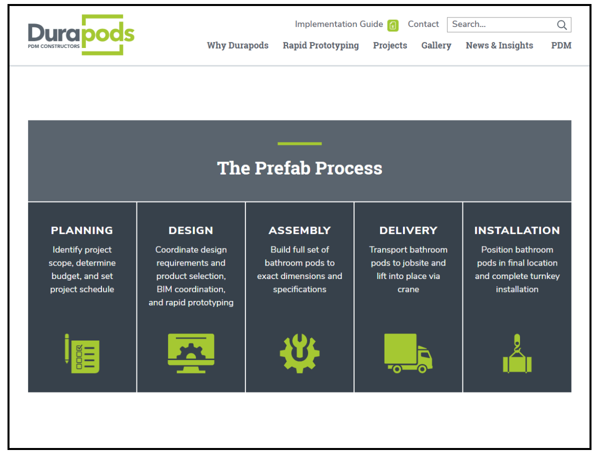


FIG 02: Screenshot of **DuraPods** (North Wales, PA) website landing page. (wwwdurapods.com)


FIG 03: **BLOX** (Bessemer, AL) website landing page. (www.bloxbuilt.com)


FIG 04: **B&T** (Rapid City, SD) website landing page. (www.bandtmfg.com)

## THESIS

**An *open-source offsite connectivity standard* will accelerate cleaner, more efficient building practices in the US offsite construction industry**, by diversifying access, manufacturer offerings, and partner builders.

In the very near future, US construction can be revolutionized by widely adopting standardized offsite construction methods. That (future) construction industry will use offsite products (i.e. mods, pods, etc.) by:

- **designing buildings without logistical fuss** concerning their product hookup,
- **ordering and installing them quickly** with standard couplings and unskilled labor, and
- **specifying products interchangeably,** to protect every project's supply chain.

That well-functioning US construction industry will see offsite building product manufacturers shipping their cataloged offerings to a *variety of customer types*:

- **Tier 1 Module Manufacturers**, delivering large buildings with large, prefabricated building parts.
- **Large US General Contractors**, delivering every scale building with a strategic blend of off- and on-site methods.
- **Small US General Contractors**, delivering smaller buildings by responding to immediate, localized demand.

*A lack of connectivity standards is blocking offsite building product manufacturers from reliably placing the hatches, interfaces, and hookups that deliver value, onsite.*

Ultimately, this missing standard is preventing offsite building solutions from reaching wider adoption in an expanded marketplace.

## SOLUTION

The offsite manufacturing industry can swiftly define this *connectivity standard* by establishing "highway lanes" in which utilities travel — a kind of USB Standard, but for prefabricated building elements to connect to their site conditions.

The shared *standard* should propose two functional guidelines: between **Building↔Module** and **Module↔Module**. To benefit all stakeholders equally, it should have these features:

- Be open-source.
- Incorporate existing plumbing, power, data connectors (without creating new connector types).
- Define physical attributes for unit connections (height, location, orientation).
- Create reliability for designers, builders, and lenders.

After reviewing various US offsite foundations/institutes (ICC, OSCC, MBI, ANSI, ISO, etc.), we have found no organization addressing this topic, let alone with appropriate urgency.

FIG 05: The (developing) medical headwall standard allows for configurable medical gas, electric, and communication service assemblies in a modular/panelized setting.

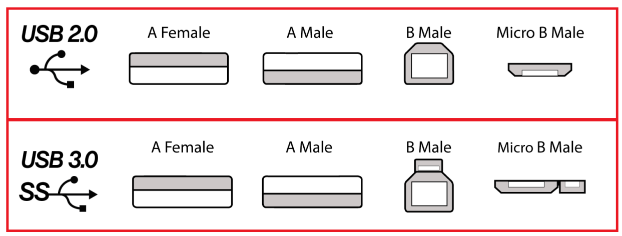


FIG 06: The USB Standard (est. 1996, designed in collaboration by Compaq, IBM, Intel, Microsoft, etc.) created explosive growth in the computer peripherals market.

## SCOPE

The scope of this effort is to version an **opt-in** connectivity standard that allows power, water, sanitary, and data ("utilities") *exchange and delivery* between various types of manufactured building products (modules, panels, etc.).

The standard specifies its own arrangement, in particular its *physical interface and communication protocols* for utilities that deliver:

- to-and-from and intermediate hub, such as a building's shaft wall, and,
- to-and-from prefabricated modules or prefabricated panels, as created by offsite manufacturers.

The effort to standardize the connection of **buildings-to-module** or **modules-to-module** *does not replace* various established joints (such as PEX, PVC, metal duct, and three- or four-pin electric outlets). Its primary focus is in organizing these existing connections into reliable "ports" for product definition.

### SCOPE OVERALL ORGANIZATION (Example)

The US offsite construction industry is currently testing several strategies to deliver utilities in pressurized, gravity-fed, and hard-wired configurations. The future standard is assumed to address these four orientations:

| | buildings-to-modules | modules-to-modules |
|---|---|---|
| Side-Draining orientations | **BtM-SD** | **MtM-SD** |
| Floor-Draining orientations | **BtM-FD** | **MtM-FD** |

SCOPE **BtM-SD HUB VERTICAL ORGANIZATION** (Example)

| **TRADE** | **HOST BUILDING SCOPE**<br>(Service Shaft or Vertical Chase) | | | **DWELLING UNIT SCOPE**<br>(Intra-wall Chase) | |
|---|---|---|---|---|---|
| | Horizontal Clearance | Connection | COUPLER | Connection | Horizontal Clearance |
| Plumbing<br>(Cold Water Supply)<br>**Level: 7’ -10”** | 0’ - 11”<br>PEX Crimper<br>(lateral operation) | 3/4” PEX Coupling<br>(ASTM F1807) | | 3/” PEX Coupling<br>(ASTM F1807) | 0’ - 6”<br>PEX Crimper<br>(hatch access) |
| Plumbing<br>(Vent Stack)<br>**Level: 7’ -6”** | 0’ - 8”<br>PVC Adhesive Tape<br>(lateral operation) | 1.5” PVC Coupling<br>(ASTM D-2466/2467) | | 1.5” PVC Coupling<br>(ASTM D-2466/2467) | 0’ - 6”<br>PVC Adhesive<br>(hatch access) |
| HVAC<br>(Vent Exhaust)<br>**Level: 7’ -2”** | 1’ - 2”<br>Duct Adhesive Tape<br>(lateral operation) | 4” Galv. Coupling<br>(ASHRAE Standard 62) | | 4” Galv. Coupling<br>(ASHRAE Standard 62) | 0’ - 4”<br>Duct Adhesive<br>(hatch access) |
| Electrical<br>(Unit Power)<br>**Level: 1’ - 0”** | 1’ - 2”<br>Utility Junction Box<br>(horizontal clearance) | 100A Pin-&-Sleeve<br>(NEMA L14-30P) | | 4-Pin 100A 120/208<br>(NEMA L14-30P)<br>Female only | 0’ - 6”<br>4-Prong SOOW Plug<br>(horizontal clearance) |
| Plumbing<br>(Sanitary)<br>**Level: 0’ -2”** | 1’ - 4”<br>PVC Adhesive<br>(lateral operation) | 3.5” PVC Coupling<br>(ASTM F1807) | | 3.5” PVC Coupling<br>(ASTM F1807) | 0’ - 6”<br>PVC Adhesive<br>(hatch access) |
| etc.. | | | | | |

SCOPE**BtM-SD HUB** DWELLING-SIDE (Example)

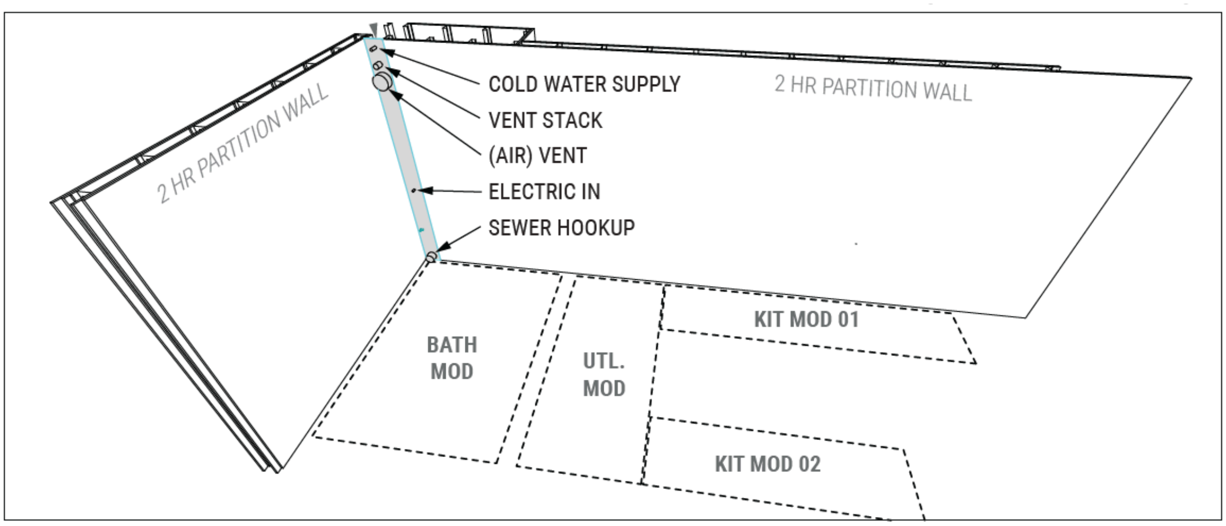


FIG 07: Example layout of a **Standard BtM-SD**.

## RESULT

In other industries (i.e. **railroad** with track gauge[1], **shipping** with container connections[2], **printing** with page sizes,[3] etc.), the adoption of connectivity standards created a rising tide, lifting all ships. These standards ushered in a period of accelerated interoperability & compatibility, market expansion, cost reduction, quality & safety assurance, and broader product innovation.[4]

Specifically, for the AEC industry, interoperability connectivity standards aim to benefit all stakeholders:

> **Manufacturers** will see new marketplaces[5] created around ***the benefits of interoperability*** between their products.
>
> - **Tier 1 manufacturers** will have a deeper module supply chain to support unique projects needs – budget, geography, or delivery time.
> - **Tier 2 manufacturers** will be able to tackle the overhead investment in the design of their products with the confidence that they serve a wider variety of customers.
>
> **Real Estate Developers (and their architects / engineers)** will enjoy a ***wider variety of offsite manufacturing partners*** – providing interoperability across building systems – with which to confidently consider offsite methods with deep supply chains, rather than making uninformed choices among siloed and opaque options.
>
> **General Contractors (and the trades they employ)** will see these standards lead to products that speed installation. Such joining devices would decouple contractual progress on either side (building trades in shafts, module installers in the dwelling units). The resulting ***benefits of project velocity*** is a path to parallel work, efficiency, and higher profit (shared across project partners).
>
> **Regulators & Lenders** will see the connectivity standards create ***clear delineation of scope, risk, and costs.*** Connection products, and their UL listings, will help regulators more confidently certify modular products. Meanwhile lenders, who rely on the certifications in lieu of bonding and reputation, will be able to make more confident investments on US construction.

We know that productizing technical parts of a building are key to ***both*** building our way out of the **US affordable housing crisis**, ***and*** renovating our way out of the **post-COVID glut of under-used commercial office buildings**. This *standard* paves the way for accelerated progress on both issues.

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[1] Puffert, Douglas J. *Tracks across Continents, Paths through History: The Economic Dynamics of Standardization in Railway Gauge.* University of Chicago Press, 2009.
[2] Levinson, Marc. *The Box: How the Shipping Container Made the World Smaller and the World Economy Bigger.* Princeton University Press, 2016.
[3] Fyffe, Charles *Basic Copyfitting.* London: Studio Vista, 1969.
[4] Hart, David M., editor. *Standards, Innovation and Competitiveness: The Politics and Economics of Standards in Natural and Technical Environments*. [Publisher], [Year].
[5] Christensen, Clayton M. *The Innovator's Dilemma*. Harvard Business Review Press, 2016.

## PATHWAY

**This *standard* eventually belongs with one of the industry foundations or institutes listed in the SOLUTION section.** In the face of the long-term, durable trend toward offsite construction, today's question is *"How do we kick-off efficiently, prove the need, draft the first spec, and hand off a legally unencumbered standard to one of these organizations (for wider adoption, versioning and maintenance)?"*

New York Tech is in discussions with the Joint Development Foundation , the International Code Council, and other standards-drafting organizations to legally steer this effort's launch, provide templated, open-source instruments, and to offer initial guidance in v1.0 of the standard.

The resulting effort would be hosted, organized, and administered through New York Tech's *Center for OffSite Construction* (CfOC).

In preparation for launch, we are also in conversations with stakeholders at MEP firms, architecture firms, construction firms, the Terner Center for Housing Innovation at UC Berkeley, members of the US Congress, and HUD to establish three types of members: **founder organizations**, **technical-leaders**, and **adoption-leaders**.

## BUDGET

This project will likely cost over US $1,000,000 by the time it is handed off to the appropriate standards organization. When drafting a budget for the development of an open-source modular connectivity standard of this magnitude, and that touches so many stakeholders, several key considerations must be taken into account.

Firstly, the allocation of funds for the establishment and operation of necessary committees is essential. This includes expenses related to committee meetings, such as travel, accommodation, and meeting venues, as well as stipends or honoraria for expert participants.

Additionally, costs associated with research and development activities, such as purchasing materials, equipment, and software needed for prototype testing, should be carefully estimated. This phase also encompasses the hiring or contracting of technical personnel and consultants who will contribute their expertise to the project.

Next, the budget must account for the dissemination and promotion of the newly developed standard. This includes organizing and participating in symposia and trade shows, which will require funding for event registration, booth setup, marketing materials, and travel expenses for the presenters.

Furthermore, creating and distributing promotional content, such as brochures, online resources, and videos, will incur costs. It's also important to allocate funds for potential outreach activities, such as webinars and workshops, to educate stakeholders and encourage adoption of the standard.

Overall, the budget should reflect a balanced approach, ensuring that both the technical development and promotional efforts are adequately funded to achieve the project's goals.

## FUNDING SOURCES

Private funding sources for this project are likely to be more nimble, responsive, and sensitive. These can include contributions from industry stakeholders, corporate sponsorships, and philanthropic foundations.

Industry stakeholders, such as construction firms, technology companies, and manufacturers of construction materials stand to benefit from standardized connectivity solutions. Corporate sponsorships represent a vested interest in advancing construction technologies and enhancing industry efficiencies. Additionally, philanthropic foundations that support innovation, technology, and workforce development, may be potential sources of grants and donations.

Public funding sources are also available, but take years of preparations to prepare, procure, and deliver.

Federal agencies, including the National Institute of Standards and Technology (NIST) and the Department of Energy (DOE), offer grants and funding opportunities for research and development projects that align with their goals of advancing technology and improving industry standards. State and local government programs may also provide financial support, particularly if the project demonstrates potential economic or environmental benefits for the region. Furthermore, competitive grants from agencies like the National Science Foundation (NSF) can support collaborative research efforts, while public-private partnership programs can offer additional funding and resources by leveraging both government and private sector contributions.

## CONCLUSION

Industrialized construction practices have floundered in the US, at the cost of today's nation-wide affordable housing crisis.

All communities stand to benefit from the kick-off of this effort and its subsequent iteration towards wider adoption, but not from a prolonged pathway to first versions.

Worldwide, the message is clear: offsite construction is a durable trend, coming to mainstream construction practices. That tidal shift makes this an exciting time to be working in the US Architecture, Engineering, and Construction (AEC) space.

Growing the connectivity standard sketched in this document promises to provide critical release of the pressures holding our industry back from higher levels of capacity, productivity, and efficacy.