8.0 Off-Site Construction Methods + Impact Introduction

One of the goals for developing the standard prototype CBOCs is to enable the use of off-site construction. Off-site construction has many variations and can enable quality, cost and schedule advantages over traditional construction and project delivery methods. Standardized designs, such as the CBOC prototypes, are crucial in allowing for the repetition required to allow the Owner to realize the advantages of off-site construction.

Prefabricated Components

Prefabricated components refer to assemblies fabricated in a factory or other off-site space. These are often repetitive elements in a building, such as toilet rooms as illustrated in Figure 8.1, exam rooms or integrated MEP racks. These elements are manufactured, fabricated and transported to a conventional construction project. These components require a high level of schedule coordination to ensure just-in-time delivery or adequate storage space at the appropriate location.

Prefabricated components can bring a high level quality control at a faster pace since they are produced in a manufacturing facility. Prefabricated components can be completed by the traditional construction team of a general contractor overseeing subcontractors or can be ordered from a factory. This method realizes the most financial benefit when the project has a sufficient number of repetitive elements.

Figure 8.1
Prefabricated toilet room components, Skanska

Panelized Structures

Panelized structures are components consisting of a series of prefabricated elements that are shipped to a site and assembled to create the three-dimensional space. Panelized structure components can constitute interior fit-out or the entire building envelope. The components are flat-packed and shipped, as seen in Figure 8.2. This reduces shipping costs by consolidating the elements and reducing the overall number of truck loads to be shipped. Panelized structures requires more on-site assembly than prefabricated modular structures and are often multi-trade assemblies.

Figure 8.2
Panelized structure flat-packed on truck (L) & install (R), Project Frog

Figure 8.3
Modular structure in the factory (L), during construction (C) and after occupancy (R), MedBuild

Figure 8.4
Panelized structure as interior fit-out, DIRTT

Modular Structures

Modular structures are volumetric prefabricated structures that form a completed section of a building, or complete a building in itself. For the purposes of this project, the term modular structure refers only to permanent modular construction.

While the perception is that a modular structure will save considerable cost, the actual building costs of using this method are may only be within 5% of on-site construction. The materials used are the same as traditional stick-built construction. Some of the cost savings realized in labor are instead spent on shipping.

The greatest benefit of using a modular structure from a cost perspective is in the shortened construction schedule. The speed to which a building is completed and occupied is its key advantage. The site preparation and the module fabrication processes can occur simultaneously, which can reduce the overall project construction timeline anywhere from 30 to 50 percent.

The design of the structural system used for modules is largely unique to each manufacturer. It is important for the manufacturer to define the variables and absolutes of the system to the architect to inform the design layout. Many manufacturers will recommend a design-build project delivery with a team consisting of manufacturer, architect and general contractor; however, it can successfully be executed with the traditional design-bid-build method.

Figure 8.5
Conceptual rendering of PACT + Extended Team work area, DIRTT

Transportation is one of the primary factors to consider when deciding to use off-site construction, particularly, modular structures. The individual State laws govern the maximum size allowed to be transported on the highways. The typical restrictions for transport via truck are 10 to 14 feet wide, 60 to 72 feet long and 14 feet high. Widths over 12 feet and heights over 14 feet can trigger the need for police escort in some jurisdictions. Other factors affecting dimensional restrictions are height of transport trailer, weight capacity of transport vehicle, weight of building material/module and planned transport route.

Modular construction utilizes the same building materials and standards to fabricate each module. All modules must meet the building, safety and occupancy code requirements (typically International Building Code) and, in many instances, modular buildings exceed local building specifications. An example of this is the Joplin, Missouri, two-story, 150,000-square-foot component hospital for Mercy Hospital. The original facility was destroyed in the deadly Joplin tornado on May 22, 2011. The hospital utilized the modular process to design and build their temporary and code compliant building within a year.

Modular construction and prefabricated components are built in the controlled environment of a manufacturer's facility and installed on-site to expedite assembly time. This will create less disruption to the site environment during the installation/construction phase. Quality control is incorporated into this process with multiple inspections at each phase. The building components are inspected and approved by third-party inspectors who are usually agents of the state, not the locality.

Modular building technique can also simplify logistics on the job site. Scheduling, trade coordination and construction sequences are all streamlined and coordinated at the manufacturer's facility and on the job site. Modular techniques and innovations develop repeatable construction processes that utilize standardized practices and process efficiencies. The result can be greater reliability and higher quality than traditional site-built construction projects, particularly in areas where a skilled labor force is unavailable.

These structures can be designed to correspond with the surrounding environment and allow for site specific architecture. Since modular construction utilizes the same building materials as on-site construction, the exterior finishes can utilize can complement neighboring buildings.

Other Considerations

The design of the One-, Two- and Three-PACT CBOC Prototype is built around standardization: a common structural grid, universal room concept, and repeatable components and modules. All can be translated into off-site construction techniques.

Prefabricated components could be used for pieces of the CBOC Prototypes; repetitive elements like the universal rooms (exam rooms, consult rooms, offices). However, the scale of the CBOC would need to be quite large to realize true savings.

Panelized structures can be utilized for interior and/or exterior construction in the CBOC Prototypes. A whole building solution, such as Project Frog, could be used in a build-to-suit situation. The prototype design would be componentized by the manufacturer, manufactured off-site, then flat packed and shipped for assembly. In an existing building or tenant fit-out situation, an interior panelized system, such as DIRTT, can be employed.

The greatest benefit to these options remains saving time in the overall construction schedule, which equals cost savings. A good example of this is the Kaiser Victorville project in South California built by Project Frog. This project consolidated the total project schedule, down from a typical MOB timeline of 21 months for design, permitting, construction and move-in, to a total project timeline of 11 months. The total time on-site for construction was only four months.

The benefits to modular construction can be summarized with improved schedule, minimized impact to job-site, reduced waste, quality control and sustainability.

8.1 Off-Site Construction Methods + Impact Comparison Matrix

Implications for Prototype Design

During the exploration of modular construction, a total of eight different manufacturers were contacted and asked to define aspects of their process, transportation and construction methods. These companies are all leaders in the modular construction process and have built a variety of outpatient clinics, medical offices, and hospitals.

Each company was asked to provide aspects of their systems for delivery, such as:

- Transportation limitations
- Typical module size
- Structural systems
- The ability to deliver the project using multiple delivery and responsibility methods
- Ability to ship off shore for locations such as Hawaii and Puerto Rico
- Any other factors they may have for clinical projects

All of the companies had disclaimers and these would need to be addressed based on the project size, the state highway regulations, building codes and costs. Further detail for costs, shipping and other regulatory issues would be noted at time of project solicitation and procurement.

Each company listed stated that they could meet the preliminary requirements of the 31'-10" x 31'-10" planning grid and the building sizes ranging from 20,000 to 90,000 BGSF. They all have the capable to provide interior components as well as exterior enclosures, internal and roof top buildings systems and all have the ability to provide the modules in multiple states.

Each company has the ability to work directly with the client, architect, and general contractor to establish the most economical solution and delivery process.

The company representatives we spoke to are available for further discussion. Their contact information is provided in the following matrix.

See Figure 8.8 for an example of an optimal transport size overlaid on the PACT module.

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Comparison Matrix by Manufacturer

Manufacturer	Transportation Limitations LxWxH	Module Standard Size LxWxH	Typical Structural System	Moment Connections	Cross Bracing	Flexible Design Contract Capability	Comments	Contact Information
MedBuild	76'-0" x 14'-0" x 14'-0"	10-'0, 12'-0, 14"-0 x 65'-0"x 11'-0"			can do cross bracing if the owner desires.	YES	14'-0"+ requires escort for transportation, varies by state.	Karen Jones | 865-803-7001 | karen.jones@medbuild.com
Project Frog	Not restricted due to flat-packing	Component Based	30'-0" x 30'-0" Moment Frame	YES		YES		Courtenay Glander | 415-814-8523 | Dill@projectfrog.com
PivoTek	8'6 w x 11'-6" h X 28' for a double drop trailer, Single drop 37 10 h 8.6 w	8'6 w 11'-6h 28' double drop Single drop 37 10 h 8.6 w	Structrual studs, welded.	Welded.	can do cross bracing if the owner desires.	GC, Arch, design assist, directly with client	8'6 width, normal permitting-, wider dimensions will require escorts.	Jerry Welte | 513 309 9945 | jerry@welte-pivotek.net Pre sales Greg Rohr | sales 513-939-9539 |
Silver Creek	Typical modules are up to 14' wide x 60' long x 12.5' tall. We have shipped modules up to 16' wide, 76' long and 16' tall, however this needs to be investigated on a site-by-site basis. Larger and taller modules can be shipped but typically require police /highway patrol escorts	Typical module sizes are 32', 40' and 60' long and 10' and 12' wide. The height varies based up the module length. A typical interior ceiling height is 8'-6" to 9'-0" when using a suspended ceiling system, however, taller ceiling clearances are possible.	Our most common system is a Ordinary Moment Resistant Frame. We do use braced frames and traditional wood framed construction as well when requested.	Welded.		GC, Arch, design assist, directly with client	14'-0"+ requires escort for transportation, varies by state.	Ryan McIntosh | 951.943.5393 | rmcintosh@silver-creek.net | Director of Design Services
Walden Structures	less than 12'w (16), 14' H 72' L	Typical module width is 12' to 14' and up to 72' in length.	Moment resistant and braced frames Type 2 1 & 2 hour construction is possible.	Welded.		Yes	Limitations are state by state, generally anything higher than 15' and wider than 16' is more costly. Can ship these units on their own chassie with hitches and axles. Based in Calif, has hipped to Maine and the east coast.	Charlie Walden | 909.389.9100 | www.waldenstuctures.com | Owner

Figure 8.6
Comparison Matrix by Manufacturer

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8.2 Off-Site Construction Methods + Impact Adaptation Diagrams

Off-site Construction

As discussed earlier, the off-site construction process has an advantage of reducing project construction time, and decreases the amount of site disruption. It may also be beneficial in areas where local labor is expensive or limited in availability.

In addition, the manufacturing process is in a controlled environment that helps to achieve higher quality assurance levels and reduced thermal loss. This in turn enhances the overall building performance efficiency due to enhanced air barrier, water barrier and continuous insulation. Mock-ups may be required to ensure the modules meet the enhance energy performance specified.

The companies that have been included in our survey have all stated that a rigorous quality review process is maintained throughout the construction and implementation sequencing.

Panelized Structures

Panelized structures would be a full building kit-of-parts, including the building structure, exterior envelope, and all the building systems. The contractor supplies the foundation and the installation of the building kit-of-parts on-site.

These manufacturers take full control of the structural system including size and location. Our understanding from panelized manufacturers is that the system can be customized to fit the building layout, and can utilize the 31'-10" column grid as identified in the prototype CBOC layouts. Therefore, the intent of the prototype design would not be impacted with this method of off-site construction.

With panelized structures, all of the building components are shipped on standard semi-trucks and do not require any special escorts. It can be shipped over land or sea. The components are packaged and delivered in order of the construction process, coordinated by the supply chain team for the just-in-time delivery.

The intent of a panelized system is to construct a building as fast as a modular construction, but have the quality and flexibility of traditional construction. This system is a good alternate to modular construction for the CBOC clinic prototype designs since it does not impact the layout with the additional structural constraints of modular.

Modular Structures

Modular structures are a cost effective solution. There are several limitations to successful execution. The success of modular construction is highly regional. The threshold of economic benefit varies widely, depending on local capability and projects underway. Another limitation imposed on the modular structures is the transportation limitations. Finally, because of the capability of the typical structural systems used, modular structures are limited to about four stories. A one- or two-story CBOC with a mechanical penthouse is well within the capability of most modular manufacturers.

Modular manufacturers typically have proprietary structural systems which may utilize intermediate supports. This type of system gives the modules more rigidity during transportation and placement on site. The spacing of these intermediate supports is manufacturer-dependent, and impacted by the location of the building and the shipping method. Care should be taken when creating the Design Build RFP to specifically state that the structure shall be coordinated with the architectural intent of the building.

Prefabricated modules are fabricated at the factory, with mechanical, electrical, and plumbing (MEP) systems fully coordinated with the MEP subcontractors. Equipment, from air handlers to central plants, can also be delivered as modular components. There are many advantages when compared to traditional penthouse/central utility plants: (1) they can be built off-site, reducing construction time and disruption; (2) they are customizable and are easily scalable to meet changing demands, and (3) they can reduce operating and maintenance costs by improving efficiency and reliability.

The scope of work for the general contractor will depend on the manufacturer and the extent to which the modules are completed in the factory. Note that some manufacturers do the general contracting for their projects. Typically, the general contractors are responsible for the site work, foundations, and construction of any site-built structures. Additionally, they are usually responsible for tasks needed to finish a permanent modular facility, including interior carpentry and exterior enclosure as well as final connections for the MEP systems.

The general contractor shall work closely with the modular manufacturer to develop and maintain the project schedule. This will ensure the time savings associated with this type of construction.

Impact of Modular Structural System

The PACT CBOC prototypes were developed with the intent of designing an optimum clinic with universal departmental layouts and rooms. This report recommends a column spacing of 31'-10". This does conform to any manufacturer's standard system. Modular manufacturers utilize proprietary structural systems commonly with widths of 10' or 12'.

The team examined several options. A 10'-wide module would reduce the universal room width by approximately 5 to 6 inches, which reduces the programmed net square feet of these rooms from 125 nsf to approximately 118 nsf. While this reduction is within the 10% tolerance allowable, it yields an exam room that is sub-optimal.

Conversely, utilizing the 12' wide module with the universal room concept would unnecessarily increase the room size. Utilizing the 12' width for modular structures for the current CBOC clinic design without changing the layout or modifying the universal rooms would reduce the number of modules needed overall. A preliminary study indicated that the 12'-wide module could reduce the overall number of modules to be transported (verses a custom module width of 10'-6" based on the universal room width) by 2 units for the One-PACT CBOC. This would reduce the overall number for the Two-PACT CBOC by 5 modules and the Three-PACT CBOC by 8 modules. Refer to Figure 8.11 for overlay of the standard 12'-wide modules.

Utilizing this system would introduce a risk of compromising the design intent of the prototypes. It is likely the modular structure will conflict with door locations, open space, clear floor within rooms or fall in the corridors. Figure 8.8 shows an area within the One-PACT prototype with an example of a door conflict. These door conflicts are difficult to avoid with the preferred diagonal door layout for the typical exam rooms.

In an effort to maintain the optimal clinic layout, as defined with the three CBOC prototypes, and mitigate or limit any structural conflicts, it was determined that utilizing the width of the universal rooms as the basis for the construction modules was advantageous. Many modular manufacturers are capable of developing solutions that can successfully adapt to the PACT CBOC prototype layouts and test fits, maintaining the design intent and clinical efficiency. The Design Build RFP must clearly state that the module is critical, and that they must work diligently with the design team to develop a solution that will respond to the PACT CBOC design. Refer to Figure 8.7 for the conventional construction column spacing.

To understand the potential impact of modular construction on the prototype, the outline of the modules has been placed on the One-PACT CBOC and the Two-PACT CBOC prototypical floor plans. Refer to Figures 8.11 to 8.14, Module Overlay.

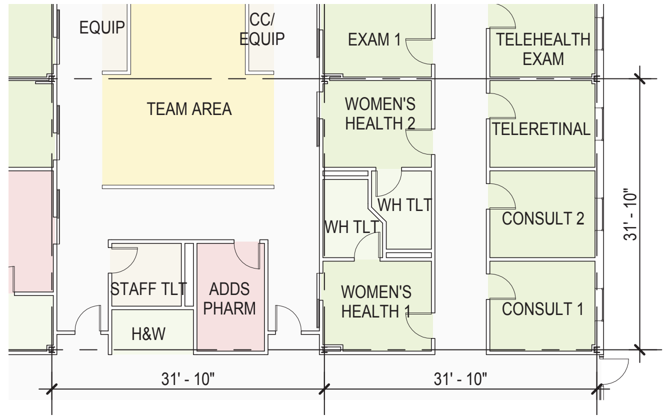

Figure 8.7
Module Overlay:
Optimum Structural Grid

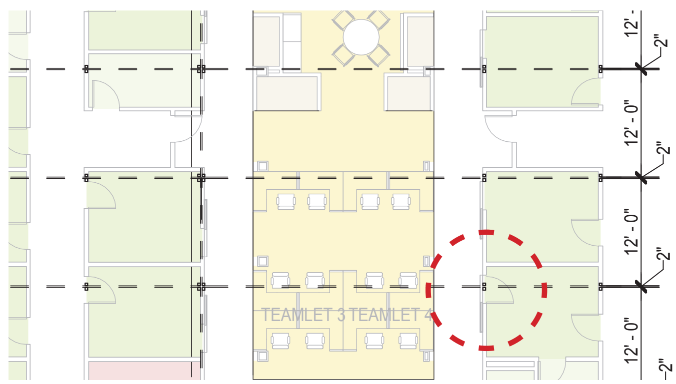

Figure 8.8
Module Overlay
12' Modular Width

The width of the modules shown in Figure 8.9 illustrates a 10’-5 1/2” module width with various lengths. This width does not change the layout of the clinic and maintains the universal room size and basic relationship to the original grid. The intermediate supports are located at a maximum of 20 feet with a typical dimension of 19’-4”. However, the limited spacing of the intermediate supports in this option impacts the Team Work Area. To accommodate the open space of the Group Room/Shared Medical Appointments, the intermediate columns would be removed after the modules are positioned on site and a structural beam is positioned to take that load. Refer to Figure 8.13.

An alternate solution to the limitations noted with the 10’-5 1/2” wide module is a more standardized size for the construction modules illustrated in Figure 8.10; and for the entire clinic refer to Figures 8.13. This module layout utilizes 10’-6” wide modules with the same intermediate supports, except at the Team Work Area and the Group/Shared Medical Appoints. In these areas, a truss is used to maintain the open span. To minimize and limit the depth of the truss, it is not being utilized to span the entire length of the module. The remaining half of the module remains with the standard structural elements. To facilitate the use of the 10’-6” wide module, the width of the universal rooms has been slightly adjusted.

This same strategy is illustrated in Figure 8.14 for the Two-PACT CBOC. With the larger CBOCs, it is clear to see how repetitive these modules would be.

The clinical area of the CBOC lends itself to modular construction. The Commons area at the front of the clinics could be modularized, with the use of additional structure; however, it is recommended that the Commons be site-built, utilizing panelized or traditional construction. This will allow the architecture to express regional influences and/or incorporate branded solutions to enable consistent patient and family experience opportunities. It also allows an open lobby/Commons area with a conventional structural system.

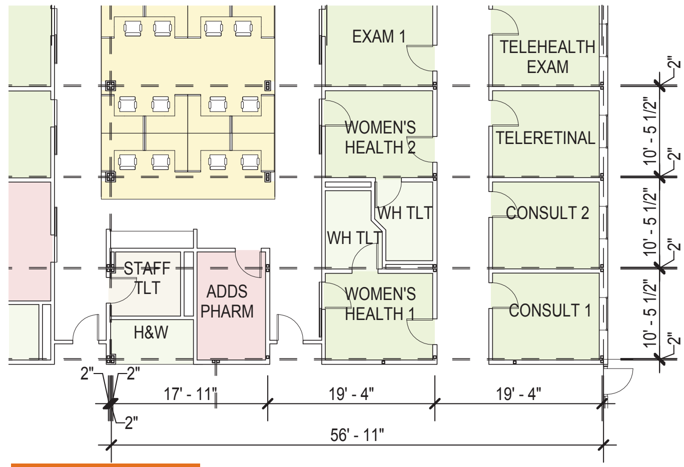

Figure 8.9
Module Overlay
10’-5 1/2” Modular Width

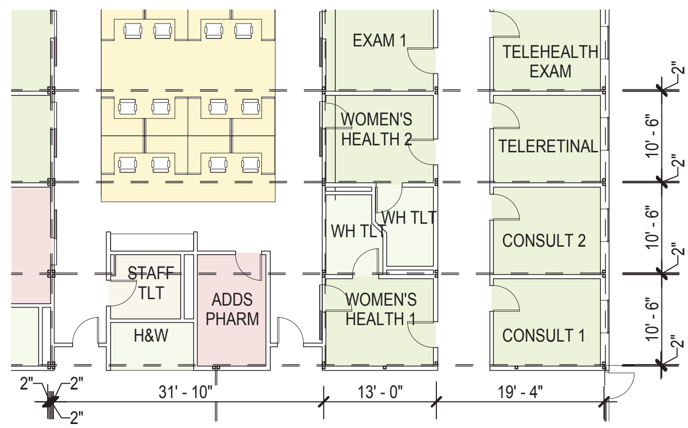

Figure 8.10
Module Overlay
10’-6” Modular Width

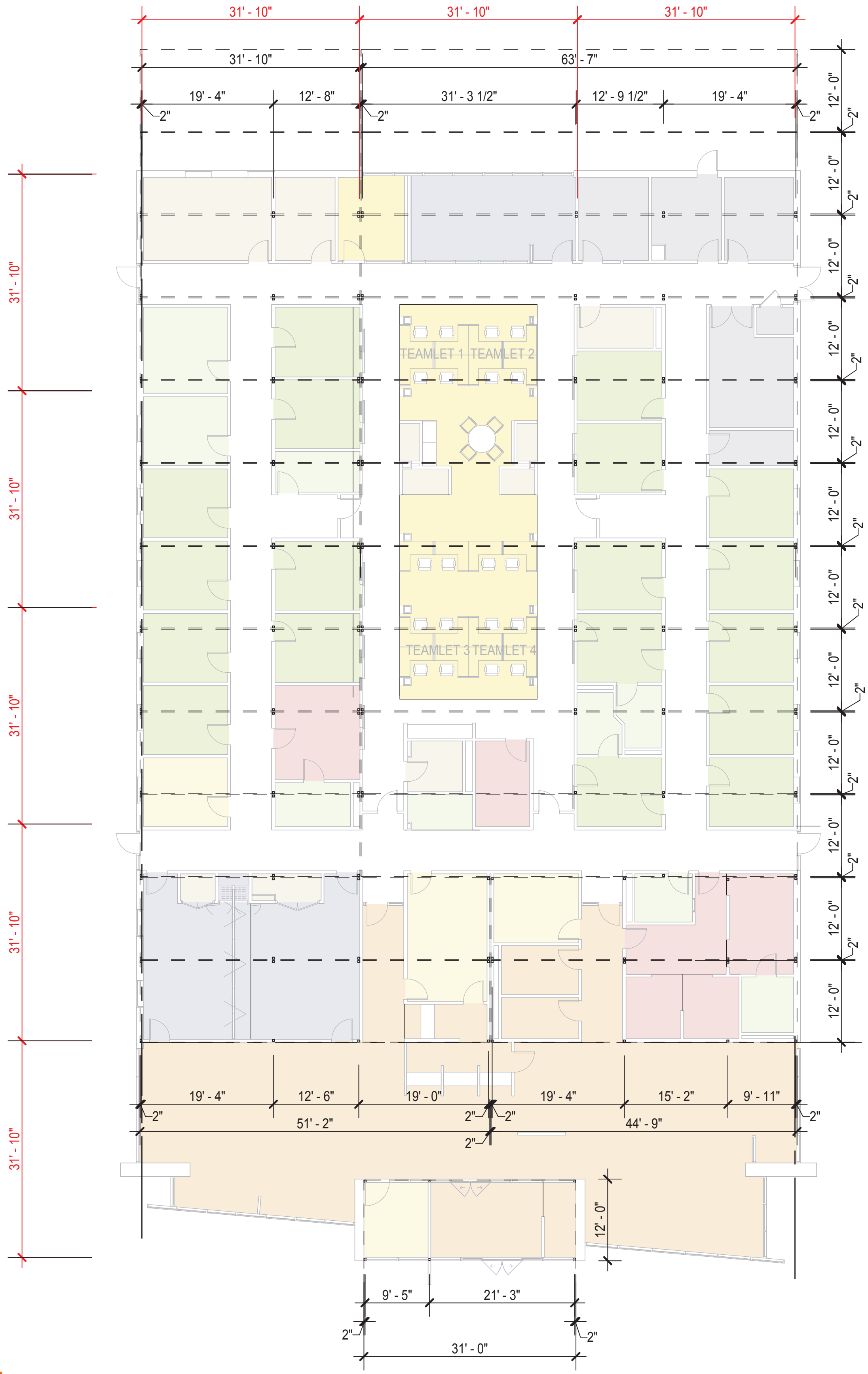

Figure 8.11
Module Overlay
12' Wide Standard Module
One-PACT CBOC

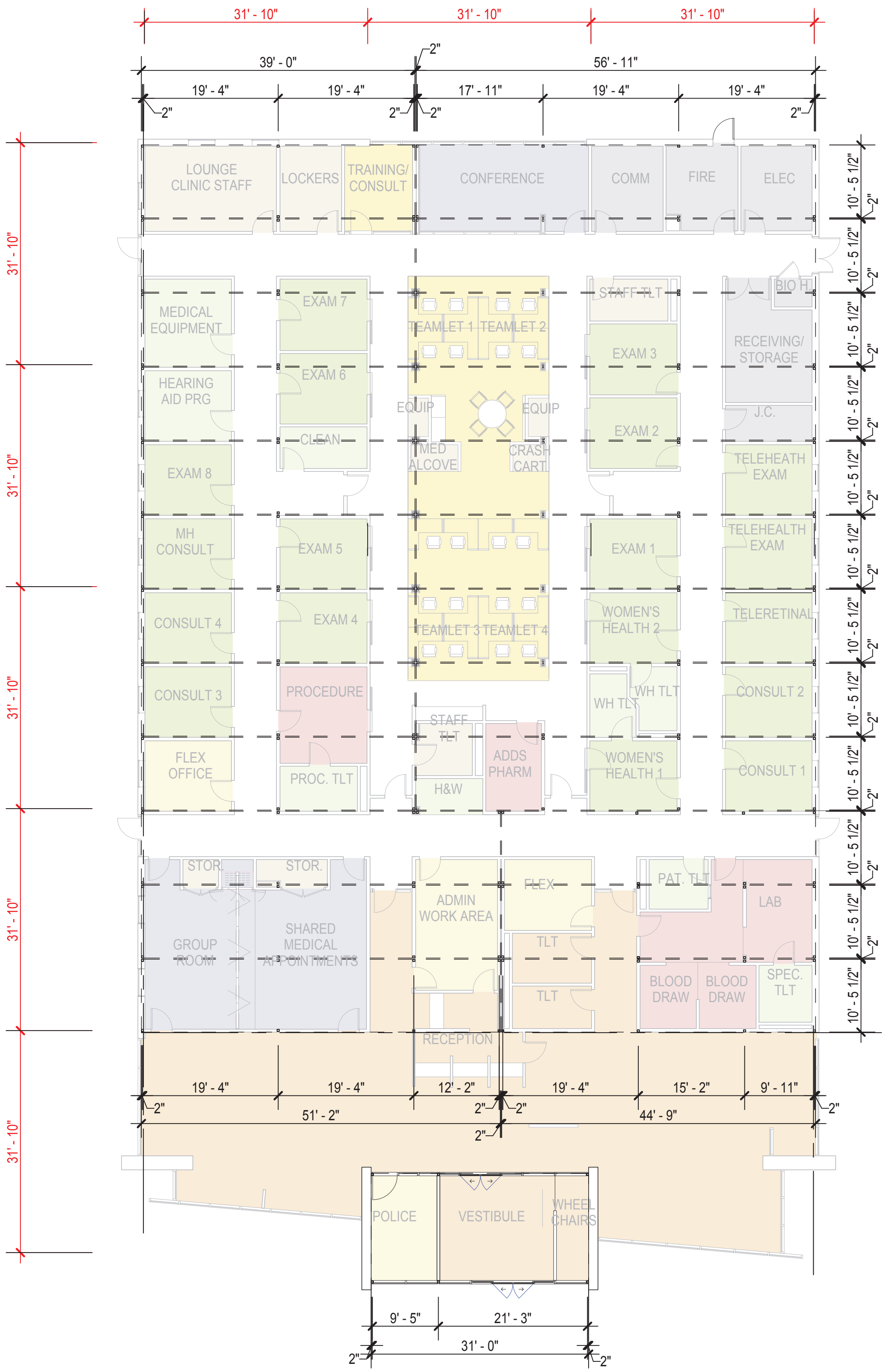

Figure 8.12
Module Overlay
10'-5 1/2" Wide Module
One-PACT CBOC

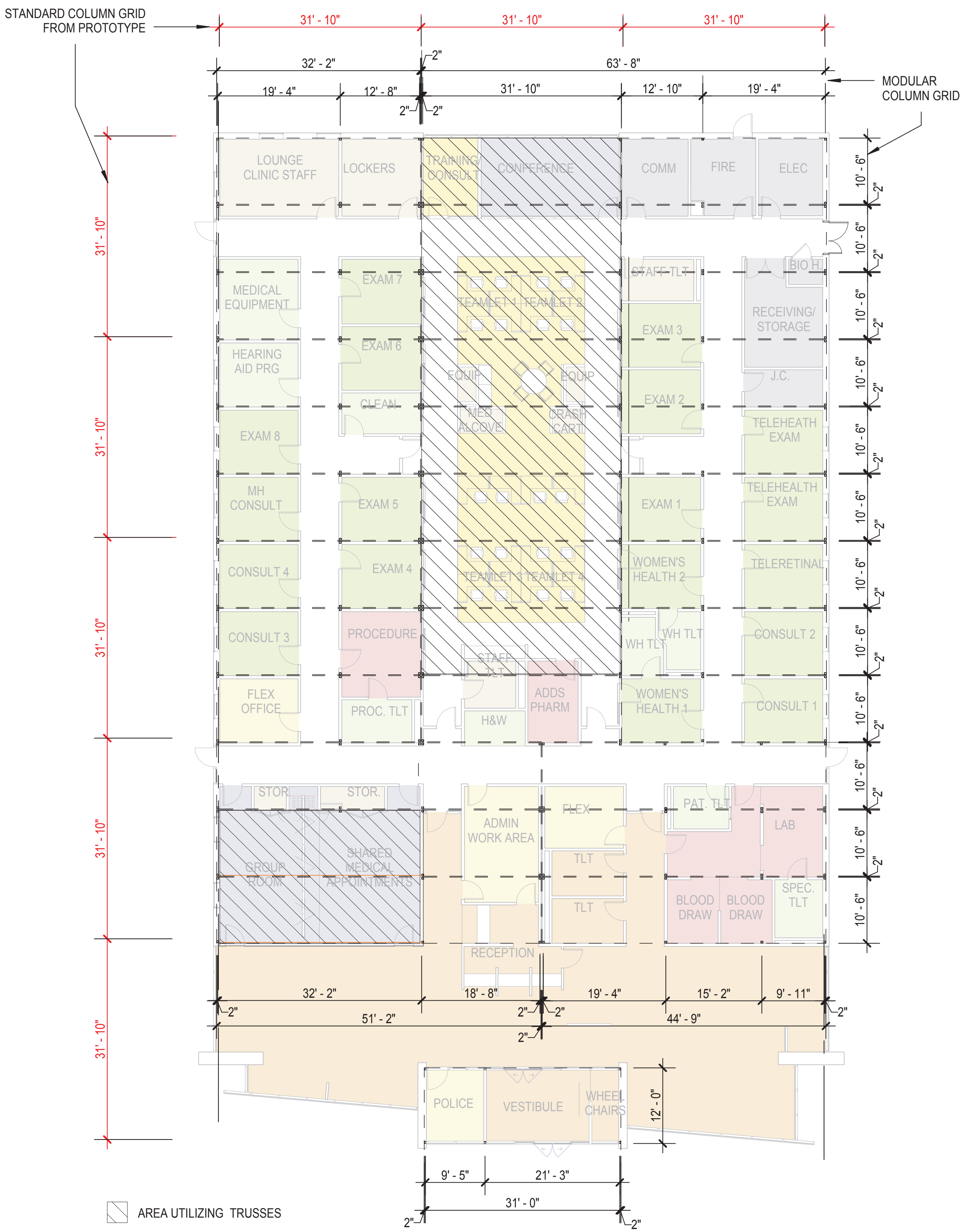

Figure 8.13
Module Overlay
10'-6" Wide Module
One-PACT CBOC

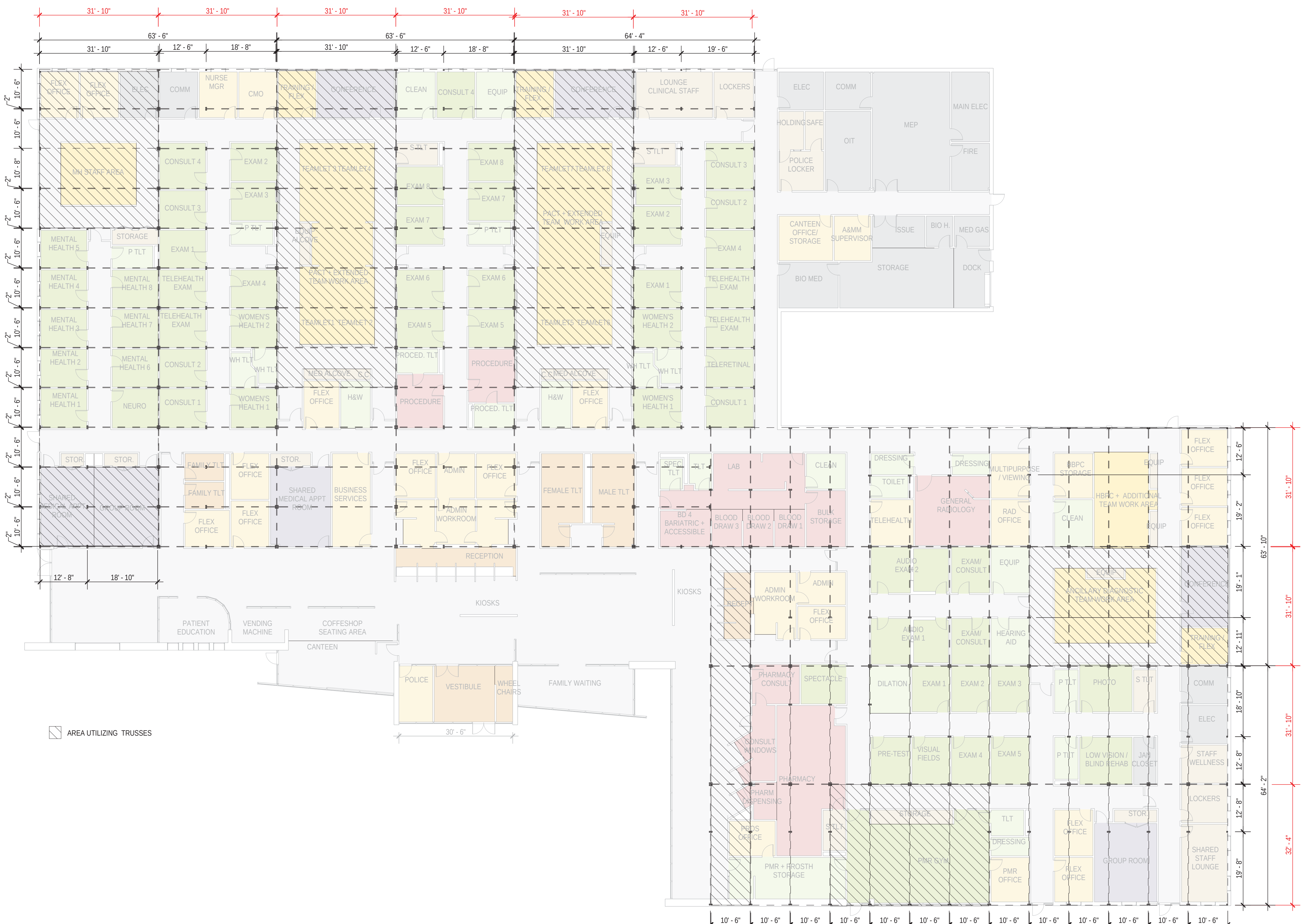

Figure 8.14
Module Overlay
10'-6" Wide Module
Two-PACT CBOC

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Other Considerations

Custom bay size may require some retooling by prefabricated modular subcontractors, all of whom have standard modules and details which vary somewhat. The prefab module sizes shall be adjusted to accommodate the model of care and the layouts shown.

The structural module is based on the prototype exam room and teaming area, which is sized by the integrated model of care, staff required for service lines, the separation of on stage and off stage circulation, and the desire for a positive healing environment for veterans and their families. No reduction of exam room size or proportion shall be allowed

Seismic bracing, moment frames, moment connections or shear walls may be introduced where necessary and may not interfere with the design intent as indicated on these drawings. When developing a modular solution for the CBOC prototype designs, care is to be taken to avoid structural elements in open work areas and structural elements impacting door locations or clearances.

Careful coordination of shop drawings for footings and foundation and superstructure is required to accommodate imposed loads. Confirm the prefabricated modular subcontractor has designed the superstructure to accommodate all imposed loads including rooftop mechanical equipment and loads imposed from the envelope.

Two story buildings will require vertical risers. The design shall coordinate these risers without disruption to the architectural design or medical equipment planning.

Floor to floor heights shall be adjusted to accommodate required structure, life safety, plumbing, electrical, mechanical equipment and distribution. Maintain required clear ceiling heights as specified. Modular structures must accommodate all systems, maintaining required ceiling height throughout without drop bulkheads.

Offer shall demonstrate that the general contractor and the prefabricated manufacturer have successfully completed similar projects previously. This requirement is important because the amount of work that the prefabricated modular subcontractor completes is often greater than the amount of work that the GC will complete, and bigger than all other subcontractors as well. This inversion can have an adverse effect on the working relationship between the general contractor and the prefabricated modular subcontractor.

It is the recommendation of this report that prefabrication not be a requirement for these projects. Rather it should be the choice of the offer. The overall intent is to quickly deliver uniform projects at a high level of quality with a consistent low cost.

Because of the variety of capabilities that prefabricated modular manufacturers possess, this report recommends performance specifications as opposed to proscriptive requirements. Design build RFP should not delineate which specification sections are provided by which subcontractors.

Department of Veterans Affairs should budget additional travel money during construction administration. Trips will be required to confirm the number of fabricated modules completed but not yet delivered. This confirmation will be necessary to approve the schedule of values for each monthly requisition for payment. Care should be taken to verify that stored prefabricated components are covered by the appropriate insurance at all times.

Some progressive general contractors have created impromptu modular manufacturing operations by renting warehouse space and requiring all subcontractors to work in that space. Should this solution be proposed by an Offeror, Department of Veterans Affairs should consider the warehouse a construction site, and have on-site representation appropriate for the level of fabrication and construction. The GC may request inspections and other activities at that location usually reserved for actual on-site execution.

Modular systems should be delineated in BIM, with models coordinated and clash detection complete before fabrication begins. A high degree of quality can be achieved through this integrated process.

Department of Veterans Affairs should consider the assistance of an architect and medical planner during the design of modular structures. Many decisions will require judgments regarding a variety of systems and components.

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