Analysis of How Data Center Pod Frames Reduce Cost and Accelerate IT Rack Deployments

White Paper 263

Revision 0

by Patrick Donovan and Wendy Torell

Executive summary

There is a better way to deploy and manage groups (or pods) of IT racks. Effective, free-standing pod frame containment systems can be quickly assembled and used as an overhead mounting point for services. Unlike traditional deployments, air containment and supporting infrastructure is attached to the frame allowing for racks to be easily rolled in and out. Pods and all supporting infrastructure can be deployed before racks are rolled into place. IT can be installed in racks in parallel with pod assembly. Overhead mounting to the frame avoids costly, time-consuming, and invasive construction that traditionally occurs in the ceiling or under a raised floor. In this paper we describe effective data center pod frame containment systems and demonstrate how they can reduce time to deploy by 21% and reduce capital costs by 15% compared to traditional methods and containment systems.

Introduction

Larger data centers tend to deploy larger amounts of IT using groups of racks or roomfuls of racks at a time. Efficiency, simplicity, and speed are all highly valued as it lowers cost and reduces error during deployment and operations. Standardizing deployments and operations makes achieving this value possible. **White Paper 260**, "Data Center Pod Architectures" specifies optimal concepts for designing and deploying groups of IT racks (i.e., a pod) at a time into the data center white space. These architectures promote high capacity utilization of the power and cooling infrastructure with efficient use of floor space supporting both low and high density racks. Standardizing on these simple architectures make deploying IT enclosures – populated or not – easier to plan and execute.

Attributes of effective IT pod frame systems

Pod frames that offer the following attributes are more capable of enabling the value described in this paper:

- Frame-attached support structures for mounting of services
- Adjustable frame length and width
- Flexible containment and frame height to accommodate different rack sizes
- Configurable for hot or cold aisle configurations
- Floor stand option for use with raised floors
- Option for mounting panel boards to frame

Pod deployments can be made more effective by using a pod frame system that is free-standing and independent of the IT racks. An effective pod frame (see **sidebar**) can reduce cost and time to deploy by being more of an assembly project vs. a construction project. IT equipment can be "racked & stacked" in parallel. By having containment attached to the frame, adds, moves, and changes are simplified while operational risk to availability is reduced. Fully populated IT racks – increasingly seen with hyperconverged solutions and large scale operators using integrators – can be more easily deployed into fully assembled and contained pods. Well-designed pod frames are suitable for different power and cooling architectures, number and dimensions of racks, as well as for differing room geometries. This inherent flexibility allows for architecture standardization across sites, regions, and designs.

This paper will first define what IT pods and pod frame systems are. The problems of deploying traditional IT pods are described along with how effective IT pod frames mitigate these challenges. Finally, the paper will present a CAPEX analysis and time study on deploying IT pods using easy-to-assemble pod frames vs. the traditional method of constructing power and cooling distribution infrastructure systems into the building structure. **Figure 1** below shows an example pod frame available in the market today.

Figure 1
Example of an IT pod frame system (Schneider Electric HyperPod™ shown)

Definition of data center IT pods and pod frames

White Paper 160, "Specification of Modular Data Center Architecture", provides a framework for creating and specifying a data center infrastructure architecture "that builds large systems out of smaller subsystems, where the subsystems have well-defined rules for interfacing with each other." Modularity offers benefits to any data center. A modular architecture can simplify and accelerate design, deployment, and commissioning. Capital expenses can be deferred and energy efficiency improved by deploying infrastructure resources that better match current needs. Modularity makes moves/adds/maintenance or adding redundancy much easier.

The paper goes on to propose a standardized hierarchy to help clarify a description of a modular data center architecture:

Data Center facility, comprised of

IT Rooms, comprised of

IT Pods, comprised of

IT cabinets, comprised of

IT devices

In this context, **an IT pod is defined as a group of IT racks either in a row or (more typically) a pair of rows, that share some common infrastructure elements like a PDU, network router, containment system, air handlers, security, etc.** Occasionally the term IT pod is used to refer to an IT Room; that is not the use in this paper.

An IT pod frame is a free-standing support structure that acts as a mounting point for pod-level infrastructure and as a docking point for the IT racks that make up the pod being deployed. Pod-level infrastructure includes:

- Air containment systems (hot and cold aisle containment)
- Power distribution (power whips, busway, panel boards & cabinets)
- Cooling distribution (overhead ducted supply/exhaust vents, water piping, and vents)
- Network cabling (fiber/copper) and switches

Disaggregating services from the building structure and flooring makes free-standing, easy-to-assemble pod frames an effective solution for traditional IT pod deployment challenges. It also makes it easier to standardize IT deployments across different sites that might use different power & cooling architectures.

Traditional IT pod deployment challenges

Particularly for sites that deploy groups or a roomful of IT racks at a time, there is desire to deploy quickly, cheaply, and only in the amount immediately required. Traditional methods, however, make this difficult to do. Ceiling support structures, underfloor cable trays, and air containment systems must be fully constructed for the entire room before IT is brought in. Air containment systems and other support infrastructure is constructed directly on to the racks. Deploying IT pods has traditionally been a construction project involving multiple trades, permits, and getting the building owner's permission. Typically, IT cannot be deployed or put into operation during construction. Assembly projects, on the other hand, are much less invasive, costly, and time-consuming. **Table 1** describes the negative impacts of using traditional IT pod deployment approaches.

Challenge	Impact(s)
Containment systems are attached to racks	• Rolling racks in and out is difficult, time-consuming, and more error prone • Colocation vendors must wait for tenant's delivery of racks – if supplied by tenant - before pod buildout can be finished • Racking/stacking IT cannot be done in parallel to pod construction
Ceiling supports, underfloor cable trays, and containment must be constructed for entire room before IT delivery	• Construction lengthens project time line • Builds out infrastructure before it's needed; does not preserve capital and risks stranding capacity
Traditional approach requires more construction vs. assembly	• Ceiling support structures, underfloor cable trays, and wall-mounted power panel construction is costly, time-consuming, and invasive • Construction requires owner permission and sign-off in leased buildings • Financial implications (depreciation & taxes) of building construction are less favorable than assembly as part of the IT infrastructure • Ceiling strength must be evaluated or enhanced before additional loads are hung
Incorrect use of raised floor	• Putting cabling under raised floor can create airflow issues • Cabling under floor is difficult to add or change • Forces the use of a taller raised floor which adds cost

Table 1

Issues related to deploying traditional IT pods and the impact on time, money, and complexity

Mitigate challenges by using IT pod frames

The frame greatly reduces the need to mount or install power, fiber, copper, ducting and piping to the ceiling, under a raised floor, or directly to the racks themselves. The disaggregation of these services from the IT enclosures and building structure is fundamentally what solves the challenges described above. How this is done is explained in this section.

Challenge: Containment systems are attached to racks

Air containment systems are assembled on the free-standing pod frame itself. This makes moving a rack into or out of a pod much easier. With traditional containment, panels must be unscrewed and pulled away to remove a rack. Racks at the end of the row are even more difficult to change since a pod door must be disconnected from the rack and likely removed. This complication not only increases the time to do maintenance or upgrades, but also makes it more likely something could go wrong (i.e., pulled loose or disconnected).

Installing IT equipment into the racks can now happen in parallel and independently from the buildout of the pod. Although not part of the time study shown in this paper, it could offer significant time savings depending on your process. While deploying fully-populated IT racks may seem impractical due to the potential weight involved, the growing trends of using IT integrators and the emergence of hyper-converged systems are expected to make this practice more common. Further, infrastructure vendors are beginning to offer unique “shock” packaging solutions designed to make shipping fully configured IT enclosures easier with little-to-no risk of damage. Additionally, to the benefit of wholesale colos who tend not to own the IT racks, the IT space infrastructure can now be fully deployed and contained **before** the tenant’s IT racks arrive. Neither party wants the vendor in the tenant’s space once the tenant begins to fill their leased space with racks and gear. Further, enabling the tenant to rack & stack their IT beforehand, means the vendor can begin earning revenue significantly sooner than they would otherwise.

Challenge: Ceiling supports, under-floor cable trays, and containment must be constructed for entire room before IT delivery

Because on-going construction work cannot take place in the same room as operating critical IT equipment, much of the supporting infrastructure for the white space must be fully built out for the entire room. Effective pod frames eliminate most, if not all, of the construction required for overhead ceiling support grids for network & power cabling and, in some cases, air ducts. Pod frames, therefore, make it possible to preserve capital and avoid potentially overbuilding infrastructure that may not be needed. Effective pod frames have overhead supports built into the frame, or that can be added to the frame as an option, to hold power/network cabling, busway systems, and/or cooling ducts/piping.

Challenge: Traditional approach requires more construction vs. assembly

Effective pod frames allow you to attach services directly to the frame or mounted cantilevers, quickly using simple tools. The frame itself can be quickly assembled using simple tools. Drilling and cutting into the building is largely eliminated. This approach saves time and labor hours as shown in the CAPEX analysis and time study sections.

Challenge: Incorrect use of raised floor

Effective pod frames make it easier to use a hard floor vs. a raised floor since services can be neatly mounted to the frame. This can include power cables, busway, network wiring, as well as cooling ducts and piping. However, if the use of raised floors is preferred for distributing cold air, it’s important not to constrain that airflow by over filling the air plenum with cabling or other obstructions. If cabling is passed under the floor, then a taller (typically 36” or roughly 1 meter) raised floor is used. With no underfloor cabling, a shorter, less expensive floor can be used as shown later in the CAPEX analysis section. Also, if you use the pod frame as a mounting point for services, you reduce or eliminate the need for floor cutouts (and brush strips) that are necessary when cabling is run under the floor. These cutouts cost time and money to make (See Cost and Time Study sections for details). And they can be a source of air mixing that can reduce cooling efficiency.

Capex analysis: traditional pod vs. pod frame deployment

Deploying pod frames and avoiding the challenges described above translates directly into cost savings. In this section, we quantify the capital cost differences of deploying data center pods using free standing pod frames compared to the more traditional approach of using ceiling grid structures and raised floors to distribute power and networking cables, and a containment system supported by IT racks.

Architectures

For the analysis, the data center IT room size and attributes were selected based on a Schneider Electric reference design: http://www.schneider-electric.com/en/download/document/RD65DSR0-pdf/. The IT room supports 1.3MW of IT load, and consists of 9 IT pods, each with 24 racks. **Figure 2** illustrates the layout of the room, which was the basis for calculating lengths of key systems like Unistrut grids, ladders, cable trays, and cables runs for both design alternatives. Air handlers and perimeter transformer-based PDUs are illustrated in the layout, but were excluded from the cost analysis, since they were common to both designs.

Figure 2

Layouts of the IT space used in the capital cost comparison

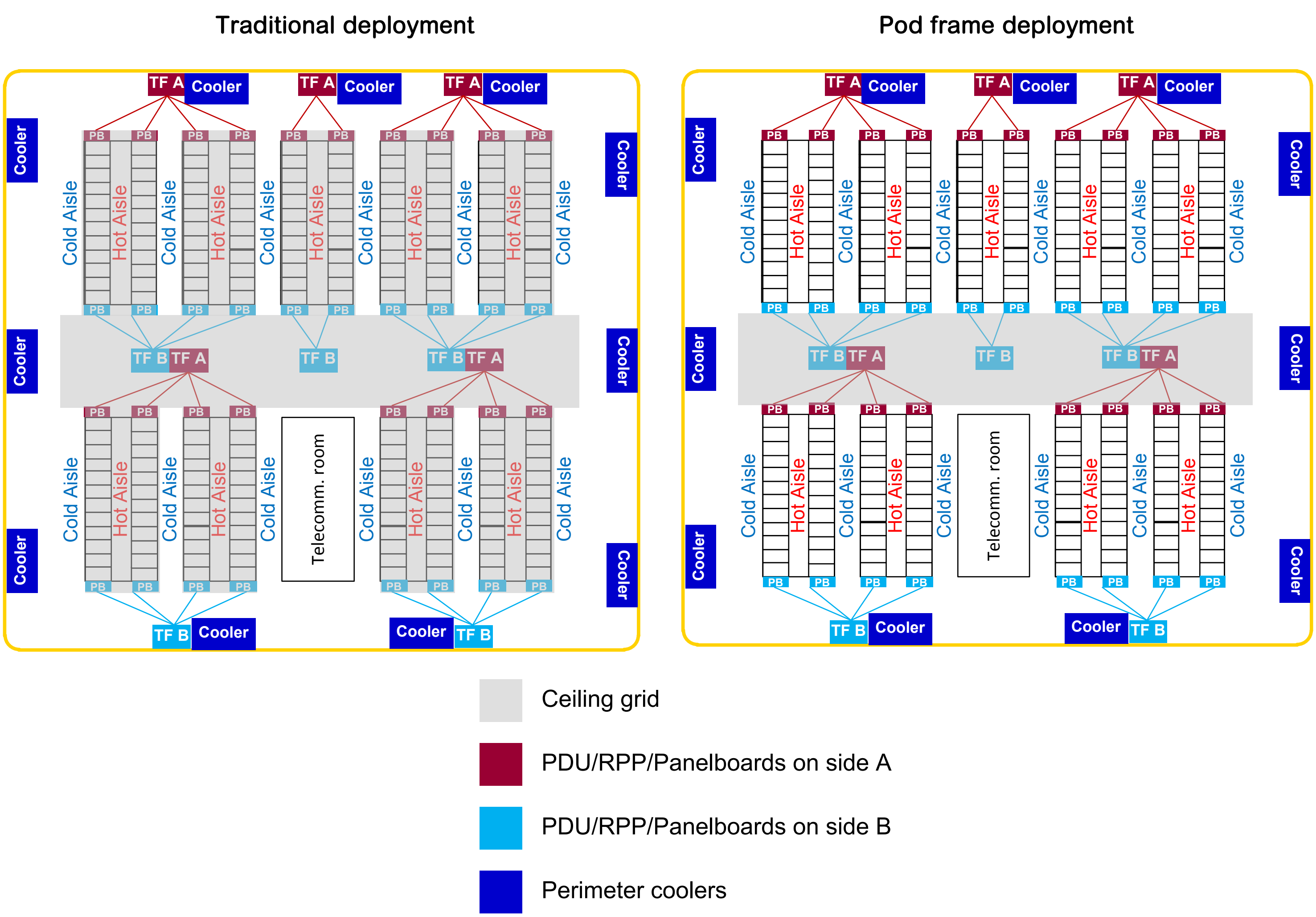


Table 2 lists the additional design details that both the frame-based and traditional designs included.

Table 2

Common design attributes and assumptions for the capital cost comparison of frame-based pod vs. traditional

Data center attribute	Value
Capacity	1.3MW
Average density	6 kW/rack
Pod count	9
Racks per pod	24 (12 per row)
Redundancy	2N power distribution
Air distribution	Raised floor air plenum, perimeter cooling
Containment type	Cold aisle containment
Power feeds to pods	100 linear feet (30.5 meters) per feeder from 10 perimeter PDUs, via Unistrut

Methodology and assumptions

By deploying the IT space with pod frames that can serve as the mounting point for services like power and data cabling, this enables key design differences over traditional designs. **Table 3** explains the dfiferences between the two design approaches in terms of containment method, raised floor specs, room size, and power and network cable distribution.

Table 3

Assumption of design differences for capital cost comparison of frame-based pod vs. traditional

Attribute	Pod frame approach	Traditional approach
Containment approach	Doors and ceiling mounted to pod frames	Doors and ceiling mounted to IT racks
Raised floor	610 mm (24") height, no cut-outs under pods	914 mm (36") height, 24 cutouts, grommets/brush strips per pod
IT room size	783 m^2 (8428 ft^2)	842 m^2 (9058 ft^2); greater because of floor mount RPPs
Unistrut grid system	From main data cabling trunk line down center of room (37.2 m^2 or 400 ft^2)	From main data cabling trunk line down center of room AND cable trays over each row (278.7 m^2 or 3000 ft^2)
Power cable ladders	Mounted on frame-system via cantilevers and ladders	130.5 linear meters (428 LF) of under floor cable trays (located under each row of racks)
Network cable ladders	30.5 linear meters (100 LF) down center of room; then mounted on pod frame	30.5 linear meters (100 LF) down center of room AND 7.3 linear meters (24 feet) over each row of racks (total = 160.9 linear meters or 528 feet)
Rack branch distribution	7.6 linear meters (25 feet) average, 30A 3Ph	9.1 linear meters (30 feet) average, 30A, 3Ph (longer whips due to going under raised floor)
RPPs	225A panels mounted to frame	225A RPPs on floor in-line with rows of racks

For each design, costs were broken down by subsystem, so that we could identify the key cost drivers. CostWorks, a construction cost estimating tool that provides industry-standard RSMeans construction costs, was used for typical material and installation costs of key subsystems, including the raised floor, Unistrut grid system, ladders, trays, and rack branch distribution. Additional costs for containment, PDUs, and panelboards were obtained from Schneider Electric's TradeOff Tool, Data Center Capital Cost Calculator. Additional assumptions in our cost estimation include:

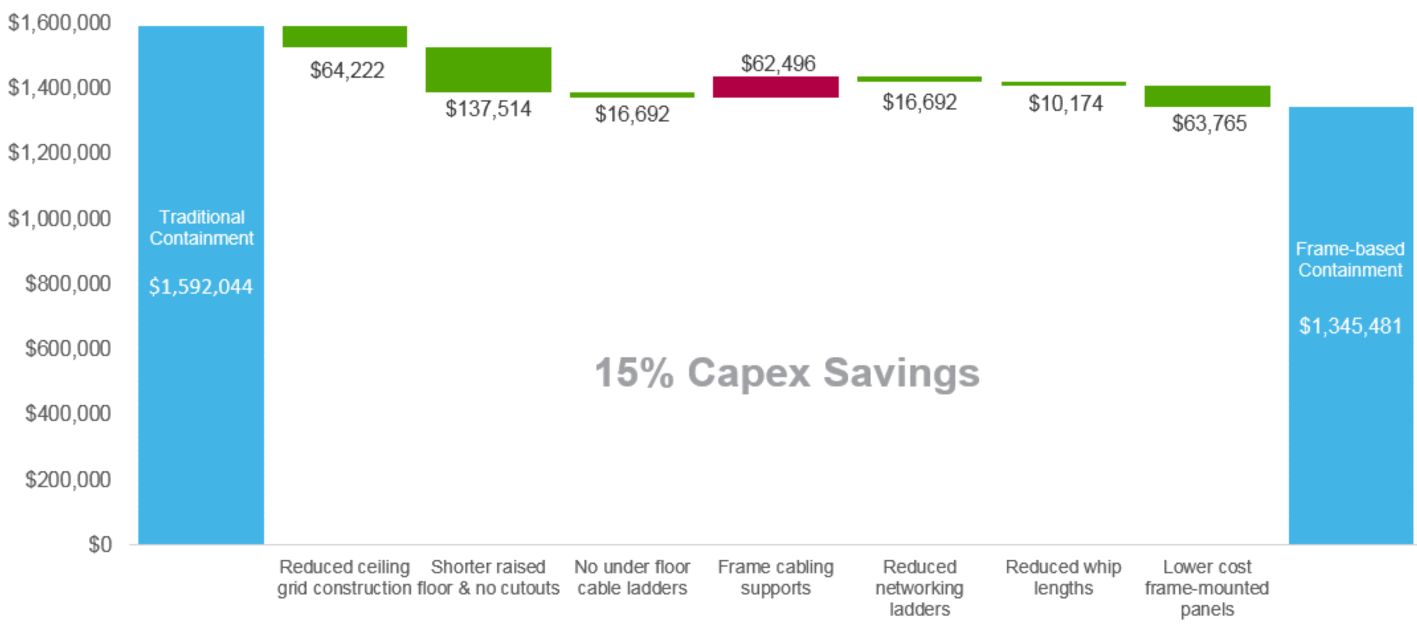
- Average US labor rates were used for design and installation estimates in CostWorks
- All pods were assumed to be deployed in one phase (complete room build-out)
- No space (leasing) cost was considered
- A taller raised floor was required for the traditional approach due to airflow obstructions with cable trays/cables underneath the floor

Findings

Figure 3 summarizes the key capital cost differences between the two designs, and shows a 15% overall savings by designing with pod frames. For this 1.3MW design, this equated to a capex savings of $246k. Most of the savings are the result of the frame-based approach having structural mounting properties to avoid or reduce the cost and labor from ceiling and floor structures. Note that traditional practices vary, from one data center to the next. In some cases, both power and networking are distributed overhead in ceiling grid systems. This reduces the savings since there is no need for the raised floor cable trays, cutouts, etc.

Figure 3

Waterfall diagram showing cost difference between traditional pod design and frame-based pod design



Reduced ceiling grid construction: The pod frame approach reduced the cost of the Unistrut ceiling grid system (material and install) by $64k, by eliminating the grid system over the individual pods. The ceiling grid was only needed from the main data cabling trunk line down the center of room to get the network cables to each pod, and then the pod frames were used to distribute cables to the individual racks.

Shorter raised floor & no cutouts: The ability to use a shorter raised floor and avoid cutouts in the floor tiles saved $137k. When raised floors are used as air plenums to deliver the cool air from the CRAHs to the IT racks (as assumed in this analysis), it is important that there is sufficient space below the raised floor, clear of obstructions, to deliver the air effectively. Because of the mounting properties of the frame, the power cables can be distributed overhead on cantilevers, resulting in no cables below the raised floor. This means a shorter floor is possible, and eliminates the need for cable cut-outs to run the cable through the tiles, and no grommets and brush strips to prevent air from leaking through the cable cut-outs. Brush strips can cost anywhere from $40-$120US, so our analysis assumed the average cost of $80, which is a savings of $17k for a data center of this size.

No under floor cable ladders: $16k is saved with the pod frame approach by eliminating the need for cable ladders placed under the floor.

Frame cabling supports: The pod frame reduces the expense of room structures, but there is a cost premium for the structures to mount the cabling to the frame. This premium was $62k for the room with 9 pods, or about $7k per pod. This includes the cantilevers, raceways, and trays needed to support and run the cables.

Reduced networking ladders: As the table above illustrated, the pod frames eliminated the need for 7.3 linear meters (24 feet) over each row of racks, or an additional 130.4 linear meters (428 feet). At an estimated cost of $26 per linear foot for material, plus $13 for installation, this translates to a savings of over $16k.

Reduced whip length: In the traditional design, the power whips are run from the PDUs at the end of the rows of racks under the raised floor, then back up to their respective rack locations. In the pod frame design, the whips are run from the panels attached to the pod frames on the cantilevers to the respective racks. This saves approximately 5 linear feet (1.5 meters) per whip, which translates to a total savings of $10k.

Lower cost frame-mounted panelboards: There are several approaches to distributing power in an IT space, but commonly, data centers use PDUs or RPPs that sit on the data center floor. In this analysis, we assumed the traditional design used 225A RPPs in-line with the rows of IT racks. The frame-based approach, on the other hand, is designed to incorporate lower-cost panels mounted directly to the sides of the frame. Not only does this save floor space, but also saves material and labor cost. This resulted in an additional $63k savings.

Deployment time study

The deployment timeline of a data center project is often as important, if not more important than the capital outlay of the project, because time your data center isn't operational means time you're not generating revenue or getting that critical business application online. In addition to the cost savings shown above, the pod frame approach enables a time savings of 21% or 17.5 days of labor.

Schedulers from Schneider Electric's design build services team created project timelines and Gantt charts for the two alternatives, based on extensive past project experience. For this size IT space, a work force of 4 people was assumed.

Findings

Figure 4 demonstrates the reduction of project time from 84 days to 66.5 days and highlights the major steps of the project. Gaps illustrated in grey between tasks are the result of critical path items, where tasks couldn't begin until prior work was complete. The detailed Gantt charts, which illustrate the critical path items, are shown in the **Appendix**.

While many of the steps remain unchanged for the installation of these two IT room approaches, there are some key differences that ultimately result in the 21% savings.

Reduced ceiling grid work: Since no ceiling grid was needed directly over each IT pod, the time to install the Unistrut grid system was reduced from 8 days down to 4 days.

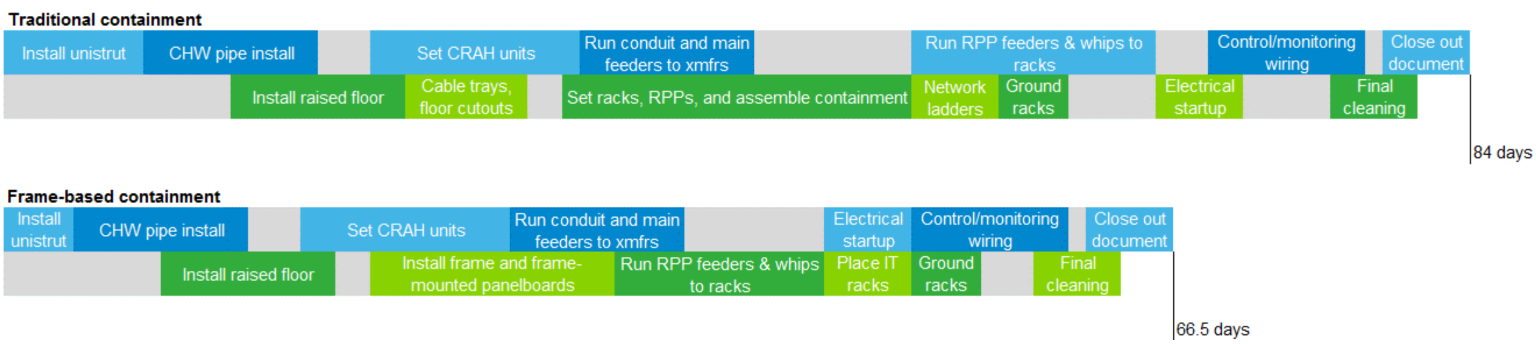
Eliminate under-floor cable trays and cutouts: In both configurations, the raised floor was installed, but in the traditional design, there were added steps of installing the under-floor cable trays, making cutouts in the tiles for the cables, and placing grommets and brush-strips in the cutouts to prevent air leakage. This additional work added 7 days of labor.

Faster containment assembly: Assembly of the frame and necessary containment panels (i.e. doors, ceiling) can vary significantly based on the containment system chosen for a design. In this analysis, we assumed 13.5 days of labor or 1.5 days per pod for the frame-based containment system which was estimated based on several actual installations of Schneider's HyperPod frame/containment system. This was compared to the traditional containment system built around IT racks, which was estimated to require 15 days of labor, or 1.5 additional days of labor.

Faster installation of power whips: Running power whips from panels over ladders on cantilevers on the pod frame to the IT racks is simpler and quicker than running power whips from PDUs under the floor, laid in cable trays, then pulled up through floor cut-outs to the IT racks. This was estimated to save 2 days of labor.

Figure 4

Timeline comparison between traditional pod design and frame-based pod design



The above time comparison didn't factor in the installation of the IT equipment. Doing so can result in further savings for the frame-based approach, since IT equipment work including unboxing, de-trashing, installing, and plugging the equipment into racks can all be done in parallel to the pod assembly. In contrast, these activities would generally be done upon project completion for the traditional design, since the racks are a necessary part of the construction of traditional containment.

For the pod sizes used in this analysis, the time for this activity is estimated at 1 day per pod, or 9 days of additional labor potentially saved.

Conclusion

Free-standing pod frames that allow for integration of services like power distribution, networking cables, power cables, and containment offer many advantages over traditional IT room build-outs with ceiling grid systems, underfloor distribution of cables, and containment mounted directly to IT racks. With pod frames:

- IT racks are no longer integral to completion of the pod, which means IT equipment can be installed in racks prior to or in-parallel with pod assembly.
- less construction work reduces the project timeline by 21%.
- reduced room structures like Unistrut ceiling grid systems, hanging ladders, and underfloor cable tray systems results in capex savings of 15%.
- IT racks can be easily rolled in and out of the pod, providing added flexibility for changes over time.
- it’s possible to preserve capital and avoid overbuilding infrastructure that may not be needed
- raised floors can be used for their primary purpose of air distribution, without being clogged with cables

As cost, efficiency, simplicity, and speed continue to drive data center decisions, we will see a natural shift towards deploying IT rooms with free-standing pod frames. The importance of flexibility for what the future holds on the IT side further supports this shift.

About the authors

Patrick Donovan is a Senior Research Analyst for the Data Center Science Center at Schneider Electric. He has over 20 years of experience developing and supporting critical power and cooling systems for Schneider Electric’s IT Business unit including several award-winning power protection, efficiency and availability solutions. An author of numerous white papers, industry articles, and technology assessments, Patrick's research on data center physical infrastructure technologies and markets offers guidance and advice on best practices for planning, designing, and operation of data center facilities

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Appendix

Figure A1 and **Figure A2** illustrate the Gantt charts for deploying the IT room described in this paper, using both approaches. As the charts illustrate, a project timeline of 66.5 days would be expected for the frame-based approach (using Schneider's HyperPod in this analysis), and an expected project timeline of 84 days would be expected using the traditional approach to deploying IT pods with ceiling structures, underfloor cable distribution, and containment mounted directly to IT racks.

Figure A1

Gantt chart of frame-based approach

ID	Task Mode	Task Name	Duration
1		**HyperPod Installation**	**66.5 days**
2		**Pre-Enclosure Work**	**39 days**
3		Space Ready for Construction	0 days
4		Unistrut Grid Installation (400 SF)	4 days
5		24 " Raised Access Floor Installation	10 days
6		**Infrastructure**	**35 days**
7		CHW Pipe Install	10 days
8		Set CRAH Units (12x)	12 days
9		Set Xfmrs (10x)	10 days
10		Run Conduit & Feeders to Xfmrs	10 days
11		**HyperPod Unit Installations**	**15.5 days**
12		HyperPod Components Delivered to Site	2 days
13		Install HyperPod Frames w/ Frame Mounted Panelbo	13.5 days
14		**Frame Mounted Panelboard (FMPB) Tie-ins**	**12 days**
15		Land Feeders in FMPBs	4 days
16		Run Whips from FMPBs to Rack Spaces	8 days
17		HyperPod Startups	5 days
18		**Completion of Install**	**17 days**
19		Place IT Racks (already set up)	5 days
20		Rack Grounding	4 days
21		Control/monitoring wiring	9 days
22		Final Clean	5 days
23		Training	2 days
24		Effective Turnover Date	0 days
25		**Close out**	**10 days**
26		Close out Documentation	1 wk
27		Provide as Built Drawings	2 wks

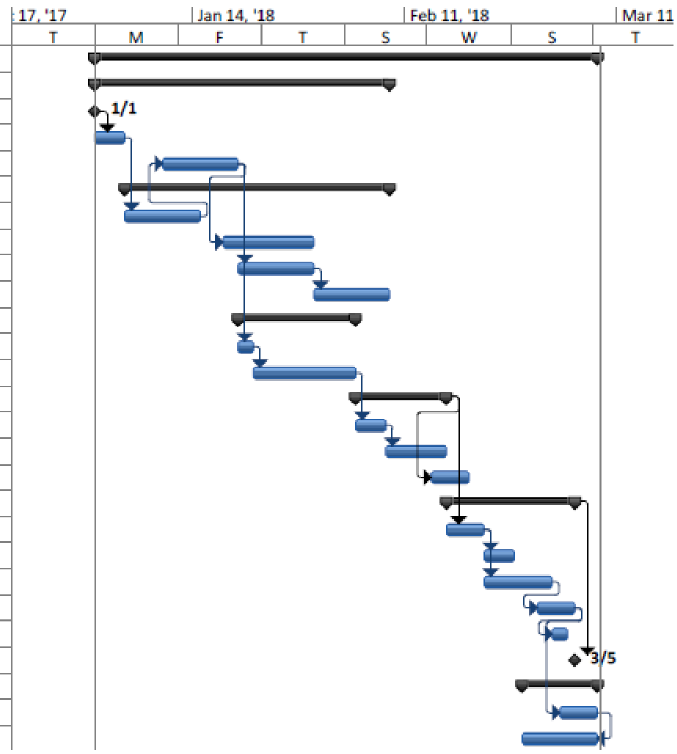

Figure A2

Gantt chart of traditional approach

ID	Task Mode	Task Name	Duration
1		**HAC System (ISX Solution) Installation**	**84 days**
2		**Pre-Enclosure Work**	**43 days**
3		Space Ready for Construction	0 days
4		Unistrut Grid Installation (4,000 SF)	8 days
5		36" Raised Access Floor Installation	10 days
6		Install Cable Trays under Floor	6 days
7		Drill floor Tiles for rack PDU grommits	3 days
8		**Infrastructure**	**35 days**
9		CHW Pipe Install	10 days
10		Set CRAH Units (12x)	12 days
11		Set Xfmrs (10x)	10 days
12		Run Conduit & Main Feeders to Xfmrs	10 days
13		**ISX Solution Installation**	**36 days**
14		HAC Components Delivered to Site	2 days
15		Set Racks & RPPs in Place	5 days
16		Assemble HAC Enclosures (9 PODs)	15 days
17		Land Feeders in RPPs	4 days
18		Network Cable Ladder Install	5 days
19		Run Whips from RPPs to Rack Spaces	10 days
20		Rack Grounding	4 days
21		HACS Startup (by APC)	5 days
22		**APC to Complete HACS Install**	**12 days**
23		Control/monitoring wiring	9 days
24		Final Clean	5 days
25		Training	2 days
26		Effective Turnover Date	0 days
27		Begin Setting up IT Racks	0 days
28		**Close out**	**10 days**
29		Close out Documentation	1 wk
30		Provide as Built Drawings	2 wks