



VERTIV WHITEPAPER

Prefabricated Modular Data Centers: From Disruption to Default Option

An Essential Strategy to Future Proof the Data Center

Executive Summary

The speed of disruption and the current data surge cycle continues to demand transformation in the data center industry. The response to these demands bring prefabricated modular (PFM) data centers to the arena - delivering low-risk, high-value implementations with the added benefits of faster delivery and easier on-site assembly.

But new technology invariably introduces a knowledge gap, and perceived risks of the unknown: what do we mean when we say prefabricated, what do we mean when we say modular, and what benefits do they confer to the construction, operation, and modification of critical facilities like data centers?

This white paper addresses those questions and provides clarity on the specific benefits that PFM data centers can offer over traditional construction techniques; benefits that could eventually see PFM shift from being an alternative and disruptive technology to becoming the default option for new data center capacity in the future.

Introduction

Disruption in the data center industry brings a multitude of challenges, but one primary concern is universal: how to manage unpredictable growing demand today while remaining flexible for the future.

Growing edge compute use cases will potentially require vast volumes of medium to small (or even micro) data centers to manage the workloads associated with an explosion in demand related to IoT. Edge site deployments could range from a 5MW facility in a city to a single, hardened-rack next to a 5G mast on a building rooftop. Meeting that disruption from the core to the edge with conventional building approaches where every new facility is a “beautiful, unique snowflake” will be near impossible.

Traditional approaches, such as the conventional ‘stick-build’ construction process, have represented the default choice for many organizations seeking to add capacity simply because there has been no viable alternative. However, traditional methods have proven insufficient in many cases. They can’t meet the accelerated development requirements of dynamic organizations and often don’t factor future growth into the design. Relying on these processes, organizations have either had to deploy capacity before it is needed —creating risk and stranding capital— or consistently stay a step behind their capacity requirements, limiting growth.

Prefabricated and/or modular methods are increasingly the choice of data center owners and operators for the value of its integrated approach. Designing, configuring, and fabricating data center infrastructure off-site is creating tighter integration across systems, streamlining processes and enhancing management of those systems. Through the review of the background and history that led PFM data center systems toward industry mass adoption, a summary of variations that meet market demands, and analysis of PFM benefits, this paper provides information and support as to why PFM should be a default consideration for data center operators.



Dimension Data: high-quality prefabricated modular Tier III compliant data center system prefabricated, integrated, and tested in Vertiv’s European facility. It was then disassembled into 12 shippable units, packed for transport, and made the journey to South Africa, where it was reassembled on site and ready for testing in under 6 weeks.

Key Findings:

- Prefabrication (manufacturing components off-site) and modularity (building in discrete units) are separate but disruptive approaches to data center construction. That disruption multiplies when the two methods combine in PFM data centers.
- PFM is gaining acceptance as operators require ever more efficient, agile and globally consistent infrastructure.
- PFM is not just containerized data centers: a wide variety of customizable form-factors now exist to meet almost any customer requirement for new capacity from whitespace to power to cooling.
- The market for PFM data centers is set to expand at a five-year compound annual growth rate (CAGR) of 14.4 percent through 2021
- The benefits of PFM include:
 - Rapid design leads to faster time to availability
 - Build capacity to match demand today instead of planning for unforeseen growth
 - Optimized performance of the components with a holistic view of the system
 - Higher quality controls extends geographic reach
- PFM has applications and benefits from the core right through to the edge. However, demand for large scale deployments of standardized edge data centers will be a dynamic driver of future demand.

Background/History

Sun Microsystems introduced one of the first PFM data centers – based around a containerized design – in 2006 with its project BlackBox. Within a few years, most of the significant server OEMs had followed suit including Dell, IBM, and HP.

The fact that the IT industry created the first wave of PFM products around ISO containers meant that this form-factor was closely associated with the term PFM – perhaps to the detriment of a speedier uptake of the technology to some extent due to its perception of being “affordable”. Another level of complexity is the fusion of the two terms “prefabrication” and “modular” when independently they mean different things.

Modularity refers to building out/adding units of capacity in building blocks to meet demand; this avoids stranded capacity which can be extremely costly in terms of CapEx and OpEx. Modularity ultimately provides option value. This value comes from closely matching the supply of needed capacity to the business demand.

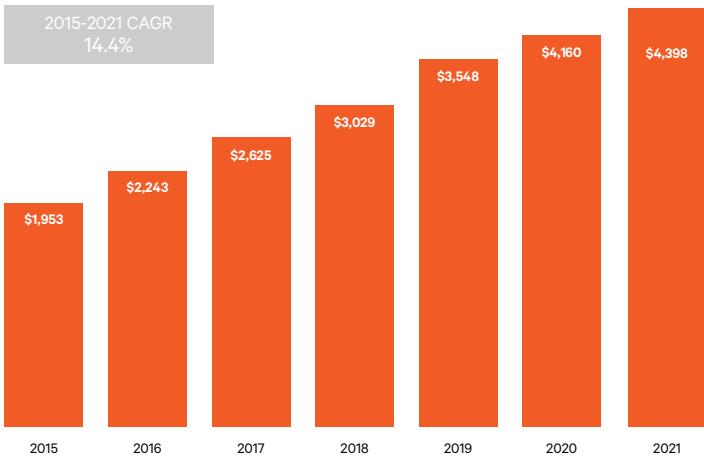
Prefabrication refers to the process of manufacturing and assembling units of capacity (rows, rooms, data halls, power, and thermal infrastructure) off-site. It allows activities to move forward in parallel, which wouldn’t be possible in a conventional on-site build.

In the last ten years, the term “prefabricated modular data centers” forged its way into industry vocabulary and has since been validated by numerous objective industry experts. PFM is its own term and encompasses the full spectrum of units of data center capacity from rows to rooms to full facilities, as well as power and thermal infrastructure.

“PFM methodology is becoming the preferred way to expand and build new data center capacity, turnkey or critical subsystems. Underpinned by industrial processes, it has distinct advantages in terms of quality control, installation speed and build consistency” said Daniel Bizo, principal analyst 451 Research.

Figure 1: Aggregate PFM Revenue Forecast Through 2021 (\$M)

Source: 451 Research, 2018



According to industry analysts 451 Research, this industrialized methodology for building data center infrastructure has taken root at numerous sizeable operators; it is not a question of “why do prefabrication?” but “how to do it best.” The market for PFM data centers is set to expand at a five-year compound annual growth rate (CAGR) of 14.4 percent through 2021 when it will reach \$4.4bn.

The continuing challenge for data center technology suppliers is to communicate to customers and partners the method, breadth, and flexibility of design PFM can support.

A Variety of Solutions

Prefabricated modular encompasses data centers and other critical facilities that are pre-engineered with systems assembled, integrated, and tested in a factory environment to shorten deployment time frame and improve the predictability of both schedule and cost performance. They are flexible, allowing for faster deployment and lower risk, scalable, allowing for customization and rapid response to unforeseen demand, and efficient, allowing for lower total cost.

It can include such subsystems as thermal management, power protection and distribution, controls and management software, and services — plus ancillary systems such as lighting, fire protection, physical security, and water treatment — pre-configured to create a complete environment for the efficient and reliable operation of technology systems.

For the expansion of pre-existing facilities and retrofits, building block solutions range from single enclosed racks to larger multi-rack contained systems may represent a viable answer, as they allow for a staged retrofit or expansion with minimal disruption and controlled growth. A refresh of this nature could include a range of other form-factors including infrastructure that is not entirely enclosed but delivered on a skid.

The IT industry is not alone in seeing the advantages of prefabricated facilities. Other sectors such as pharmaceuticals as well as oil and gas have invested in PFM buildings to house complex machinery within strict timelines and often in difficult locations like remote oil fields or offshore platforms. During the 1960s and 1970s, the US and other countries adopted PFM designs for residential housing to meet the growing demand for affordable homes.

A Hypothetical Example of Retrofit for Success

A legacy data center that houses six (6) Liebert® 610 UPS units, each with a capacity of 625kW, in a 2N architecture with three (3) units on each bus. To provide 1.5 MW to the IT load, the UPS units in the system run at approximately 42% capacity and 90% efficiency. Although that utilization rate is standard for modern UPS deployments, the efficiency is low and outdated, and very costly to the operator of this data center.

To upgrade, we can develop a purpose-built skid with pre-integrated system components: in this case, a modern UPS and Lithium Ion batteries with input/output connections specifically designed to line up with the existing connections for the replacement system. These upgrade skids can be integrated off-site but staged on-site ahead of the critical upgrade commencement.

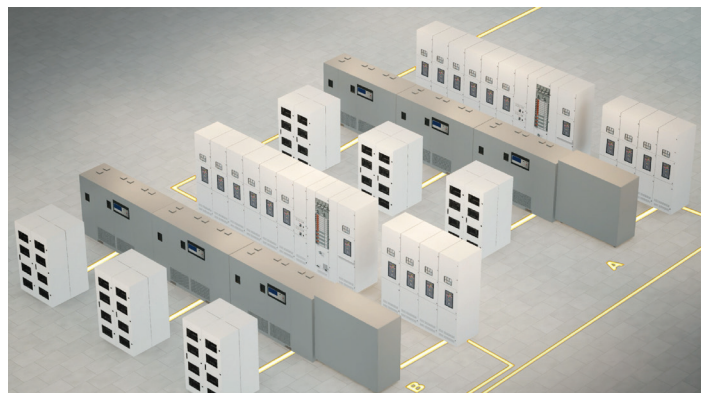
The upgrade is completed one unit at a time, one bus at a time, much like the performance of preventative maintenance on UPS units – without taking the critical loads offline. Once the process is complete, the power system provides the same 1.5 MW of power to the IT load, still running at similar utilization as before the upgrade, but at a much-improved efficiency rate of over 96% and in a reduced footprint. In this example, the data center operator saves over \$125,000 of annual operational cost on power alone.

Watch The Full Video Here:

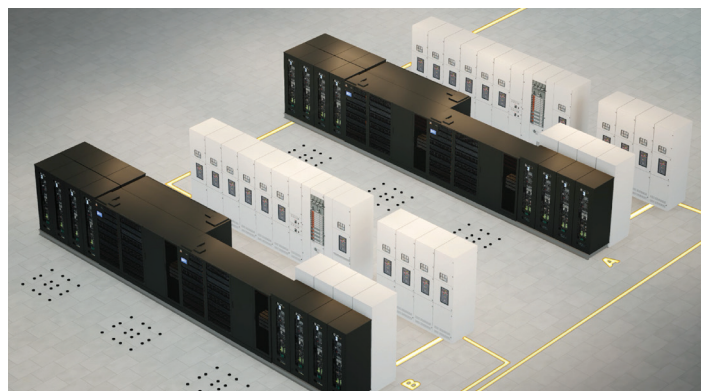
<https://vertiv.biz/GH2017StructuralRefreshAnimation>



Before



After

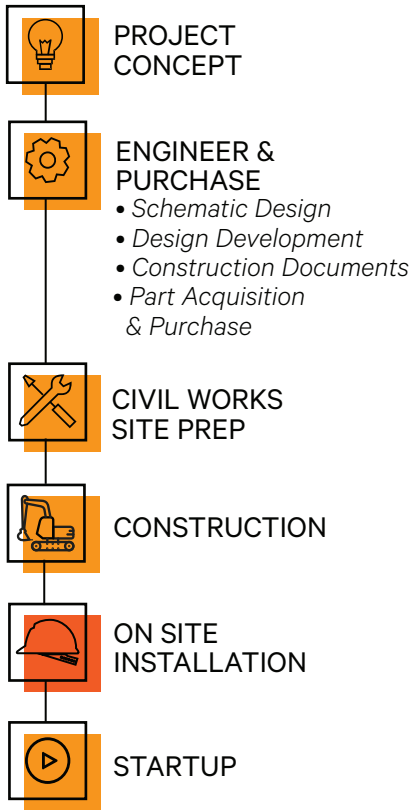


For new builds, prefabricated facilities represent an emerging solution. These modular, facility-sized solutions allow organizations to bring new capacity online faster and can be easily scaled. Prefabricated methods design the growth plan into the solution from the beginning.

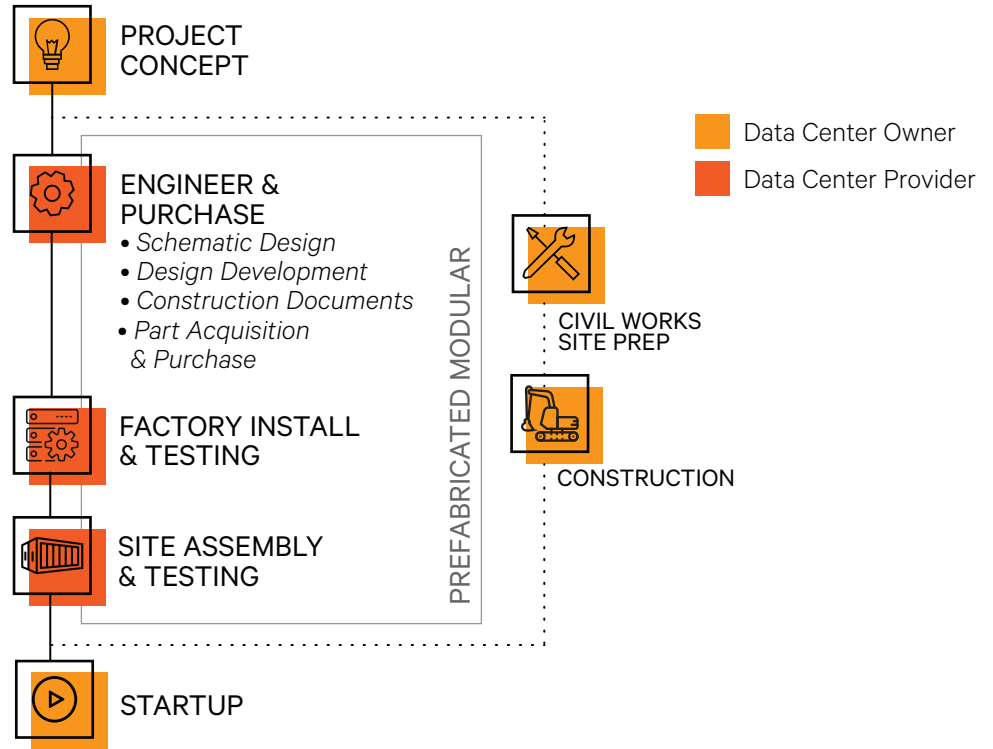
A PFM data center is custom designed to match the geography, climate, technology profile, IT applications, and business objectives of a project while taking advantage of the speed and economy of modular design and pre-fabrication.

Modular integration techniques combined with the off-site prefabrication process results in a state-of-the-art, tightly integrated facility deployed faster and at an overall lower cost than a similar facility using traditional construction practices.

Traditional New Build



Prefabricated Modular New Build



For augmentation of conventional facilities, PFM units can be deployed to add additional power (UPS) or cooling capacity to a new or existing site that may have sufficient whitespace but that are constrained from a thermal or resiliency perspective.

A specific example of this technology in action is Vertiv's Power Module product family. The Power Module design is for deployment in new or existing facilities that require an agile and flexible way to scale-up power distribution and resiliency.

At new sites it allows the data center operator to deploy critical power infrastructure in a pre-packaged way, independent from other construction activities. For existing facilities, the module deploys outside the facility without taking up expensive floor-space that could otherwise be used for IT equipment. Operators can also utilize the module in a site architecture that is hot scalable – meaning you can add capacity to the site by simply adding additional units, without taking the critical loads offline.

For expansion beyond the core data center, PFM units come in various shapes and sizes, but come fully self-contained and, in some cases, ready-to-order. The all-in-one data center generally includes IT cabinets, power distribution, and uninterruptible power supplies (UPS) with batteries and direct expansion cooling.

This 'plug and play' approach has the benefit of not only cutting the time for startup and commissioning – to just a few days instead of weeks or months – but also reducing the potential for quality issues as components are pre-integrated and pre-tested off-site. The pre-engineered and integrated design also provides greater cost-certainty for customers by reducing the likelihood of additional on-site modifications. The ability to enable on-site assembly rather than build and integration allows the data center to push closer to businesses and consumers in previously inaccessible locations.



Rapid Design

Tailored Integration

Simplistic Assembly

Benefits:

Efficient

Low Risk

Cost Certain

Scalable

Repeatable

High quality control

Extended geographic reach

Rapid Design

Simplistic, repeatable, subsystem building blocks create an efficient, automated, and low-risk design process.

Leveraging repeatable subsystem building block designs enables simplicity, resulting in an efficient, automated, and low-risk design process. Mass-customized MEP designs are uniquely constructible, easy to operate and low cost using a system that utilizes a repetitive and standardized modular approach.

This efficiency on the front end of the process can cut months off the time-to-deploy, and organizations seeking to accelerate data center deployment should strongly consider it as an option.

Also, the standard set of building blocks remove inherent limitations in terms of functionality or aesthetics.



HANTHAWADDY DATA CENTER (KSGM)

This full design new build was a two story, Tier 2 compliant modular data center, but the location façade had to meet strict requirements for city code. PFM allowed the aesthetics to be adjusted to meet the customer demands.

Tailored Integration

Complex mechanical & electrical integration activities are completed at the factory to maintain quality and velocity.

Highly complex mechanical & electrical integration activities are offloaded to the factory where quality and velocity can be maintained. All systems are designed and configured in concert, resulting in a tightly integrated facility that can meet the highest standards of availability and efficiency. Assembly in a factory-controlled environment enables more control over the fit, finish, and quality of workmanship, and supports more thorough pre-testing and optimization before delivery.

Simplistic Assembly

Clear documentation and a dedicated team of engineers enables on-site teams to assemble factory-integrated modules easily in a variety of locations.

Concise and clear site documentation provides on-site teams with essential information needed to assemble modules effortlessly. The focus on assembly rather than build and integration dramatically reduces complexity as well as the risk of malfunctioning or poorly configured system deployment. Barrier-free assembly allows deployment across a global estate, without needing highly skilled and experienced local construction crews at each location. This opens up opportunities to extend global reach to regions of the world previously thought unavailable.

PFM continues to rise to the top with overall risk reduction through better quality controls, repeatable results, and streamlined project management.



Customer quote: "The modular design gives us increased flexibility and scalability for future investment, while immediately offering an array of benefits for our customers," says Núria Berché, Program Manager at T-Systems Iberia.

LINK TO T-Systems case study:

www.vertiv.com/globalassets/products/facilities-enclosures-and-racks/integrated-solutions/t-systems-case-study-english.pdf

Examples of PFM Success

Dimension Data

The burgeoning growth of data-enabled businesses across the developing markets of Africa has led to an explosion of data center demand closer to users. It is no longer economical to serve these customers from hubs located thousands of kilometers from where the information is produced and consumed. For this reason, Internet Solutions, with their partner Dimension Data made the decision to expand its data center footprint in the increasingly connected center of African commerce, Johannesburg. However, the key challenge in this market is to build a highly reliable, world-class facility in a way that offers future flexibility and enhanced performance.

Internet Solutions and Dimension Data turned to Vertiv to deliver a high-quality prefabricated modular Tier III compliant data center system for their Parklands facility. The solution consists of 120 racks with expansion to up to 286 racks and built around industry-leading Vertiv power (including the Liebert® Trinergy™ Cube UPS) and thermal management technologies (including room cooling, and SmartAisle containment and control), as well as advanced Lithium Ion batteries for reduced operational expenses. Designed to accommodate ocean shipment, the facility was prefabricated, integrated, and tested in Vertiv's European facility. It was then disassembled into 12 shippable units, packed for transport, and made the journey to South Africa, where it was reassembled on site and ready for testing in under six weeks.

www.vertiv.com/globalassets/documents/case-studies/dimension-data/vertiv-dimension-data-case-study-cs-en-na-ch-00084-web_270338_0.pdf

T-Systems

Following its strategic vision to provide cloud services, T-Systems' need for data center expansion became paramount. To fulfill the company's expectations and meet their clients' business cases, a combination of requirements needed to be achieved for availability, reliability, security, scalability, transparency, efficiency and sustainability - plus a rapid deployment. Expanding or building a traditional data center in a short timeframe can be a great challenge which requires significant resources. After a thorough analysis, a modular, containerized construction proved to be the ideal option to achieve rapid availability and high scalability successfully, quickly allowing for future phases of expansion as well as a staged investment. For more see:

<https://www.vertiv.com/globalassets/products/facilities-enclosures-and-racks/integrated-solutions/t-systems-case-study-english.pdf>

Mobile Disaster Recovery Unit

A leading provider of satellite-based communications systems needed a mobile disaster recovery unit to support its terrestrial network in the event of a fixed facility failure. Never knowing when and where a disaster might occur, this company required that the mobile backup unit be easy to transport and maintain, and designed to operate in extreme environments. Specializing in critical technologies that always work, Vertiv created a custom trailer-mounted SmartMod™ solution with an internal sliding rail system for easy access to keep their backup system always ready. The trailer solution offers a quick-connect system for power and signal, as well as DX-based condensers mounted on the trailer. It delivered a backup infrastructure with a constant "ready for service" state that exceeded the communication company's needs. Our SmartMod is a modular, customized data center enclosure. It is a fully integrated, self-contained, rapidly deployable system that's adaptable, flexible, and efficient. The compact nature of the SmartMod allows for easy transportation without compromising functionality or long-term value. For more see:

www.vertiv.com/globalassets/documents/case-studies/na_communication_provider_case_study_252412_0.pdf

Household Product Manufacturer

A leading household product manufacturer needed to add a new data center to its facility to support critical production applications. Due to the nature of its production facility, the company required a data center to optimize space as well as tolerate a dusty manufacturing environment, which can be hostile to computing systems. They needed to increase their mission-critical capacity while protecting the new data center. They chose Vertiv. Working with its electrical contractor partner, we helped by providing turn-key delivery for a local, yet separate data center facility built around Vertiv's compact and powerful SmartMod™ infrastructure. Ensuring that critical technologies always work, the SmartMod is a modular IT infrastructure solution in the form of a customized data center enclosure. It is a fully integrated, self-contained, rapidly deployable unit that is easy to relocate and architected to support organizations for years to come. For more see:

www.vertiv.com/globalassets/documents/case-studies/household_product_manufacturer_case_study_252410_0.pdf

Conclusion

Prefabricated modular data centers are the technology to help combat future challenges the data center industry faces to build out efficient, agile and globally consistent capacity from the core to the edge. As established practices and dated proclivities are increasingly compared with PFM - driven by new core and edge demand - modular and prefabricated approaches will only gain more traction; possibly even so much that PFM becomes the default approach and operators will need to come up with a compelling business case for not adopting it. For more about Vertiv's PFM approaches check out:

<https://www.vertiv.com/en-us/solutions/>

<https://www.vertiv.com/en-emea/solutions/>

<https://www.vertiv.com/en-asia/solutions/>



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