Critical Data Center Design Decisions

Planning to build a new data center?

One of the first and most critical decisions you'll need to make is how to distribute services such as cabling, power wiring, liquid-cooled piping and air. Learn how the Interstitial's electro-mechanical distribution system follows best practices, is code compliant, safe and provides a level of sustainability second to none.

Sustainability Begins with Building a Lifelong Structure

A purpose-built data center is risky—who has a crystal ball to know the ultimate and Life-Long needs? The best design is one that is readily adaptable for air cooling, rear-door heat exchangers, direct to chip cold plates, immersion or any combination thereof—a genuine hybrid.

Sustainability is furthered by building a right size data center. Too often data centers, especially on-slab flooded ones are significantly larger than need be due to the selection of poor distribution methods.

Effective distribution of cooling methods plays a significant role in energy efficiency. When all server fans have the correct volume of air the server energy is in accordance with name plate specifications. However, if server fans are compelled to work harder to draw air into the servers the energy consumption of the server can be increased by 40 %, wich waste energy and distorts PUEs.

Current Design Methods

Conventional raised floor seemed like an effective way to distribute cooling and wires in the 1960's when heat loads were minimal and cooling was a combination of air and liquid. But, with today's intensified cooling demands, running electrical, data, air and cooling liquid all in one plenum simply doesn't work.

The most common alternative to raised floor designs are the two variations of the on-slab design. In both, the room is flooded with cold air, containment is used to separate the supply air from the return air, cabinets sit on the slab, and wires are run overhead. While the Flooded Room approach is an improvement in air and cable distribution over traditional raised floor design, the trade-offs to make it work are considerable. It consumes too much floor space, it isn't easily reconfigured, isn't adaptable for liquid cooling methods, and it doesn't allow for efficient operation of the air cooling system. Varying cabinet kW densities within an aisle of cabinets have to be sub-cooled to the warmest cabinet. A/C fan limitations limit the length of cabinet runs. Having to run all power and structured cabling overhead has a 25% cost premium, poses a risk for operations staff having to work from ladders and interferes with air return, sprinklers and lighting.

Hot or cold aisle containment is necessary for the function of the mechanical system. Containment is costly and burdensome. It makes the placement of light fixtures, sprinklers and smoke detector infrastructure problematic. Any reconfiguration of cabinets has a domino effect resulting in these infrastructure elements possibly having to be reconfigured.

Those trade-offs require further design considerations, cause significant compromises in sustainability, operations, adaptability and impose substantial short and long-term costs.

Critical Data Center Design Decisions Comparative Checklist

It may come as a surprise, but in addition to choosing a cooling method (e.g., air, rear door heat exchangers, direct to chip cold plates, or immersion). One of the first and most critical decisions you'll have to make, is how to distribute mechanical and electrical services to the cabinets. What you choose will affect your operational procedures and the effectiveness of the facility over a lifetime. This easy-to-use chart is a side-by-side comparison of the importance of each line in relation of one methodology over another. An in-depth review of each line item is available upon request.

A comparative list of essential design elements

Compare between 4 different data center design methods and check the items that you find to be important features for your next data center.

To know which is best for your situation, you need to take a realistic approach as there are often trade-offs when it comes to improving airflow, and the distribution of liquid cooling, power and cables effectively with traditional design practices.

Below are 28 critical architectural, mechanical, electrical and structural infrastructure features that are compared between 4 data center designs. As is often the case, the best design seeks a balance across all those features. The 28 items were chosen as they directly impact speed, reliability, flexibility, agility, and initial as well as ongoing operating costs in a significant way.

1- Raised floor with overhead wiring

The long-used conventional single-level raised floor approach to conceal wires pipes and provide limited air delivery all in a single plenum.

2- On-slab flooded room—cooling from perimeter

The more recently evolved on-slab approach, flooding the room with cold air entering the space horizontally from the perimeter of the room requires containment, and overhead power and cabling.

3- On-slab flooded room—cooling from rooftop

The on-slab approach with air entering the cold aisle from the rooftop by means of downwardly extending ducts into cold aisle containment with overhead power and cabling.

4- Interstitial—electro-mechanical distribution system

Interstitial is a 2-tier distribution system—separating pressurized air from piping and wiring for effective and efficient distribution of services.

		Raised floor with overhead Wiring	✓	On-slab flooded room cooling from perimeter	✓	On-slab flooded room cooling from rooftop	✓	Interstitial	✓
	Architectural								
1	**Optimization of the building design & floor space** Space is gold and cabinets are diamonds	Consumes valuable floor space because of A/C equipment placement and distribution limitations	☐	Consumes valuable floor space because of cooling equipment and distribution limitations	☐	Consumes valuable floor space because of cooling equipment size, and placement	☐	Optimizes floor space: Can reduce white space by 30%, or increase cabinet quantity by 40%	☐
2	**Building heights** Higher buildings are more cubic footage to build and operate	More height required for floor, overhead power, cable tray spacing and return air	☐	More height required for overhead power, cable tray spacing and return air	☐	More height required for overhead ductwork, power, cable tray spacing and return air	☐	Can reduce building height by 20% with effective underfloor air and wire distribution	☐
3	**Cabinets installed per row** Row length can be limited by air throw and A/C equipment	12-24" Cabinets 9-30" Cabinets	☐	15-24" Cabinets 13-30" Cabinets	☐	24-32" related to the size of rooftop cooling unit	☐	94-24" Cabinets 75-30" Cabinets	☐
4	**Flexibility/adaptability MAC** Moves, adds and changes of cabinets are inevitable	Containment complicates flexibility because it can involve sprinklers, smoke detectors and lighting	☐	Containment complicates flexibility because it can involve sprinklers, smoke detectors and lighting	☐	Moving cabinets is limited to the placement of the rooftop cooling equipment	☐	Simple changes for air, piping, power and wiring. There's no containment or need to work from ladders	☐
5	**Deployment time** The quicker the better...	Longer construction because of containment and overhead wiring installation	☐	Longer construction because of containment and overhead wiring installation	☐	Longer construction because of containment and overhead wiring installation	☐	Faster construction, because of less trade interference	☐
6	**Build out only the space to be used** Finish the space as you go	Yes	☐	Yes	☐	Yes	☐	Yes	☐
7	**Design engineering time** The faster the space is designed the quicker the deployment begins	Complicated because of air distribution limitations and poor performance	☐	Complicated because of coordination with containment, sprinklers, detection, lighting cable trays, piping and air flow	☐	Complicated duct design and coordination with containment, sprinklers, lighting, detectors, cable tray and piping	☐	Less design time because of predictable airflow and no interference with sprinklers, detectors, lighting, cable trays or hoses	☐
8	**Sustainability** Right sizing the space and the materials within the space	Larger footprint, more cooling equipment, wasted energy	☐	Larger footprint, more cooling equipment, wasted energy and shorter building life-span	☐	Larger footprint, more cooling equipment, wasted energy and shorter building lifespan	☐	Smaller footprint, less cu. ft. less A/C, and related materials saves energy, is readily adaptable for life changes	☐

		Raised floor with overhead Wiring	✓	On-slab flooded room cooling from perimeter	✓	On-slab flooded room cooling from rooftop	✓	Interstitial's	✓
	Mechanical								
9	**Precision air distribution method** There's little value in having precision cooling equipment unless there's a precision means of delivering that cooling	The floor leaks air is cluttered with pipes and wires. It's not a pressure plenum resulting in low static pressure	☐	Flooding the room is an inefficient means of distribution resulting in server fans working harder wasting energy, and resulting in a skewed PUE	☐	Flooding the aisle is better controlled when ducted from overhead into cold aisle containment	☐	Precise air delivery to the top of each and every cabinet anywhere in the entire room	☐
10	**Effective cooling of servers** Cooling servers is costly... even more costly when they aren't cooled effectively	Low static pressure generally won't cool more than the lower third to half of the cabinets	☐	32% of server fans work harder in an aisle with 9 kW cabinets, therefore, resulting in a distorted PUE	☐	The entire aisle must be cooled to the highest kW cabinet regardless of surrounding cabinets	☐	All servers have the required airflow throughout the entire room	☐
11	**Containment hot or cold aisle** Containing the hot and cold air from one another	Generally used attempting to get some energy benefits	☐	Hot and/or cold aisle is mandatory & costly	☐	Generally cold aisle which is mandatory & costly	☐	Not required.	☐
12	**A/C redundancy** Uptime is critical and downtime a catastrophe	A/C units are zone limited. 25-30% more units required for effective redundancy	☐	Requires 20-25% more cooling units attempting to achieve limited redundancy	☐	No effective redundancy because each rooftop cooling unit is dedicated to the specific aisles they feed	☐	Effective N+1 using mixing box technology	☐
13	**Adaptable for water-based cooling** The flexibility to add refrigerant lines for the addition of chilled water and/or immersion cooling	The underfloor plenum is ideal, however, pipe accumulation & access to plenum will affect airflow	☐	Overhead piping not acceptable per NFPA	☐	Overhead piping not acceptable per NFPA	☐	Simple underfloor install in the upper utility level and does not affect airflow when accessing	☐
14	**Venturi effect for some cabinets** A negative pressure in aisles requires special planning	The first airflow panel must be 8'-0" from the A/C Unit	☐	The distance from the A/C equip. to first cabinet & aisle widths must be wider than is necessary	☐	Effect for some of the top servers because of high velocity air entering the aisle	☐	There is no meaningful Venturi effect	☐
15	**Typical cabinet kW density**	≈5 kW	☐	≈8-12 kW	☐	Generally, ≈8-12 depending on cooling unit	☐	Up to 50 kW with a 4'-0" cold aisle	☐
16	**Varying cabinet kW density within a row**	Variable at each cabinet, but only the lower third to half of cabinet	☐	Must cool entire aisle to the highest cabinet kW in the aisle	☐	Must cool entire aisle to the highest cabinet kW in the aisle	☐	Variable control for ea. cabinet anywhere in the aisle	☐
17	**Dampered airflow control**	Yes	☐	No control of airflow	☐	Control of airflow to aisle only	☐	Opposed blade damper control at each cabinet	☐

		Raised floor with overhead Wiring	✓	On-slab flooded room cooling from perimeter	✓	On-slab flooded room cooling from rooftop	✓	Interstitial	✓
	Electrical								
18	**Power distribution** Power cables are a reliable means for distributing power	Overhead or underfloor, however, underfloor will obstruct airflow	☐	Overhead only, which requires higher ceilings and roof reinforcement	☐	Overhead only, which requires higher ceilings and roof reinforcement	☐	Faster install underfloor. Ex: Power cables for 232 cabinets were installed in one day	☐
19	**Use of busway** Busway is an alternative to power cables	Yes Can be underfloor if not an air plenum	☐	Yes Overhead only, more costly and restrictive than power cables	☐	Yes Overhead only, more costly and restrictive than power cables	☐	Yes Overhead or underfloor	☐
20	**Structured cable distribution** The method of distribution will affect operational efficiency	Overhead or underfloor Must use plenum rated wiring if in air plenum. Underfloor tray spacing 6" per TIA 942	☐	Overhead only. Cable tray spacing 12" per TIA 942	☐	Overhead only. Cable tray spacing 12" per TIA 942	☐	Overhead or underfloor. Underfloor easier to install and maintain—no ladders	☐
21	**Overhead distribution** Is costly, and burdensome when overhead	There is a 25-30% premium for power & cables—if overhead	☐	There is a 25-30% premium for power & cables	☐	There is a 25-30% premium for power & cables	☐	Underfloor installation in the utility plenum is least expensive	☐
22	**Grounding/bonding** It's imperative to have an effective grounding means	Yes, every other pedestal in every other row	☐	No built-in bonding system, requires bonding of all trays	☐	No built-in bonding system, requires bonding of all trays	☐	The system only requires 1 bonding point. per 200 lineal feet in either direction	☐
23	**Floor finish—anti- static** Protecting against ESD in a data center is critical	Yes, the surface material dissipates the ESD to ground	☐	No effective static control	☐	No effective static control	☐	Yes, the surface material dissipates the ESD to ground	☐
24	**Zero signal reference system (SRS)** EMI hardening can prove to be invaluable	Available using a special copper grid	☐	None	☐	None	☐	Yes, it's a built-in signal reference structure (SRS)	☐
25	**Gasketed cutouts for cable openings**	Required in floor to minimize air leakage	☐	Yes, in top of cabinet to minimize air loss	☐	Yes, in top of cabinet to minimize air loss	☐	Not required anywhere	☐

		Raised floor with overhead Wiring	✓	On-slab flooded room cooling from perimeter	✓	On-slab flooded room cooling from rooftop	✓	Interstitial	✓
	Structural								
26	**Slab Loading** Design approach could drive thicker slab than necessary	312 # per sf for 2,500 # Cabinets 24"x48"	☐	312 # per sf for 2,500 # Cabinets 24"x48"	☐	312 # per sf for 2,500 # Cabinets 24"x48"	☐	189 # per sf for 2,500 # Cabinets 24"x48"	☐
27	**Roof Reinforcement** Overhead wire distribution requires additional support, cost and building height	Mandatory	☐	Mandatory	☐	Mandatory, significant and costly to also support A/C equipment	☐	Not required	☐
28	**Seismic Requirements** Mandatory in applicable zones	Requires special bracing of the understructure	☐	Complicated because of bracing interference with containment	☐	Complicated because of bracing interference with containment	☐	This is built into the system for anywhere in N. America	☐

The Interstitial Solution

Designing and operating a data center should be clean and simple. In a functioning effective and efficient room complications, obstructions and restrictions just aren't necessary when there's a simple, logical and sustainable solution.

Hands down, the more modern Interstitial 2-tier electro-mechanical distribution system provides the most efficient use of data center floor space permitting the greatest cabinet densities, as compared to any other design choice available today. It provides ideal, consistent, adjustable air, pipe, wire and cable distribution, along with flexibility and user-friendliness for the life of the data center.

Interstitial is a system designed to sustain the constantly changing needs of the customer in the most user-friendly way—it's not just a day one system—it's a life-long building system. Interstitial does not require expensive trade-offs, and presents no design complications. With Interstitial you don't have to make compromises. All of the listed parameters in the check list prove no other approach can compare to the sustainability, reliability, effectiveness, efficiency, and the ROI available with Interstitial.

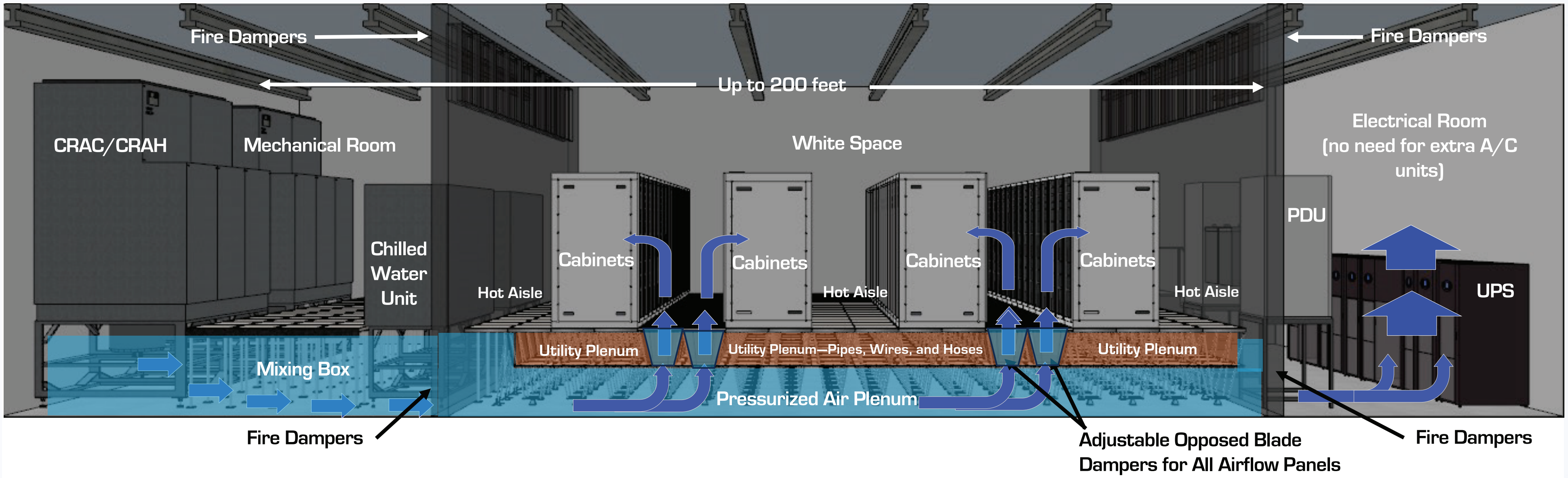
Data center design using Interstital

Interstitial allows all AC units to be on a common header in a single mechanical room The dedicated pressure plenum means air travels much further and is a precise delivery system to the servers. Power, piping and data in the upper utility plenum is a simple, safe install.

Build the right size data center, up to 30% smaller than a flooded room design that is easily adaptable to all cooling methods (e.g., a hybrid air and/or liquid or a purpose built Next-Gen data center. No one would seriously argue with the proposition that a sustainable, energy efficient, flexible, adaptable space that meets best practices and conforms to building standards is a preferred design.

A simple example:

Section drawing demonstrates one of many ways to design a room using Interstitial



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