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COMMISSIONING DATA CENTER ICT CABLING

Getting It Right the First Time

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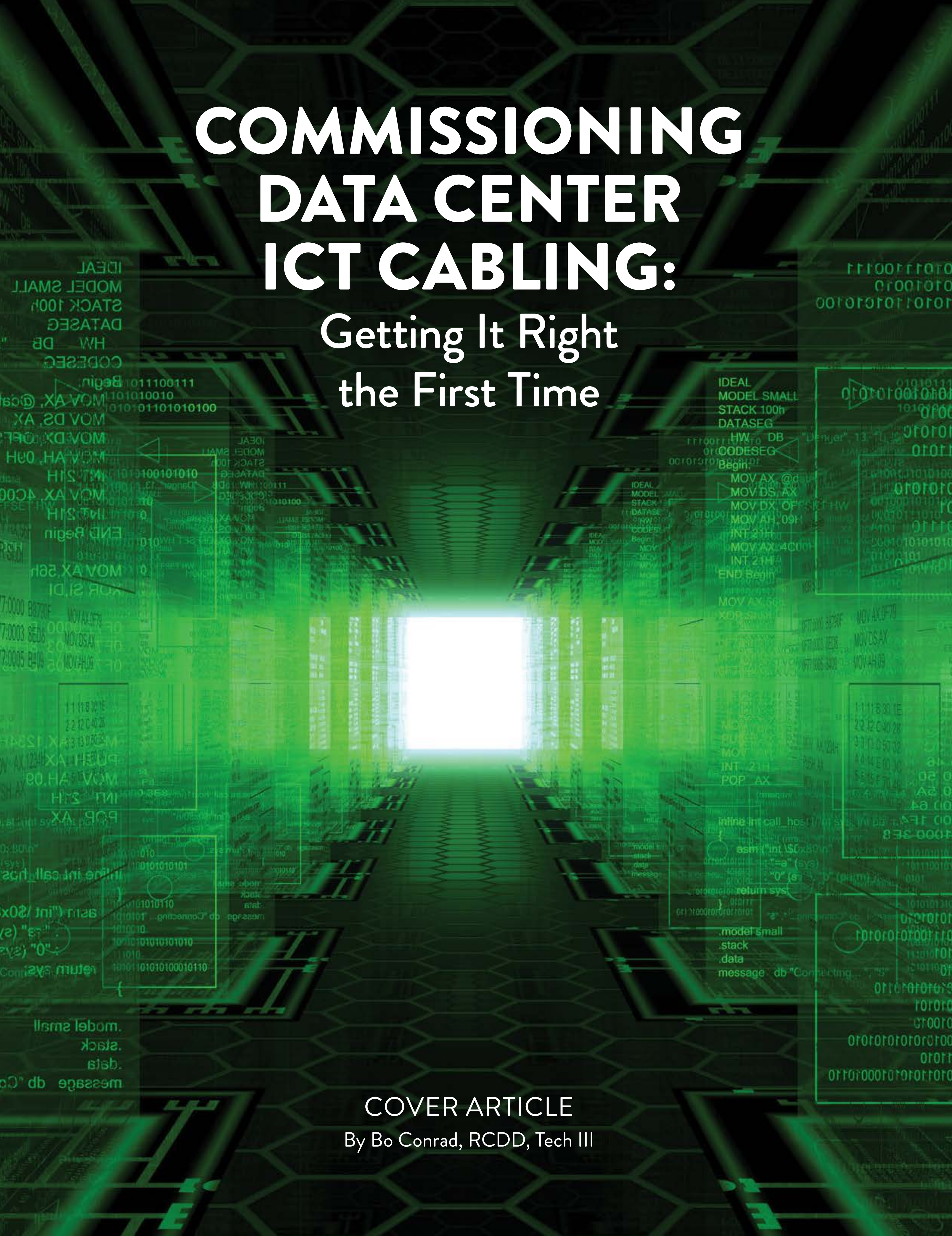


COMMISSIONING DATA CENTER ICT CABLING:

Getting It Right the First Time

COVER ARTICLE

By Bo Conrad, RCDD, Tech III

Most everyone has seen and heard many insurance commercials' common theme of "saving money" with tailored coverage. Data center commissioning can be considered in a similar context, but more as a quality assurance (QA) policy. Data centers are mission critical to business operations and cybersecurity, and they need to have end-to-end operational fulfillment through all stages of project delivery.

The primary focus of commissioning is how it affects the client as the data center end user. Greater efficiency reduces project and operating costs, giving the client a positive return on investment (ROI) throughout the life cycle of the data center's operations.

FIGURE 1: Shown is a data center under construction and the data center's "white space."

COMMISSIONING TERMS

The practice of commissioning a data center project has been evolving for over 25 years. Given the different disciplines in the construction of a data center (Figure 1), commissioning has common themes and definitions. Commissioning is critical in all aspects of the data center design/build plan. This article focuses primarily on the ICT cabling piece of this complicated puzzle.

The commissioning plan describes all aspects of the commission process. The plan defines the guiding principles detailing schedules, defined responsibilities, full and accurate test documentation, and functional performance guidelines.

Furthermore, commissioning identifies potential issues before they become a problem. The realized benefits of commissioning include less repairs, fewer moves, adds and changes (MACs), and unplanned downtime prevention. It is soon recognized that liability costs and the resulting damage to a business reputation far outweigh the costs associated with a comprehensive commissioning plan.

DATA CENTER CLASSIFICATIONS

Data centers are defined into five classes per the BICSI non-profit standards body:

- **Class-0** (no redundancies, no backup power)
- **Class-1** (no redundancies to protect IT load from failure)
- **Class-2** (component level redundancy in key systems)
- **Class-3** (concurrently maintainable)
- **Class-4** (fault tolerant to most events, except for severe building damage/destruction)

The Telecommunication Industry Association (TIA) non-profit standards body uses Rated 1-4 criteria to define data centers, while the Uptime Institute, a for-profit commercial organization, uses proprietary Tiers I-IV.

Data center definitions, based upon "uptime" or "availability" and derived from TIA and Uptime Institute formulas, indicate (as does BICSI) that the higher the number the better. Per TIA and the Uptime Institute, a Rated-1 or Tier-I data center has a minimal 99.671 percent uptime and 28.8 hours of downtime per year. Rated-3 or Tier III is a data center with 99.982 percent uptime and no more than 1.6 hours of downtime annually; and one Rated-4 or Tier IV has 99.995 percent uptime and 26.3 minutes of annual downtime, approaching a similar result to that of BICSI's Class-4 fault tolerance.

What happens when a backhoe accidentally digs up an OSP backbone? Or when a contractor inside the facility or in a shared manhole damages the conduit system cable or connections while installing another's cables? Mayhem can happen.

Critical facility power and cooling, as well as backup systems, are always a requirement, but a defined ICT cabling infrastructure commissioning plan is often overlooked until reaching the higher Classes, Ratings, or Tiers. This can be attributed to newer buildings having higher-tech equipment, fuller redundancy in all power and cooling services, as well as incorporating into the design a more secure and redundant ICT cabling infrastructure.

Downtime is a data center owner's worst fear, but it means little to the people and businesses it does not affect; that is, until it happens. Is it mission-critical? Consider the recent crashes with Wells Fargo financial services, Southwest's operations centers, Apple's iCloud music, and Google's Gmail? What is the customer's opinion of the company now?

When people do not hear about a cloud service's mayhem failure, this can be attributed to a proper dynamic commissioning plan at work! In case of an unscheduled downtime, a proper commissioning process should contain this same accountability and preparation for immediate resolution.

PLAYING BY THE RULES: THE COMMISSIONING GUIDELINES

The commissioning plan guidelines are the foundation for a data center's "Commissioning 5-Phase (Test) Process" from inception to turnover and includes:

1. Program or Pre-design Phase
2. Design or Planning Phase
3. Construction or Build Phase
4. Acceptance Phase
5. Post Acceptance Phase

Typically, the client or "end user" of the data center white space hires either a commissioning authority (CxA) or commissioning agent. This can be a person, company, or agency that plans, coordinates, and oversees the entire commissioning process.

Commissioning agents have legal authority and direct control over decisions. Alternatively the commissioning authority is more advisory, providing professional guidance and recommendations to the client who makes the decisions. When limited to a specialized discipline, such as cabling infrastructure, an ICT consultant may be a preferred choice.

The ICT consultant or the commissioning team should be comprised of experienced and certified subject matter expert (SME) project managers having engineering, tech support, and CAD support staff. The culture should be one that creates a cohesive environment between the end user's commissioning stakeholders.

The commissioning plan commonly encompasses the many disciplines as covered in the ANSI/BICSI 002-2014 *Data Center Design and Implementation Best Practices* standard and listed in Table 1.

Electrical power and backup	Fuel/oil containment and pumping systems
HVAC and computer room air conditioning (CRAC)	Inventory monitoring systems
BAS control systems	Lead detection
Fire protection and suppression	Grounding and bonding
Security	IT infrastructure

TABLE 1: The disciplines in a commissioning plan according to ANSI/BICSI 002.

Further discussion of the five commissioning plan phases specifically addresses the data center ICT cabling infrastructure. To help identify specific tasks involved in the commissioning process a 👉 symbol is used.

Within the phases (Figure 2) are the industry-recognized 5-stage "commissioning test" processes that are used for carrying out the inspection-testing procedures applicable to each phase of the commissioning plan:

- **First Stage:** Factory Witness Testing
- **Second Stage:** Site Acceptance Inspection
- **Third Stage:** Pre-Functional Testing
- **Fourth Stage:** Functional Performance Testing
- **Fifth Stage:** Integrated Systems Testing

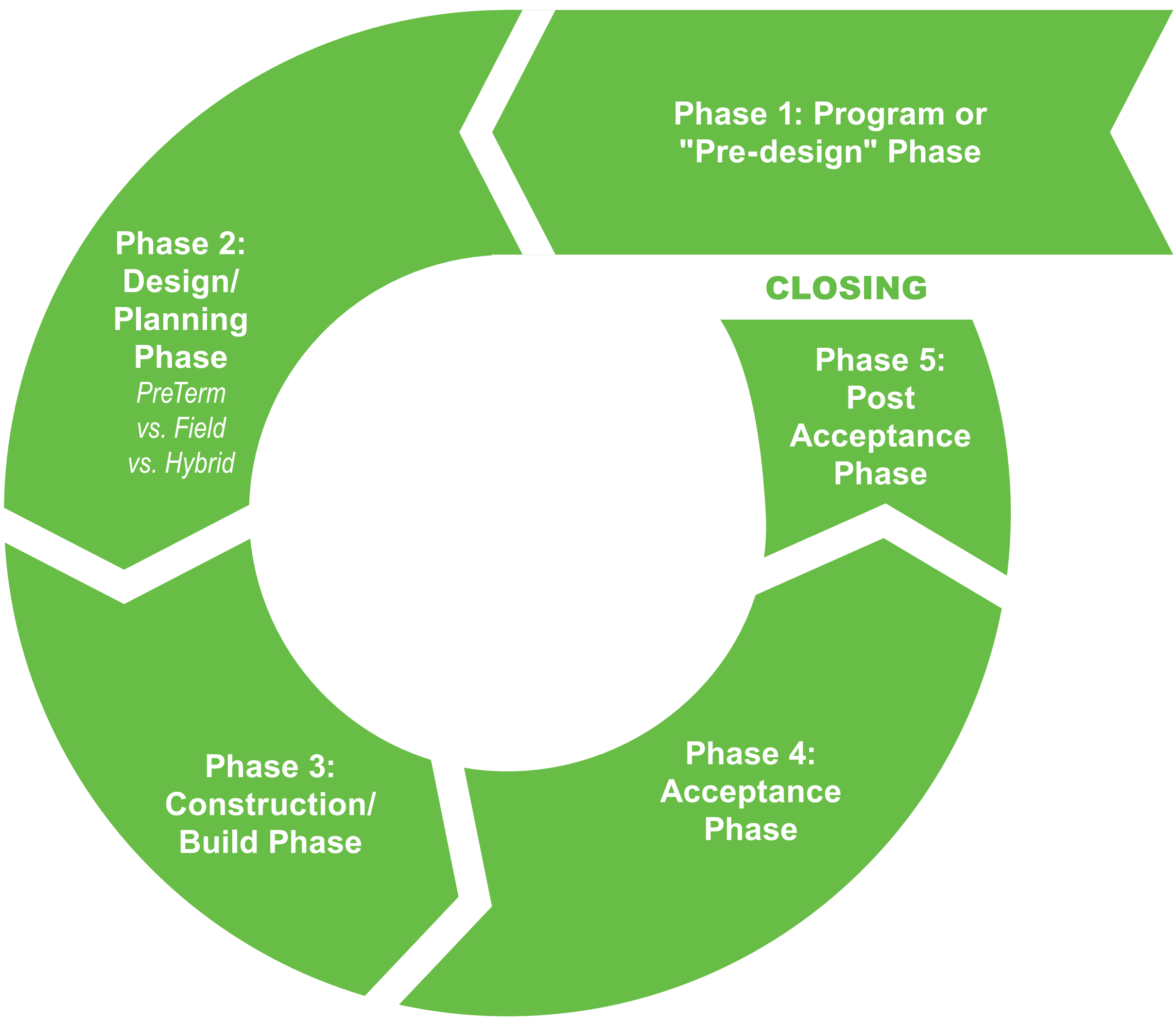


FIGURE 2: The five commissioning phases.

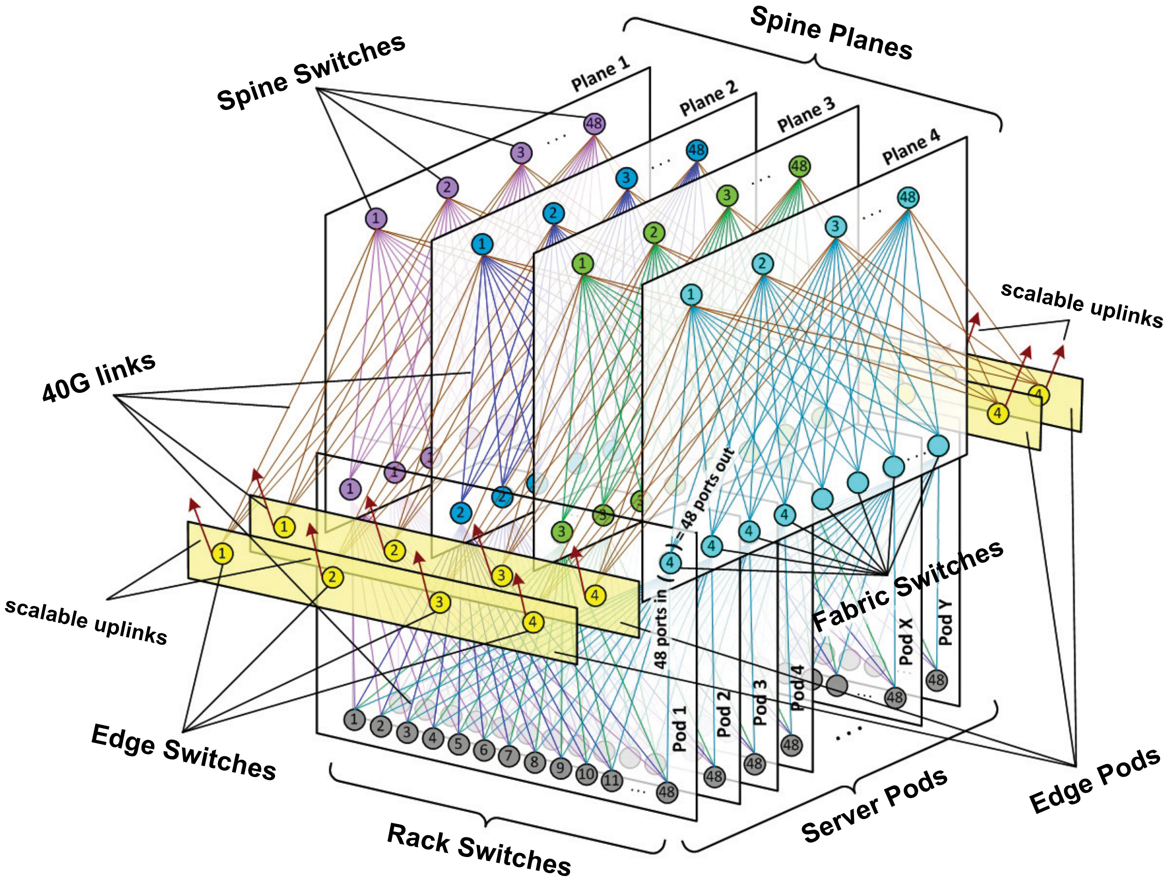


FIGURE 3: Logical 3-layered architecture topology.

Phase 1: Program or Pre-design Phase

The program phase establishes the foundation or the vision for the next four phases to develop the scope of work (SOW) content, strategies and schedules. Furthermore, it is also the phase that identifies the ICT cabling infrastructure bill of materials (BOM) and the technologies to be commissioned.

The client begins the process by selecting and assembling a commissioning team. The team's assignment is to compile the project expectations, guidelines, and objectives into a formalized owner's project requirements (OPR) document. As the project progresses, the ICT consultant contributes ongoing documentation to the OPR of the CxA or the agent's team.

👉 The first step in commissioning the ICT cabling infrastructure is for the ICT consultant to meet with the client's operations stakeholders. Together, they conceptualize the logical 3-layered (Figure 3) architecture (lower 3 ISO layers) inclusive of network, server, and storage requirements.

Each segment or layer of this design requires a combination of a supporting media solution, such as optical fiber and copper, tailored to the logical layer processing and bandwidth requirements.

Subsequently, the ICT consultant engineers a supporting media diagram (Figure 4) connecting the devices in a logical design concept: wide area network (WAN), edge to spine switches, servers, and all scalable links to the performance optimized data centers (PODs). Take note of the ICT cabling infrastructure's mesh redundancy that is necessary to reduce any possibility of downtime related to cabling failure.

The next consideration is determining the cabling/connector performance and bandwidth requirements that are needed to support the client's stakeholder's network, server and storage optic processing requirements. The demand rate for higher fiber count with a low profile is rising exponentially, as are wave division multiplexing (WDM) and dense WDM (DWDM) technologies. Budget consideration must also be an underlying factor.

One of the critical questions in the pre-design phase of commissioning is whether the ICT cabling infrastructure concept was designed for the long-term. Will it allow for the future growth and high demands of the Internet of Things (IoT)?

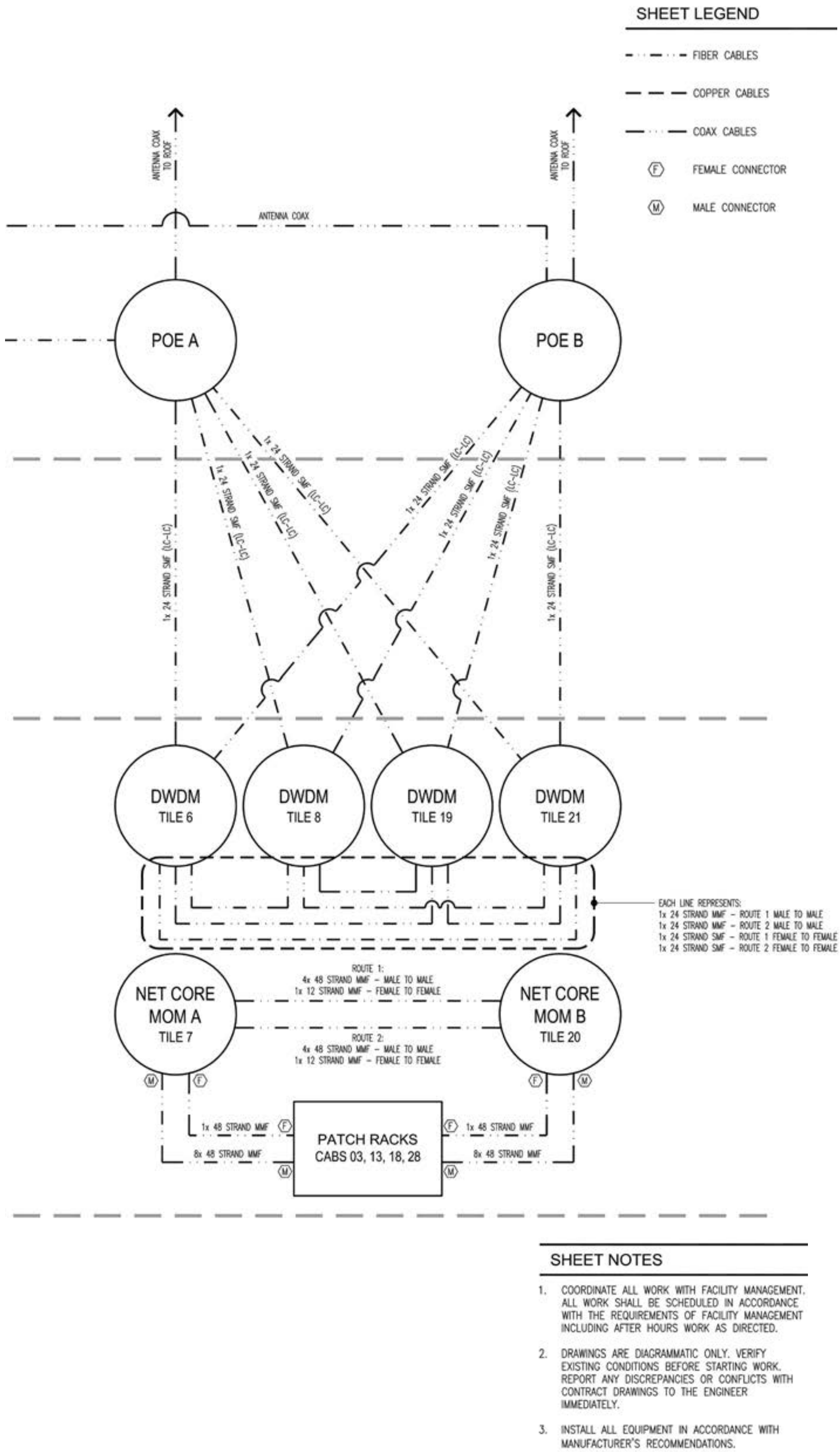
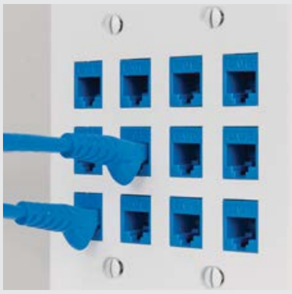


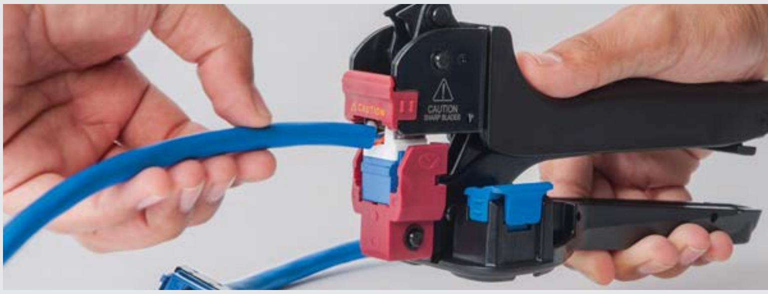
FIGURE 4: An example of a cable media diagram connecting the segments from the 3-layer architecture topology.

Expensive = Higher Quality,

...Right?

Wrong!





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Phase 2: Design/ Planning Phase

The cabling plant design phase must be able to "fit-for-purpose" the ICT requirements as specified in the program/pre-design stage.

The first step in this second phase is an architectural review of the campus, buildings, service entries, and the "white space" room. Focus is on the ICT cabling infrastructure design considerations and identifying any issues and concerns. Specifically, is there security and redundancy in the pathways? Does the cables' jacketing comply with environmental conditions, local codes and best practice industry standards?

Will there be an inter-building cable run through manholes between buildings for outside plant (OSP) pathways into the building's fiber equipment room (FER) or main point of entry (MPOE) or point of penetration (POP)? Accordingly, the cabling must be OSP-rated and have its own dedicated (not shared), secured, and redundant conduit pathways.

Data center room pathways are commonly routed in a hierarchical fashion as follows:

- The meet me room (MMR) is where the service providers house their equipment and cable connectivity to the outside world.
- From the MMR, direct underfloor/underground 4" conduits, as well as overhead pathways (tray and conduit), are routed to the multiple points of entry (POEs).
- In turn, each of these POEs has a mesh redundancy pathway routed to each POD.

Who will have access to the conduits and the more susceptible overhead pathways? Are the cable runs redundant as to not share the same pathway(s)? Will it require conduit or armored cable between the POEs and POD(s)? Always assume that water will migrate into underground conduits, even within innerduct. Consequently, this intra-building cable should also have an indoor-outdoor (I/O) rating, or it should be armored. Be cautious as raised floors may also be classified as a plenum environment.

Another critical aspect in this phase of design is choosing when it is practical to specify preterminated versus hybrid cable assemblies both for optical fiber and copper. Successively, the design parameters and proper testing of interfacing the two with field terminations should be addressed for QA considerations.

The culture of maintaining open and informative communication with all stakeholders of the commissioning team members is essential to meeting the project's objectives.

The ICT consultant now creates a design package that outlines all details associated with a data hall fit-out. This package includes design drawings (such as that shown in Figure 5), SOW, BOM, project schedule and full commissioning requirements.

The applicable documentation then goes out through a bidding process via the client to certified installation companies. Qualified vendor(s) that are certified by the selected cable manufacturer and have industry-recognized (BICSI) certification will most likely be selected.

The next step is vendor management. The ICT consultant should conduct the first stage, factory witness testing (FWT), to audit and document the manufacturer's QA process from procurement, assembly, testing, packaging, and shipping. Does it comply with industry standards and practices? The same should be applied for the supplier and distribution channels.

The installer should also have a formalized, all-inclusive QA (and safety) protocol demonstrating full compliance to the SOW including:

- Written installation guidelines and standard operating procedures (SOPs)
- Trained industry and manufacturer certified personnel
- Testing procedures
- Documentation for submittal

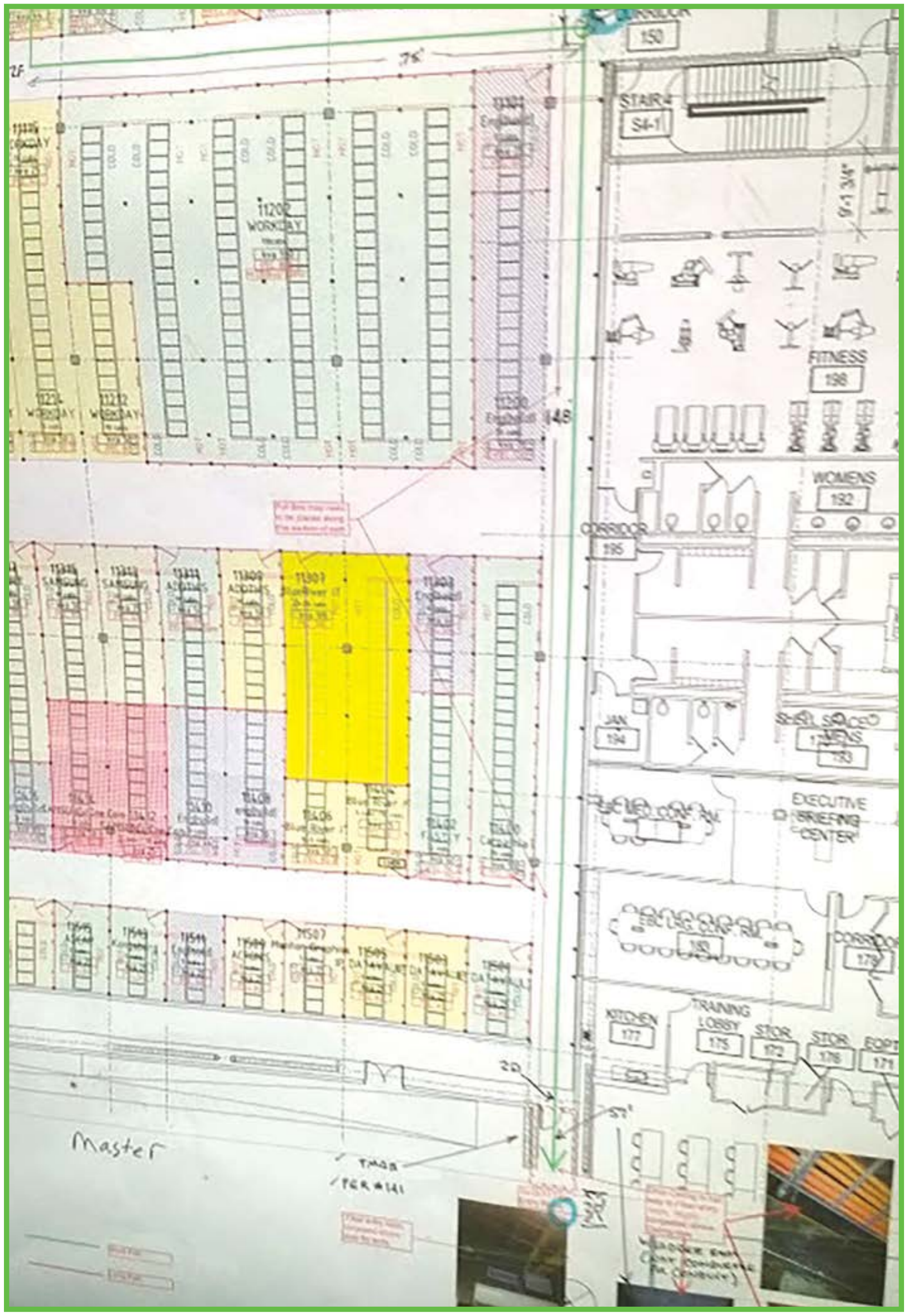

FIGURE 5: An example of a CAD floor plan that provides the physical layout for the cabinets/devices and the cable route configurations used for "take offs."

In coordination with the client, the ICT consultant is also responsible for creating and auditing cabling cut sheets, also referred to as schedules (Figure 6). Cabling schedules are spreadsheets showing sequential connectivity between patch panels and/or devices, including "hops," for each cable segment. There cannot be enough emphasis on cabling cut sheets/schedules needing to be 100 percent accurate. These are the strategic guideline maps used for identifying pathways, cable routing and patching fields. Changes can have a major domino effect. Wrong information may require pulling out and rerouting cables or even replacing them because of inaccurate lengths.

The spreadsheets are then converted to printing labeling schemes (Figure 7). They are provided to the manufacturers for preterminated cable assemblies and to the cable installers for all cable segments and patch cords between devices. Before proceeding to the next phase, the ICT consultant will have all these elements documented into a procedural operations report.

USE	FROM/TO												Panel Designation		Route	Length	Labels		
	FROM				Cable			TO											
		Patch Panel			Strands	Cable Type	Connector		Patch Panel										
	CABINET	Bottom U	Adapter / Slot	PORT	Fiber Count	MM/SM	MTP/LC	CABINET	Bottom U	Row	Adapter / Slot	PORT	From Panel	To Panel			Label - 1st Row	Label - 2nd Row	Label - 3rd Row
Misc. Fiber	M34	16	A-B	1-24	48	MM	LC	F09	57		A1-B1	1-24	SR3UL-J05	SR2UH-J05	MFR1	121.0	M34-U16 (A-B)	F09-U57 (A1-B1)	Route MFR1
Misc. Fiber	M34	16	D-E	1-24	48	MM	LC	F14	57		A1-B1	1-24		SR2UH-J05	MFR1	111.0	M34-U16 (D-E)	F14-U57 (A1-B1)	Route MFR1
Misc. Fiber	M34	16	G-H	1-24	48	MM	LC	F20	57		A1-B1	1-24		SR2UH-J05	MFR1	99.0	M34-U16 (G-H)	F20-U57 (A1-B1)	Route MFR1
Misc. Fiber	M34	16	K-L	1-24	48	MM	LC	F33	57		A1-B1	1-24		SR2UH-J05	MFR1	80.0	M34-U16 (K-L)	F33-U57 (A1-B1)	Route MFR1
Misc. Fiber	M34	13	A-B	1-24	48	MM	LC	F39	57		A1-B1	1-24	SR3UL-J05	SR2UH-J05	MFR1	85.0	M34-U13 (A-B)	F39-U57 (A1-B1)	Route MFR1
Misc. Fiber	M34	13	D-E																
Misc. Fiber	M34	13	G-H																
Misc. Fiber	M34	13	K-L																
Misc. Fiber	M34	10	A-B	1-24	48	MM	LC	G03	57		A1-B1	1-24	SR3UL-J05	SR2UH-J05	MFR1	129.0	M34-U10 (A-B)	G03-U57 (A1-B1)	Route MFR1
Misc. Fiber	M34	10	D-E	1-24	48	MM	LC	G06	57		A1-B1	1-24		SR2UH-J05	MFR1	122.0	M34-U10 (D-E)	G06-U57 (A1-B1)	Route MFR1
Misc. Fiber	M34	10	G-H	1-24	48	MM	LC	G33	57		A1-B1	1-24		SR2UH-J05	MFR1	76.0	M34-U10 (G-H)	G33-U57 (A1-B1)	Route MFR1
Misc. Fiber	M34	10	K-L	1-24	48	MM	LC	G39	57		A1-B1	1-24		SR2UH-J05	MFR1	79.0	M34-U10 (K-L)	G39-U57 (A1-B1)	Route MFR1
Misc. Fiber	M35	46	A-B	1-24	48	MM	LC	H09	57		A1-B1	1-24	SR3UL-J05	SR2UH-J05	MFR1	103.0	M35-U46 (A-B)	H09-U57 (A1-B1)	Route MFR1
Misc. Fiber	M35	46	D-E	1-24	48	MM	LC	H14	57		A1-B1	1-24		SR2UH-J05	MFR1	93.0	M35-U46 (D-E)	H14-U57 (A1-B1)	Route MFR1
Misc. Fiber	M35	46	G-H	1-24	48	MM	LC	H20	57		A1-B1	1-24		SR2UH-J05	MFR1	81.0	M35-U46 (G-H)	H20-U57 (A1-B1)	Route MFR1
Misc. Fiber	M35	46	K-L	1-24	48	MM	LC	H33	57		A1-B1	1-24		SR2UH-J05	MFR1	62.0	M35-U46 (K-L)	H33-U57 (A1-B1)	Route MFR1
Misc. Fiber	M35	43	A-B	1-24	48	MM	LC	H39	57		A1-B1	1-24	SR3UL-J05	SR2UH-J05	MFR1	66.0	M35-U43 (A-B)	H39-U57 (A1-B1)	Route MFR1
Misc. Fiber	M35	43	D-E																
Misc. Fiber	M35	43	G-H																
Misc. Fiber	M35	43	K-L																
Misc. Fiber	M35	40	A-B	1-24	48	MM	LC	J03	57	1	A1-D1	1-24	SR3UL-J05	SR1UH-J05	MFR1	109.0	M35-U40 (A-B)	J03-U57 (A1-D1)	Route MFR1
Misc. Fiber	M35	40	D-E	1-24	48	MM	LC	J06	57	1	A1-D1	1-24		SR1UH-J05	MFR1	102.0	M35-U40 (D-E)	J06-U57 (A1-D1)	Route MFR1
Misc. Fiber	M35	40	G-H	1-24	48	MM	LC	J10	57		A1-B1	1-24		SR2UH-J05	MFR1	92.0	M35-U40 (G-H)	J10-U57 (A1-B1)	Route MFR1
Misc. Fiber	M35	40	K-L	1-24	48	MM	LC	J15	57	1	A1-D1	1-24		SR1UH-J05	MFR1	81.0	M35-U40 (K-L)	J15-U57 (A1-D1)	Route MFR1
Misc. Fiber	M35	37	A-B	1-24	48	MM	LC	J18	57	1	A1-D1	1-24	SR3UL-J05	SR1UH-J05	MFR1	74.0	M35-U37 (A-B)	J18-U57 (A1-D1)	Route MFR1
Misc. Fiber	M35	37	D-E																
Misc. Fiber	M35	37	G-H																
Misc. Fiber	M35	37	K-L																
Misc. Fiber	M35	34	A-B	1-24	48	MM	LC	K03	57	1	A1-D1	1-24	SR3UL-J05	SR1UH-J05	MFR1	100.0	M35-U34 (A-B)	K03-U57 (A1-D1)	Route MFR1
Misc. Fiber	M35	34	D-E	1-24	48	MM	LC	K06	57	1	A1-D1	1-24		SR1UH-J05	MFR1	93.0	M35-U34 (D-E)	K06-U57 (A1-D1)	Route MFR1
Misc. Fiber	M35	34	G-H	1-24	48	MM	LC	K10	57		A1-B1	1-24		SR2UH-J05	MFR1	83.0	M35-U34 (G-H)	K10-U57 (A1-B1)	Route MFR1
Misc. Fiber	M35	34	K-L	1-24	48	MM	LC	K15	57	1	A1-D1	1-24		SR1UH-J05	MFR1	72.0	M35-U34 (K-L)	K15-U57 (A1-D1)	Route MFR1
Misc. Fiber	M35	31	A-B	1-24	48	MM	LC	K18	57	1	A1-D1	1-24	SR3UL-J05	SR1UH-J05	MFR1	65.0	M35-U31 (A-B)	K18-U57 (A1-D1)	Route MFR1
Misc. Fiber	M35	31	D-E																
Misc. Fiber	M35	31	G-H																
Misc. Fiber	M35	31	K-L																

FIGURE 6: Example spreadsheet of a fiber pull schedule to determine cables routes and lengths.

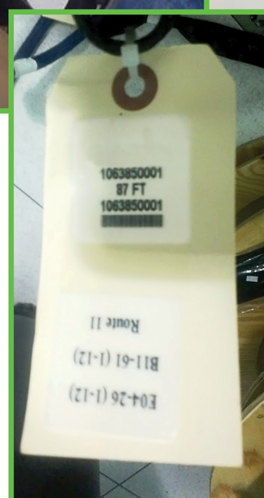

FIGURE 7: The cabling cut sheet or schedule provides pre-labeling for the manufacturer and is the essential vortex of the cable runs for the installer. Shown left to right: An installer labeling a patch panel; a label for a copper trunk; labeled cable spools of multimode optical fiber at a site inspection.

Phase 3: Construction/ Build Phase

The ICT consultant manages the project's construction/build phase to ensure cabling design criteria and milestones, as defined in the design/planning phase, are being delivered accurately and on budget.

The culture of maintaining open and informative communication with all stakeholders of the commissioning team members is essential to meeting the project's objectives. Do the installation vendors need manufacturer assistance or training? Do they need to attend a client's safety or security courses?

Once the cabling arrives at the construction site, it should undergo the second stage testing of site acceptance inspection. Once accepted off the truck, the cable needs to be inspected for shipping damage, inventoried, and moved to a secure stage area. The practice of obtaining factory or distributor test documentation is mandatory. This includes the documentation affixed to the outside spools of unterminated cable.

FIGURE 8: Testing an OSP spool of optical fiber. It is always recommended to test cables after delivery and compare the OTDR test results to the affixed test document on the spool.

In pre-design, consider whether the cabling infrastructure concept was designed for the long-term. Will it allow for the future growth & high demands of IoT?

👉 The cabling installers should also conduct the third stage pre-functional testing (PFT) of raw (unterminated) fiber spools. This requires field testing by fusion splicing selected optical fibers from each spool and conducting optical time domain reflectometer (OTDR) tests before installation begins. The PFT test results are compared to the test documentation removed from the spools and should be nearly the same (Figure 8). Any abnormalities need to be immediately addressed before beginning the installation.

Preterminated fibers are usually shorter in length and packaged securely. It is still a good practice to organize and store the manufacturer's hard copy test documentation. Like the spools, when testing a link that fails, it can be compared to the manufacturer's test documentation. This can help to determine whether the cable was damaged during field manufacturing or installation.

👉 Continual commissioning includes site visits to perform QA visual inspections. This is to ensure installation best practices are being followed. Cable routing, securing, and dressing should have a professional and consistent clean look that is maintained throughout the entire installation process. The ICT consultant must be able to guarantee that the installation is following the SOW/BOM and drawings, as well as ensuring that the labeling and testing procedures are in full compliance.

Phase 4: Acceptance Phase

The acceptance phase is based upon the fourth stage, functional performance testing (FPT), and inspection of the ICT cabling infrastructure. This testing is performed on all cabling-related systems to ensure conformance to the design/planning and construction/build phases (Figure 9).

- The ICT consultant has an itemized QA checklist for all components of the ICT cabling infrastructure. Attention must be given to visual inspection, as well as labelling compliance. The installation vendor should also have its own QA check list to hand over in addition to the testing documentation. All codes, installation (BICSI) best practices, and industry standards must be in full compliance.

- FPT subjects all inter and intra-building cabling components of the ICT cable installation to a full-cycle performance test. The ICT consultant verifies that the correct test equipment is being used (fiber optic testing Tier I vs. Tier 2) and set up properly in accordance with the SOW specifications. The calibrations must be current and the technicians certified in order to meet tester manufacturer and cable manufacturer warranties.

Be aware; the cable manufacturers or other members of the commissioning team may want to witness all or a percentage of the testing. Any irregularities are reported on a punch list and corrected, but this may necessitate a change order (CO). The final step involves the authority having jurisdiction (AHJ) signing-off, thereby ensuring compliance with local applicable construction codes.

All QA, testing documentation, and as-built drawings are formulated for client acceptance and integrated into the OPR.

FIGURE 9: Testing is the integral step in commissioning, starting from the set-up process through documentation.

Phase 5: Post Acceptance

The fifth and final post acceptance phase entails the submittal of the final commissioning report. It should reflect a well-organized and orchestrated commissioning process. This phase includes the operations and maintenance procedures, which are needed to see the ICT cabling installation through its life cycle and manufacturer warranties.

It is important to note that unless specified in the OPR, the fifth stage, integrated systems testing (IST), is not applicable to a passive ICT cabling infrastructure.

The content of the commissioning report contains the "acceptance" documentation, including all test documentation, visual inspection reports, checklists, observation notes, lessons learned, safety reports, manufacturer cut sheets, and warranties.

Manufacturer and installation warranties that are all on record, stored correctly, and easily accessible are then incorporated into the OPR. SOPs should establish a process through which the client can address current and future issues and trends.

Does the client have the proper training, technical knowledge, tools and test equipment necessary to support an efficient operation?

The ICT cabling infrastructure should be inspected periodically, not only for the consistent clean look of cable routing and dressing important in the construction/build phase and continual commissioning (Figure 10), but also for possible cable degradation. Some potential problems to look for include cable in conduit not having sufficient water blocking properties, cracks or pinching of the cables, sagging of the support structure, corrosion, and general abuse. The importance of maintenance may open an opportunity for the installation vendor to offer a maintenance contract to provide on-site tech support.

FIGURE 10: Take note of the clean, professional cable dressing that is consistent throughout the POD.

KEY TAKEAWAYS

A commissioning plan is an intricate process critical to improving system performance and to ensuring a well-tuned, high-quality, and reliable data center operation.

Questions to ask include:

- Did the program/pre-design logical architecture transform into a properly designed physical ICT cabling infrastructure in the design/planning phase?
- Did the installation adhere to the QA guidelines and test procedures of the construction/build phase?
- Did the project pass both the visual inspection criteria and performance testing as required in the acceptance phase?
- Finally, were all the expectations and objectives of the commissioning team met and all documentation submitted in the final commissioning report to the client?

The best solution to protect the data center's ICT cabling infrastructure against mayhem, such as downtime, is to do it right the first time. Tailor a cabling QA and testing plan into a comprehensive commissioning plan. The result will be a happy client with a positive ROI and the continued "building" of the ICT company's excellence and trusted reputation in the industry!

BIOGRAPHY:

David "Bo" Conrad recently celebrated his 35 years as a BICSI member and an RCDD. He also holds Tech III and former BICSI ATF (Master) Instructor certifications. His current role is with Align as regional business development manager and also as a senior project manager co-managing operations. Bo's specialty is in design/build of Class/Tier 3-4 ICT data center white spaces, ISP Co-Los, and large commercial building installations. Bo has authored, produced, and instructed six industry-recognized manufacturer cable/connectivity and industry trade organization contractor warranty training programs. He is also a former instructor for Berkley and the University of California, Santa Cruz and an owner/operator for 17 years of two BICSI ATF schools in California and the ATF curriculum in Hawaii. Bo is one of the founders and a long-time member of the ANSI TIA 568 committee. He has served on numerous BICSI committees, including ATF/ITSIM and exam writing committees, and he is a contributing author to the TDMM and former Wi-Fi and residential standards. He is also a frequent speaker at regional BICSI events. Bo holds an MBA and a BS in engineering. Bo can be reached at bconrad@align.com.

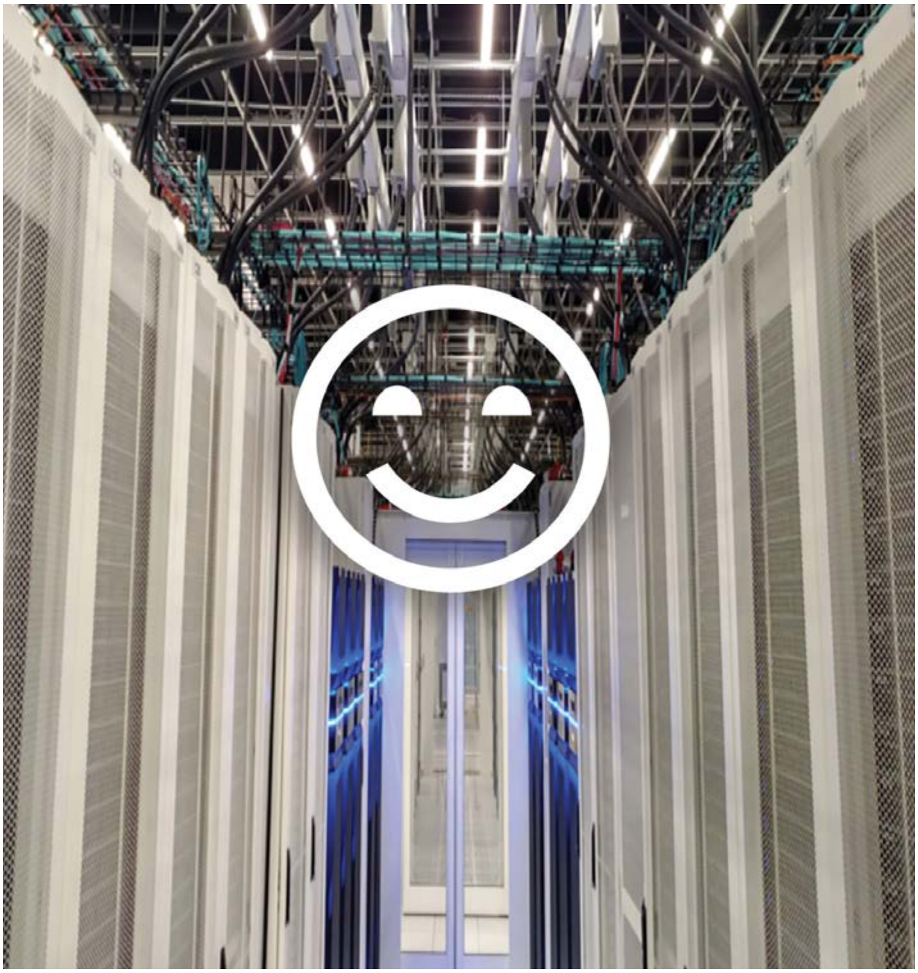

FIGURE 11: A completed and well-commissioned data center leads to both a happy data center and a happy client.

Is that a Cloud or is the Fog Rolling In? Keeping Up with the Ever-Changing Patterns in Data Centers (includes 002 standard updates)

By Jeff Silveira, CAE, RITP

As the data center is to the cloud, edge computing is to the fog.

Another "year" and new forecasts abound for the data center market. When not automatically popping up everywhere, these forecasts can be found with a simple keyword search, resulting in an abundance of diverse numbers and projections. They tell a similar story; the five to ten year forecast on the data center market is all sunshine, with compound annual growth rates (CAGRs) ranging from 6 to 9 percent.

Much like the weather in certain areas, to understand where the data center market is headed all one needs to know are the past trends. Since the introduction of the smartphone just 10 years ago, the need and consumption of data has significantly grown year-over-year, leading to a similar growth in the infrastructure to store and serve it. Looking deeper, there have been changes in data center efficiencies and the longer-term patterns of who manages that data and where it is stored.

Change may seem justifiably overwhelming for data center operators, engineers, designers, consultants, project managers, and installers who must simultaneously attend to their daily responsibilities while keeping up with the large and continuous influx of new technologies and paradigms. The new ANSI/BICSI 002-2019, *Data Center Design and Implementation Best Practices* standard provides assistance and a path forward amid ongoing changes and trends in the age of the Internet of Things (IoT), big data and ICT transformation.

A CLOUD IS BORN

In 2009, enterprise data centers were seemingly all the rage. Store the data internally to the company, and provide it to staff as needed. To most people, reference to "the cloud" meant something that existed on the horizon that could bring rain; those in data center circles thought similarly. Except to them, the cloud was bringing a new paradigm. Shortly thereafter, the cloud entered common use.

The cloud became an easy to use metaphor to describe data that was stored somewhere and waiting to rain down on the user. Use of the cloud grew quickly as some companies saw financial benefits for having "someone else" store information that reduced internal infrastructure and labor costs. Other companies viewed the cloud as the provider of much needed redundancy for critical data systems. As demand grew, so too did the number and physical size of data centers.

Data center construction was in a steady growth pattern as more applications drove people and certain areas of the globe to create and demand more data. As construction was trending upward, technological advancements were performing as historically expected by decreasing features and function sizes of key items and allowing for more powerful servers, storage systems and network equipment to reside in the same physical space. Because the ability to send data from point A to point B depends on the pathway and space available, not unlike automobile traffic (Figure 1), advancement in networking protocols allowed networks to start determining optimum routing.

These advancements and growth occurred in the course of about eight years and led to the realm of the hyperscale data center. While the term "hyperscale" often connotes a very large computer room area in excess of 9,000 m^2 (100,000 ft^2), hyperscale may also refer to a data center with as little as 5,000 servers and 929 m^2 (10,000 ft^2) that can provide high-volume traffic and the ability to handle heavy computing workloads for organizations that run most of their applications in the cloud.[1] Granted, having additional space assists with the potential volume and proper selection of equipment and components to fit specific use case requirements, but running a data center is much more than about space. The data center, regardless of size, must also be operationally efficient.

FIGURE 1: Data traffic is similar to vehicle traffic; both need available pathways and space.

DATA CENTER EFFICIENCY

Hyperscale architecture is only one of the ongoing trends within data center design. Focus continues on improving the efficiency of data centers, especially in cooling and power consumption. Immersion cooling is one area of progress; while the use of air is relatively risk free, fluids, such as water, can transfer heat 24 times faster from a surface and can store more heat within an equivalent volume. Immersion cooling has taken a few different forms. In 2018, Microsoft began testing the concept of submerging a data center built into a shipping container. The concept was to evaluate viability of deploying these types of data centers on the coastline of population centers. Measures, such as using the surrounding water, resulted in reduced power consumption, potentially using power generated only from wind and tidal forces.

Liquid cooling is not just for the data center building or external heat exchangers, since rack and server level cooling has also emerged. While the presence of liquid within any structure that has a high reliance on electrical power is often considered a risk, traditional air-cooling methods become less efficient to the extent that cooling densities of 60 to 70 kW per rack can become extremely difficult. While data centers are not yet seeing this level of load, densities are increasing in both typical and hyperscale data centers.

Liquid cooling currently is used to cool the central processing units (CPUs) within a server; it is the part of the server that generates a significant amount of heat and is most affected by it. Unlike full immersion, liquid is only used in conjunction with the CPU heat sinks, allowing other elements to run within the ambient airflow. Liquid cooling does not necessarily require chilled liquid (i.e., liquid at 30 to 40 C (86 to 105 F)), because it supplies more than adequate heat absorption while supporting traditional heat exchangers.

Liquid cooling, while expected to be a significant part of the data center industry, is not the only endeavor to decrease costs. Originating from Facebook's research and development, the Open Compute Project (OCP) is an effort modeled on open-source software where participants provide and share information about data center issues. Broken into a number of subject areas, including equipment and infrastructure, OCP looked at what was needed to meet objectives, leaving little unchallenged. Since its incorporation in 2011, OCP concepts have been increasingly adopted in hyperscale designs, as changes to the physical dimensions of servers allowed for increased heat transfer potential. Because these new dimensions were physically incompatible with standardized EIA/ECA-310-E racks, this led to the envisioning of the ubiquitous telecom rack.

Other areas of OCP focus on electrical power distribution. Movement has been made on refining dc infrastructure that avoids potential power losses and heat generation when converting traditional ac power into dc for IT equipment and batteries. These developments triggered a review of the building infrastructure, which included a look at pathway sizes. As the height of racks have been increasing, wider racks and the option to move fully loaded racks into place may require larger pathways capable of handling increased loading.

THE FOG ROLLS IN

Much like any weather system, the cloud continues to move and change according to its surroundings. Where the cloud meets the horizon line, some notice a new formation, one caused by continued development of IoT. IoT is no longer a new concept, and much has been written about it. However, IoT's impact is much larger and continues to be a force for change. IoT is often viewed as wired connections between devices and their respective systems.

Regardless of the actual definition, edge data centers will be required, either as new construction or possibly created from smaller existing enterprise or colocation data centers.

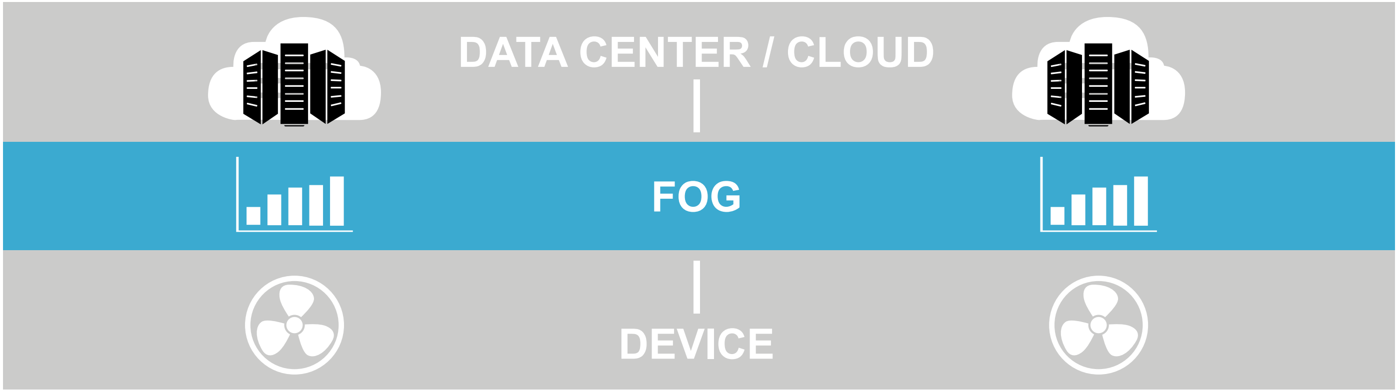

FIGURE 2: The fog extends the cloud closer to the devices producing data, thereby reducing latency.[2]

The data supplied by each system can contain thousands or millions of data points and is analyzed or processed for a particular purpose in advancing decision making and the generation of new data points to further drive improvement and change. Current examples of big data analytics include determining root causes of failures and defects of an oil rig in near real time, generating coupons at the point of sale based on a greater understanding of customers' buying habits, or tracking wheelchairs and other resources at hospital facilities for improved asset management.

According to the *Wireless Telecommunications Carriers in the US IBIS World Industry Report* (2017), "The share of wireless connections that are Machine-to-Machine (M2M) connections is set to increase from 15.0 percent in 2017 to 30.0 percent by the end of this decade." While internal building systems may remain wired, the build-out and upcoming implementation of 5G wireless will allow device placement to no longer be limited by the reach of a cable.

While any one IoT device may not provide nor require much in the way of data, forecasts have suggested that at least 20 billion IoT devices will have been deployed by the end of 2020. Where will the data go? For internal building systems, this has traditionally been the internal infrastructure. However, as cloud-based solutions for software and monitoring have been accepted, this data would be transferred to the cloud. For many systems, time of transmission difference between the equipment or server room on-site and the cloud data center hundreds of miles away is negligible. But as data volumes and the amount of processing increase in conjunction with an increased need for real-time response without impact by inherent latency, a new design paradigm is emerging to address the fog or localized low-lying cloud layer (Figure 2).

FIGURE 3: A cable company distribution node.

As the data center is to the cloud, edge computing is to the fog. While there is not a consistent definition of edge computing, it is generally agreed that the processing of data for devices or systems occurs somewhere closer to the area of need than a traditional data center. This computing may take place in the actual device, a system aggregation point, or in the fog, where the fog is really a localized cloud supported by localized or "edge" data centers.

Some people define an edge data center as one that must meet a number of criteria, such as serving a minimum percentage of the local market and meeting a specified performance level; others view an edge data center as just a data center with an intended purpose, much like a colocation or enterprise data center. For how this may play out, one simply needs to look at the longer-term historical trend within ICT, beginning with the first room-sized computers where the location of data and processing oscillated between localized and "at a distance" infrastructure, occasionally stopping at mid points where aggregation nodes and consolidation points are created.

Regardless of the actual definition, edge data centers will be required, either as new construction or possibly created from smaller existing enterprise or colocation data centers. With edge computing and the trend to make objects smaller and closer, another potential exists in moving requisite processing for some applications even closer to the device. Figure 3 shows a distribution node for a cable television provider located at a signaled intersection that passes through approximately 90,000 vehicles[3] per day. With the growth of intelligent transportation systems for traffic management and road safety, structures such as this may provide a functional site.

FINDING A PATH FORWARD

For data centers, finding a path forward in the midst of ongoing change can seem daunting. However, over the last eight years, a number of industry standards were developed to address ongoing change. While some elements of the data center, such as power and cooling, are fairly constant due to their use within most industries, data centers also provide an interesting mix of unique disciplines and conditions. Until 2010, most data center standards focused on one segment of a data center, occasionally providing insight into related areas. For example, ANSI/TIA-942 provided some environmental and power distribution information as it related to telecommunications infrastructure in and around the computer room.

Over the years, ANSI/BICSI 002 has been revised and expanded, balancing the needs of the current data center while looking ahead at oncoming trends.

In 2010, the first of a new type of data center standard was released in ANSI/BICSI 002. Rather than looking at any particular vertical, its focus brought all of the different data center disciplines together to provide common connection points, serving as a Rosetta Stone. This approach has since been mirrored in other standards, such as EN 50600.

Over the years, ANSI/BICSI 002 has been revised and expanded, balancing the needs of the current data center while looking ahead at oncoming trends. In 2014, ANSI/BICSI 002 was expanded in a number of aspects, including emerging cooling methods, modular data centers, and the use of multiple data centers as part of an overall availability and redundancy plan.

The newest entry, ANSI/BICSI 002-2019, continues that tradition. During revision work, several areas were addressed. The first was colocation planning, as hyperscale concepts and methods can present interesting challenges for even the most experienced data center designers, consultants, or owners. While the planning information is new, existing content with planned updates were sufficient to complete the material. Since OCP is now established, several volunteers provided additional information. While information on open racks and some foundational concepts are new in the 2019 version, most of the architectural and space requirements were already sufficient and required only minor edits.

Given that without power, there is no operation, refinements to dc power distribution and information about lithium-ion batteries was added. Since cooling is the other ingredient for a "happy" computer room, the mechanical chapter was restructured for flow, providing insights into adding further support for liquid cooling and other potential cooling methods.

Other major changes were focused on building systems and commissioning. Given the evolution of building systems to utilize network power, share data, and be integrated into a larger whole, additional cabling may be present in both the computer room and adjoining spaces. While some disciplines, like security, are already "riding the network," low-voltage lighting and lighting management, sound masking, and first-responder and emergency services communications are some of the many other systems which are being incorporated in the style of an intelligent premise.

As there is always a need for commissioning information, which is not found within any one document, the commissioning section was expanded to provide more detail about planning and structure. In the structure section, roles and responsibilities were defined, thereby providing a guide to explain who needs to perform which functions and when.

The revision of ANSI/BICSI 002-2019 would not be complete without some larger restructure or relocation of content. With the parallel development of BICSI 009 for data center operations, those sections with operation materials, such as security and maintenance,

Frequently Given Answers for ANSI/BICSI 002

- An international standard found in over 105 countries across six continents
- Over 4 out of every 10 are shipped outside the United States
- More than 50 percent can be found within data centers, used by owners and operators
- EIT 022012-59 มาตรฐานดาตาเซนเตอร์ สำหรับประเทศไทย, (Thailand Data Center Standard) incorporated ANSI/BICSI 002 into national requirements

FIGURE 4: Interesting facts about ANSI/BICSI 002 and its global reach.

were reviewed. Content applicable to operations only moved, with the remainder rearranged and condensed for use within 002 design decisions. ANSI/BICSI 002 is a standard used worldwide, and its global reach continues to grow (Figure 4).

NAVIGATING WITHIN THE FOG

Professionals in and around the data center environment are often the best guides available. Data center content is easy to find as sunny market forecasts provide the perfect conditions for anyone to hypothesize based on recent news and events. For those less familiar with the data center field, finding a guide is not difficult since design and general knowledge can also be acquired. But while anyone can say they can provide design and consulting services for data centers, there are several elements one should look for so that the envisioned destination is achieved. While some elements seem obvious, such as how power, cooling, connectivity and IT equipment are interrelated within a data center, just the ability to understand requirements and enumerate different potential solutions before any actual design occurs can make a big and positive difference in a project. And knowledge should not be limited to just design, as the ability to keep a data center secure and operating in a practical manner after Day 1 is also desirable. Buying a replacement data center off the shelf, if it breaks, is not yet an option.

Simply put, a data center can be described as a room with several servers, but the reality is that a data center is a complex facility with interdependencies on multiple disciplines, systems and equipment. As the complexity of a data center continues to increase, so does the project that enables its construction, thereby requiring more comprehensive guides.

One such guide is BICSI's new *Essentials of Data Center Projects* (EDCP), 1st Edition (Figure 5). Since a design can only perform as well as the project implementation allows, the EDCP provides the underlying knowledge necessary for data centers large and small. The EDCP contains a holistic view of the overall data center project, from conceptualization, to planning, implementation, and project closeout.

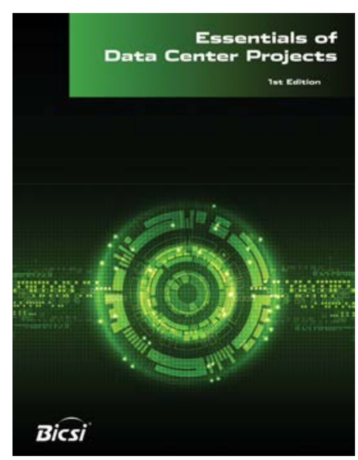

FIGURE 5: The EDCP is a valuable resource for professionals involved with the conceptualization, project planning or construction of data centers, and it is an excellent complement to ANSI/BICSI 002.

THE THREE YEAR OUTLOOK

There will be plenty of growth for the data center market in the next three years, regardless of greenfield builds, technology updates, or refurbishment of existing sites. The demand for data will continue to drive this growth with the need to gather, process and access data even faster, altering where and how large a specific data center needs to be. Some researchers conjecture that the next wave of data centers may be placed in more non-traditional spaces, such as retail buildings, office space, and physical product distribution and shipping centers. With ANSI/BICSI 002-2019, regardless of location, purpose or use, the information therein ensures that the data centers being designed tomorrow will operate well into the future.

BIOGRAPHY: Jeff Silveira, CAE, RITP, currently serves as the BICSI director of standards. Jeff has been engaged in global standards development within the semiconductor and ICT industries for over 20 years. He has a BS degree in Mechanical Engineering from Santa Clara University, has been a Certified Association Executive (CAE) since 2013, and is finishing work towards an MBA with a concentration in Business Intelligence. He can be reached at jsilveira@bicsi.org.

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