Telecommunications Industry Association

TIA POSITION PAPER

Central Office Evaluation Strategy for Deployment of Information and Communications Technology (ICT) Equipment

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Authors & Contributors

Authors:

Bill Price	AT&T
Brian Boutilier	AT&T
Jeffrey Betz	AT&T
Hany Fahmy	AT&T
Tom Anschutz	AT&T
Curtis Ashton	CenturyLink
Mickey Driggers	CenturyLink
Michael Fargano	CenturyLink
Craig Culwell	CommScope
Richard Kluge	Ericsson
Atsushi Sakurai	NTT
Hiroshi Yamamoto	NTT
Harry Smeenk	TIA

Contributors:

Justin Davis	CenturyLink
Seth Roy	iBwave
John Greene	New Lisbon Telephone Company
Atsushi Sakurai	NTT
Marta Soncodi	TIA

Executive Summary

Next generation networks coupled with the rollout of 5G will require a significant evolution of the traditional central office to function more like a data center. To increase speed, capacity, and to ensure delivery of critical items for enhanced end-user experiences, content and computing needs to function using commodity servers and white-box switches similar to data centers. Combined with Network Function Virtualization (NFV) and Software Defined Networks (SDN), there is a driving need for central offices and data centers to coexist at the connection points. Significant differences in HVAC, power, backup, cabling and fire control/ suppressant requirements create challenges in this coexistence.

Fortunately, these challenges can be addressed through industry collaboration in the development of thought leadership, positioning papers, practices, guidelines and standards. There are many groups focused on the software aspects of this central office transition, however, only the Telecommunication Industry Association (TIA) and its members are focused on the infrastructure, connectivity, and environmental requirements. This positioning paper begins the journey towards defining, developing and consolidating this TIA thought leadership to speed the transition, drive awareness, and reduce costs along the way. This paper should be used as a guidepost in consideration of the transition, however it should not be considered definitive as each transition is unique.

It is our intent with this paper to establish a common definition around the infrastructure, connectivity and environmental differences that must be addressed in the central office to data center transition. TIA and the members of this working group invite others in this ecosystem to join in the next steps of development of these concepts. Contact hsmeenk@tiaonline.org or msoncodi@tiaonline.org for more information.

Fundamental Aspects of Central Office Evolution Strategy

When looking to update central offices, consideration must be given to the scale of the existing location and the update, and for the new equipment the heat dissipation and the ability to perform in a higher temperature environment. This positioning paper categorizes exemplar configurations for “small”, “medium” and “large” depending on square footage and the number of racks per cabinet. These scale considerations can affect the levels of precautionary measures needed for each center.

Fundamental aspects to consider in any central office evolution strategy include: applicable Code Compliance, Fire Protection, Heating, Ventilation, Air-conditioning, Electrical Power, and deployment options. Deployment options are based on size and location of the central office and customer demand for services.

Throughout this paper, three scenarios are identified for HVAC, electrical power and fire protection considerations. The first is within a self-contained pod or container, the second is a central office space carve-out, and the third is placing equipment that meets applicable code requirements in an unmodified central office space.

Specific Considerations for Small, Medium, and Large Scale Central Office Evolutions

For Small scale installations, electrical power considerations and fire protection are dependent on the applicable codes for that location and may differ from one location to another. Generally, for small scale deployments, there is less focus to change the existing environment, and more focus on adapting small deployments to existing facilities.

For Medium scale installations, power scenarios may vary based on the scale and location of containers, and additional fire suppression requirements may be necessary, while power scenarios and considerations are largely the same for both a "small" and "medium" deployment. Medium deployments should, however, undertake a thorough analysis of the installed capacity to assure that there is sufficient capacity to take on the potentially significant additional power and cooling load.

This paper does not define requirements for large scale installations. Generally, large scale deployments will target traditional data center facilities.

Introduction

Communications equipment is deployed in the Central Office (CO) or Public Exchange. A central office (CO) is an office in a locality to which subscriber home and business lines are connected on what is called a local loop. The central office has switching equipment that can switch calls locally or to long-distance carrier phone offices to establish telephone calls between subscribers. These buildings are typically located in the center of town and are used to house equipment from which a telephone obtains dial-tone. Sometimes they are referred to as Wire Centers since all subscribers' lines terminate there. Central Offices, Public Exchange, Serving Offices, Cell Sites, and Mobile Telephone Switching Offices (MTSOs) are all referred to as COs in this paper.

The evolutionary milestones of the telephone communications system are easy to identify. We have all seen images of the early central office consisting of one to several hundred plug boards staffed by switchboard operators.

Over time, the switchboard operator was replaced by a very large and very loud mechanical switching machine consisting of electric components that interconnect (switch) telephone subscriber lines to establish telephone calls. Callers were then able to make direct calls without the assistance of a switchboard operator. Later, these mechanical switches were replaced by much quieter and more efficient electronic, digital switches. These allowed for many more subscribers, quicker connections, and better call quality.

More recently, the same COs have been used to support modem access to digital networks and then the Internet. Customer demand for faster access to the Internet then drove adoption of Digital Subscriber Lines (DSL) and eventually Fiber to the Home (FTTH).
For over a hundred years the central office switching, and later routing systems have been very hardware-centric. Companies around the world lined up to develop a "better box" and the hardware kept getting better, more efficient, and less costly. Features such as call-forwarding were added with hardware and software combinations and switching centers became capable of placing calls directly over the Internet. Services were traditionally embodied in single-purpose hardware like switches, routers, load balancers, and firewalls. However, today those services are now loadable applications for common hardware infrastructure like off-the-shelf "white box" servers and switches. Today's CO applications are workloads that increasingly resemble those found in cloud or data centers and run on hardware like that found in those locations.

The evolution of the network is now moving towards a more software-defined capability requiring immediate connections. Users now expect much more functionality from service providers to support IoT devices, virtual reality applications, connected vehicles, telemedicine, immersive media, and other products and services that require faster speeds, higher capacity and larger throughput on-demand. Service providers, in turn, are requiring much more from their central offices. New applications need to be hosted very close to users, and network functionality needs to be performed in milliseconds to meet these critical requirements, similar to the way data centers function. That functionality needs to be integrated into the Smart Central Office where the wireline, fiber, and mobile worlds come together to connect and support fixed and mobile traffic. Moreover, with more devices per person, connected cars, buildings, and cities, and the attachment of Internet of Things (IoT) these Smart Central Offices need to support a large increase in the number of served connections.

Legacy communications functionality is transforming to perform similarly to Information Technology (IT) systems. These newer technologies are known as Software Defined Networking (SDN), Network Function Virtualization (NFV), and Network Function Virtualization Infrastructure (NFVI). SDN and NFV/NFVI will be key to supporting the reliable deployment and flexible configuration of new infrastructure and services, while optimizing networks to manage the current mix of services. Independent of size (small, medium or large), carriers can utilize a variety NFVI configurations (rack, CPUs, NICs, storage and management). However, at times, carriers will have some choice on how and where to deploy equipment and certain requirements and impacts will accompany that decision. This paper and the follow-on work it encourages intends to guide and provide better clarity on these options for how to deploy this new infrastructure.

These are well described in the AT&T and ETSI referenced public white papers: **https://www.att.com/Common/about_us/pdf/AT&T%20Domain%202.0%20Vision%20White%20Paper.pdf** and **https://portal.etsi.org/NFV/NFV_White_Paper.pdf**.

The Operator Survey conducted by IHS Markit, "Smart central offices to be in 85 percent of service provider networks this year" released on January 25, 2018 suggests the following:

- In 2018, 85% of respondents plan to create, or will have already deployed, smart central offices - that is, installing servers, storage and switching to create mini data centers in selected central offices.
- More than half (55%) of operators surveyed plan to move each of 10 different router functions from physical edge routers to VNFs running on commercial servers in mini data centers in smart central offices, including customer edge (CE) router, route reflector (RR) and others.
- Seven out of ten respondents plan to deploy Central Office Rearchitected as a Data Center (CORD) in smart central offices.
- Operators expect 44% of their central offices will have mini data centers (or smart central offices) by 2023 and deploy CORD in half of those central offices.

Data centers were built to house computing systems and associated components such as local area networking and storage - and to serve as infrastructure for the "Cloud." They are typically built with different expectations about power and cooling systems, as well as different operational models, and typically use different governing standards and regulations. Yet there is significant interest in applying technologies and systems that were developed for datacenters to support workloads in central offices.

Today a central office and a data center remain very different in both functionality and physical infrastructure. Cabling, power, HVAC, and fire protection, for example, can be significantly different between central offices and data centers.

Some essential characteristics are in direct conflict with each other, yet central offices and data centers are now required to coexist. In this paper, we examine the key components that need to be considered in the transition of the central office facility so that it can house both the central office and data center equipment. Models are proposed and discussed to establish an industry foundation for furthering the development of thought leadership and future standards to enable consistency and efficiency. Future documents from this working group will address these in greater detail.

The considerations described here are for general situations and may be modified and augmented as needed to meet local laws, individual and carrier requirements for safety, codes and guidelines.

Scope

The objective of this paper is to suggest general technical considerations for the Evolution of COs for the inclusion of next generation Information and Communications Technology (ICT) equipment required to provide the expanded suite of services customers today demand and need. Important references, acronyms and abbreviations, and definitions are provided at the end of the paper.

Scale Considerations and Definitions

Equipment may be deployed inside or outside the CO in either traditional racks or cabinets. Consideration should be given to heat dissipation of the equipment, the ability of the equipment to perform in a higher temperature environment and the potential need to provide supplemental cooling in support of a hot aisle/cold aisle configuration.

For the purposes of this discussion examples will be described in general terms of “small”, “medium” and “large” categories as defined below (actual deployment may differ):

- Small – one to eight cabinets/racks at 4kW-8kW per cabinet/rack (generally < 200 sq. ft.)
- Medium – four to twelve cabinets/racks at 6kW-12kW per cabinet/rack (generally 200-500 sq. ft.)
- Large – twelve+ cabinets/racks at 10kW-14kW per cabinet/rack (generally > 500 sq. ft.)

Conversion/Carve-Outs Scenarios

Small Scale	Medium Scale	Large Scale
1-8 Cabs 4-8kW per Cab <200 Sq. Ft.	4-12 Cabs 6-12kW per Cab 200-500 Sq. Ft.	12+ Cabs 10-14kW per Cab >500 Sq. Ft.

The overlap in the number of cabinets and power for the examples described above is to demonstrate that there are no clear delineations between these segments. If the initial deployment is a smaller number of cabinets, but the ultimate configuration (to be deployed within a reasonable engineering interval) is known, then it is more cost effective to deploy infrastructure for the largest possible configuration to accommodate the ultimate need. However, if the deployment is to remain limited, the smallest configuration will limit the potential for stranded capacity resulting from overbuilding.

The reason for the variation in the power (kW) per cabinet/rack is in recognition that the cloud services that may be deployed in a geographic area that may only warrant a small deployment are generally not very processor intensive. In a medium or larger configuration, those services that would be in demand in that geographic area may require more server cards or be more processor intensive. These power (kW) ranges are for illustration of trends; actual deployment configuration may widely vary.

Fundamental Fire Protection Considerations

The International Building Code (IBC) [1] / International Fire Code (IFC) [2] contains fire protection requirements and exceptions.

NFPA 75 [3] Standard for the Fire Protection of Information Technology Equipment and NFPA 76 [4] Standard for the Fire Protection of Telecommunications Equipment Facilities have been adopted as law by a limited number of states and other Authorities Having Jurisdiction (AHJs). Other AHJs may consider them best practices. Analogous to NFPA 76, NFPA 75 provides fire protection practices for use in data center environments. These requirements and modifications should be addressed by the service provider in any central office evolution.

Fundamental HVAC Considerations

Carriers have a choice on whether to install a separate HVAC system/capacity for either exterior or interior Pod/Container spaces. If fire suppression is provided, consideration should be given to isolation of the local area in the event of a fire suppression discharge. Consideration should also be given to the heat dissipation characteristics of the equipment, to determine if existing HVAC has the capacity and is sufficient to adequately cool the equipment. If not, augmented cooling strategies (back-of-cabinet, in-row, etc.) should be considered.

Fundamental Electrical Power Considerations

Either AC (typically single-phase from 100-230VAC), -48VDC, or 380VDC power could be provided to the equipment. This could be sourced from the existing, if available, or a new DC plant which typically includes significant backup from a combination of batteries and generators. Power could also be provided by a new Uninterruptible Power Source (UPS) with proper consideration given to placement requirements and typically less backup.
380VDC input power supplies are presently less common but are becoming more common as Asia (primarily) and other parts of the world rapidly deploy this newer DC architecture due to the high cost savings in distribution copper cables.

Deployment Scenarios

Some Industry practices will be discussed later in terms of the following "scenarios":

- Self-Contained Pod/Container inside or outside a Central Office
- Central Office Space Carve-out
- Legacy Communications Space (LCS) Equipment Deployment

Small Scale Fundamental Aspects of Central Office Evolution Strategy

Small Scale Central Office space – one to eight cabinets/racks at 4kW-8kW per cabinet/rack (generally < 200 sq. ft.)

Conversion/Carve-Outs Scenarios

Small Scale	Medium Scale	Large Scale
1-8 Cabs 4-8kW per Cab <200 Sq. Ft.	4-12 Cabs 6-12kW per Cab 200-500 Sq. Ft.	12+ Cabs 10-14kW per Cab >500 Sq. Ft.

Small Scale:

#1:	#2:	#3:
Pod/ Container	Small DC Space	LCS DC

Electrical Power Considerations

Scenario 1: Self-contained Pod/Container

In addition to the fundamental aspects outlined above, the following applies:

- Equipment may be deployed inside or outside the CO.
- For an external Pod/Container, AC or DC power can be placed into the pod/container; however, if running power from the building to an outdoor container, only AC power should be provided due to concerns of bringing lightning back into the DC plant inside the building (AC is more easily protected with surge arresting than DC).
- Inside the CO, the limited equipment deployment in this scenario may sufficiently meet power safety requirements.

Scenario 2: Central Office Space Carve Out

In addition to the fundamental aspects outlined above, the following applies:

- Inside the CO only
- In lieu of a UPS, for loads under approximately 100kW, inverters coupled to an existing DC plant are more reliable, but more expensive.

Scenario 3: Legacy Communication Space Equipment Deployment

In addition to the fundamental aspects outlined above, the following applies:

- Inside the CO only
- -48VDC powered only
- As small deployments will likely grow, a thorough analysis of the installed capacity should be undertaken to assure that the electrical and HVAC capacity is adequate or designed for easy augmenting for future growth.

Fire Protection Considerations

The following options are provided as viable opportunities, but it must be understood that the applicable requirements and modifications only apply to certain equipment.

Scenario 1: Self-contained Pod/Container

In addition to the fundamental aspects outlined above, the following applies:

- If installed equipment does not meet the applicable requirements, non-compliant equipment is placed in self-contained closed cabinets, provide internal detection or suppression within the cabinet.
- If installed equipment does not meet applicable requirements but is UL 60950-1 [5] listed, options may be provided such as fire suppression (area or in-cabinet), sufficient spatial separation, smoke management, combination fire/smoke dampers, hazard fire rated separation, or fire detection.

Scenario 2: Central Office Space Carve Out

In addition to the fundamental aspects outlined above, the following applies.

- In a carved-out space if installed equipment does not meet the applicable requirements, fire suppression may be an option. An alternative to suppressing the entire equipment space is to place the non-compliant equipment in self-contained closed cabinets, provide internal detection or suppression within the cabinet, smoke management or special fire detection.

Scenario 3: Legacy Communications Space Equipment Deployment

See the fundamental aspects outlined above.

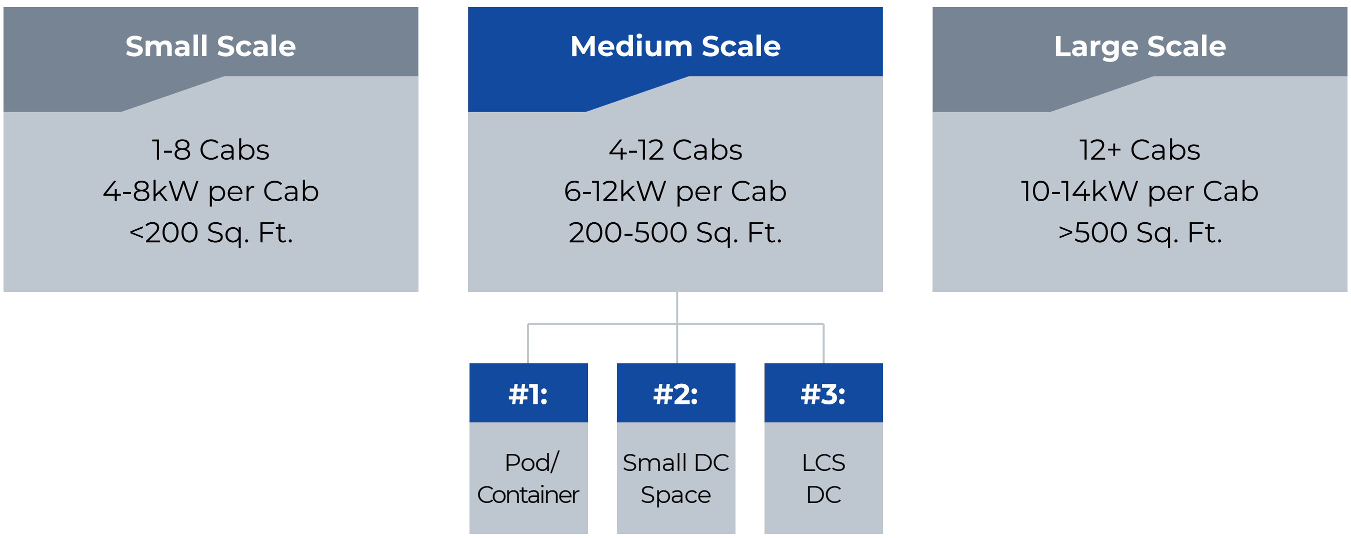
HVAC Considerations

There are no additional technical considerations for a small-scale deployment, beyond those described earlier.

Medium Scale Fundamental Aspects of Central Office Evolution Strategy

Medium – four to twelve cabinets/racks at 6kW-12kW per cabinet/rack (generally 200 - 500 sq. ft.)

Conversion/Carve-Outs Scenarios



Electrical Power Considerations

Scenario 1: Self-contained Pod/Container

In addition to the fundamental aspects outlined earlier, the following applies:
Equipment may be deployed inside or outside the CO.

» For an external Pod/Container, AC or DC power can be placed into the Pod/Container; however, if running power from the building to an outdoor container, only AC power should be provided due to concerns of bringing lightning back into the DC plant inside the building (AC is more easily protected with surge arresting than DC).

Scenario 2: Central Office Space Carve Out

See the fundamental aspects outlined above.

Scenario 3: Legacy Communications Space Equipment Deployment

In addition to the fundamental aspects outlined earlier, the following applies:

- Inside the CO only
- -48VDC Powered only.

In all three of these scenarios, the power considerations are the same for both a “small” and “medium” deployment. However, for medium scenarios, a thorough analysis of the installed capacity should be undertaken to assure that there is sufficient capacity to take on the potentially significant additional power load and HVAC load presented by a “medium” deployment.

Fire Protection Considerations

Scenario 1: Self-contained Pod/Container

In addition to the fundamental aspects outlined earlier, the following applies:

- If installed equipment is not compliant with legacy communication space equipment requirements, additional options may be considered.

Scenario 2: Central Office Space Carve Out

In addition to the fundamental aspects outlined earlier, the following applies: In a carved-out space if installed equipment does not meet the applicable requirements, fire suppression may be an option. An alternative to suppressing the entire equipment space is to place the non- compliant equipment in self-contained closed cabinets, provide internal detection or suppression within the cabinet, smoke management or special fire detection.

Scenario 3: Legacy Communications Space Equipment Deployment

See the fundamental aspects outlined above.

Fundamental HVAC Considerations

There are no additional technical considerations for a medium-scale deployment, beyond those described in Section 3.

Large Scale Fundamental Aspects of Central Office Evolution Strategy

Large – twelve or more cabinets/racks at 10kW-14kW per cabinet/rack (generally > 500 sq. ft.)

Conversion/Carve-Outs Scenarios

Small Scale	Medium Scale	Large Scale
1-8 Cabs 4-8kW per Cab <200 Sq. Ft.	4-12 Cabs 6-12kW per Cab 200-500 Sq. Ft.	12+ Cabs 10-14kW per Cab >500 Sq. Ft.
		Full conversion to Data Center environment including full compliance with NFPA and NEC requirements

Defining considerations for large scale carveouts and conversions is beyond the scope of this bulletin. As with any other scenario, compliance with ICC, NFPA and NEC requirements as applicable.

Conclusion

Within this paper we described the evolution reasons and established a common definition around the infrastructure, connectivity and environmental differences that must be addressed in the central office evolution. Consideration must be given to the scale of the existing location, the heat dissipation and the ability to perform in a higher temperature environment. We categorized configurations as “small”, “medium” or “large” depending on square footage and the number of racks per cabinet and we determined that fire protection, HVAC, and electrical power vary greatly.

TIA and the members of this working group invite others in this ecosystem to join in the next steps of development of these strategies.

Appendix

Important References

[1] ICC IBC, International Building Code, 2018 Edition.

[2] ICC IFC, International Fire Code, 2018 Edition.

[3] NFPA 75, Standard for the Fire Protection of Information Technology Equipment, 2017 Edition.

[4] NFPA 76, Standard for the Fire Protection of Telecommunication Facilities, 2016 Edition.

[5] UL 60950-1, Information Technology Equipment – Safety – Part 1: General Requirements, 2013.

Acronyms and Abbreviations

AC	Alternating Current
AHJ	Authority Having Jurisdiction
ANSI	American National Standards Institute
APC®	American Power Conversion
CPU	Central Processor Unit
CO	Central Office
CORD	Central Office Rearchitected as Data Center
DC	Data Center; Direct Current
FTTH	Fiber to the Home
HVAC	Heating, Ventilation, Air-conditioning
ICC	International Code Council
ICT	Information & Communications Technology
IoT	Internet of Things
IT	Information Technology
LCS	Legacy Communications Space
MDC	Modular Data Center
MTSO	Mobile Telephone Switching Office
NEC®	National Electrical Code
NIC	Network Interface Card
NFPA	National Fire Protection Association
NFV	Network Functions Virtualization
NFVI	Network Functions Virtualization Infrastructure
SDN	Software-Defined Networking

UL Underwriters Laboratories
UPS Uninterruptable Power Source
VNF Virtualized Network Function

Definitions

Cabinet/Rack

This term is used to describe cabinet/rack-based systems. A common type is a simple 19” rack, which is a standardized frame or enclosure for mounting multiple equipment modules that is available in a large variety of heights and depths. Legacy telco equipment may use a 23” rack. The standard requires equipment to have front panels that are 19 or 23 inches wide and include “ears” for attachment to a pair of rails at either side of the rack. Simple cabinets are more commonly called racks and are extremely common in both CO and data center facilities. Sophisticated cabinet products often include more than just the supporting frame and mounting rails. For example, cabinets can also include external enclosures, fans, cooling equipment, power distribution, sensors, lighting, wheels and security devices.

Examples of Cabinets:

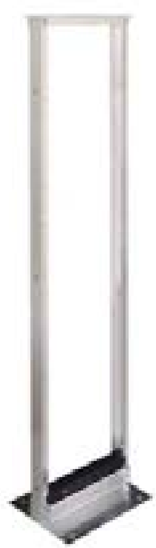


Figure 1:
Simple Cabinet – “Relay” Rack

Figure 2:
Sophisticated Cabinet – CG-OpenRack-19

Pod

An enclosure for housing information and communications technology equipment, generally considered to be located inside the CO. Pods provide separation between the information technology equipment and the other more traditional communications technology equipment. The reason for this separation may be due to environmental conditioning, the need to provide fire suppression in a non-fire-suppressed area or to provide augmented cooling due to the heat dissipation characteristics of the equipment within the Pod. Pods are considered most appropriate for small to medium deployments.

Examples of Pods:

Figure 3:
APC® by Schneider Electric EcoAisle

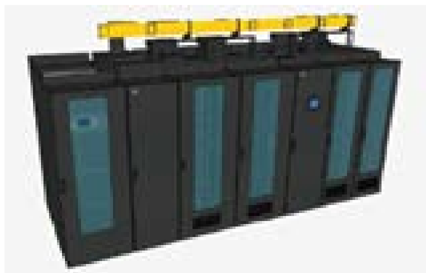


Figure 4:
Vertiv SmartRow™

Figure 5:
Delta/Eltek – POD
(May include fire-rated perimeter wall)

Container

An enclosure for housing the information and communications technology equipment, generally located outside the CO and hardened for exterior elements. Fire suppression may or may not be required. Considerations for deployment of Containers may include available space inside the CO, number of cabinets/racks to be deployed, heat dissipation characteristics of the equipment, etc. Containers are typically located immediately adjacent (i.e. in the parking lot) to the CO to have access to the transport network/fiber backbone in the CO.

Containers are considered most appropriate for medium to large deployments but may include small deployments if space within the CO is restricted. While there is no requirement for a separate HVAC system for the Container, it may be problematic to share the HVAC with the CO. In this case the Container(s) may have its own HVAC separate from the CO. Power may be internal to the Container or in a separate adjacent Container. The engine-alternator (generator) serving the Container may be separate from the standby engine-alternator plant that serves the main CO structure or included in that load, as capacities allow.

Examples of Containers:

Figure 6:
Dell Modular Data Center (MDC)

Figure 7:
Vertiv™ SmartMod

APPENDIX A: Building and Fire Codes

The core requirements for the design, construction, alteration, modification, and operation of all buildings falls under the codes adopted and enforced at the time of original construction or modification. Currently most AHJs are using model building, existing building and fire codes published by the International Code Council, Inc. Communications facilities have qualified for code exemptions, exceptions, and permissible omissions that have evolved over many code editions and interpretations related to fire suppression system requirements within the building footprint.

The correct identification of the designation of the space or area and equipment and the choice of the code used for the alteration of existing space is key to ensuring that the requirements to maintain any current identified "exception" regarding fire protection requirements of the space are maintained.

For local fire code requirements in your jurisdiction consult with your local Fire Department.

Patent Identification

The reader's attention is called to the possibility that compliance with this document may require the use of one or more inventions covered by patent rights.

By publication of this document, no position is taken with respect to the validity of those claims or any patent rights in connection therewith. The patent holders so far identified have, we believe, filed statements of willingness to grant licenses under those rights on reasonable and nondiscriminatory terms and conditions to applicants desiring to obtain such licenses. The following patent holders and patents have been identified in accordance with the TIA intellectual property rights policy:

No patents have been identified

TIA shall not be responsible for identifying patents for which licenses may be required by this document or for conducting inquiries into the legal validity or scope of those patents that are brought to its attention.

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