Case Study

Building a Robust Data Center that is Modular, Scalable and Flexible

A unique approach to data center design for a military customer

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Abstract
Over the past ten years US Central Command (USCENTCOM) based on MacDill AFB in Tampa, FL has experienced dramatic growth in information technology (IT) based requirements for its intelligence users. This is mostly due to increased military activity within the US CENTCOM AOR (area of responsibility) as well as the post 9/11 buildup to the Iraq war. This dramatic growth placed tremendous burden upon the CENTCOM IT facilities within the last two years. These issues began to have a negative impact on growth, services as well as availability. This overall situation culminated over the past calendar year to the point which IT growth came to a standstill. The rollout of new and improved intelligence initiatives and services to the war fighter was in jeopardy.

During this period the Defense Intelligence Agency established five Regional Service Centers worldwide with the purpose of improving efficiency and reducing duplication of effort within the IT community. The Central Command (CENTCOM) J2 IT staff was absorbed by DIA and transformed into the Southeast Regional Service Center (SE RSC). The region includes Southern Command (SOUTHCOM) and Special Operations Command (SOCOM) both major commands with a heavy intelligence mission.

In order to optimize the current IT footprint and move forward the SE RSC established the Support Services group. The role of this group was to embark upon the task of not only optimize but to expand where necessary and plan for the future.

After several modest but costly attempts to optimize the current IT footprint it became evident that the organization needed more than a consolidation of resources and lifecycle replacement initiatives to modernize the data center infrastructure. The organization needed a dedicated data center space approximately 2,000 to 3000 sq. ft. in size and capable of providing as much redundancy as possible. In addition, this space needed to be able to support growth for approximately 2-3 years after which a new 11,000 sq. ft. footprint would be available.

The final decision was to build within currently available CENTCOM space by relocating personnel and converting office space to data center space. In addition, compounding requirements left only 4 to 5 months to resolve funding, contracting, engineering and construction challenges.

Leading up to this point, the Support Services team had conducted several months of study, analysis and optimization. The SE RSC Support Services team developed a best practices and recommendations guide for data centers design and management. The team determined that the next generation data center should utilize pre-engineered solutions from established vendors which adhere to current industry standards. The goal: a data center that has three design objectives it must be modular, scalable and flexible. This objective was achieved within budget and timeline by forging strategic partnerships with American Power Conversion (APC), Corning Cable Systems and close coordination with MacDill AFB infrastructure engineering teams as well as strong support from SE RSC leadership.

Business situation
During FY05 and FY06 the largest IT challenges the SE RSC faced were facilities related. Not only was growth at a virtual standstill, systems availability was becoming more and more of a challenge. This was due not only to unprecedented IT growth but to a largely unmanaged facilities infrastructure. The organization was for the most part unable to determine how power and HVAC resources were being utilized. In turn Support Services was unable to properly
provide guidance and planning support for the installation of inbound as well as current requirements within the data center footprint.

On the surface the customer recognized the very serious problem of space, power and cooling. This simplistic view transcended throughout the entire organization and was not just confined to the intelligence facilities. Due to this reality, the users became accustomed to disruptions in service. Recurring cooling and power issues within CENTCOM facilities had become commonplace and unfortunately routine.

**Technical situation**

During FY06 increased demand for power and cooling within CENTCOM facilities became such an issue that the HQ Commandant, whom is responsible for the overall facility, issued multiple warnings to the IT organizations that facilities related failure was imminent with the Headquarters Building and disruptions would be inevitable. This put the SE RSC in an awkward position of providing uninterrupted services to the intelligence customers with no confidence in the building infrastructure on which it relied.

**Research**

The SE RSC began the research process by looking back at the past 10 years of growth by conducting a “Trend Analysis”. This was an attempt to gauge where the organization was headed as well as to help quantify requirements for the new data center in the planned JICCENT facility (completion in 2009).

The requirements for the new data center was derived from a culmination of emerging industry standards such as EIA/TIA 942 (the first published data center design standard) as well as lessons learned from past data center projects. By examining industry best practices the organization began to realize dramatic design flaws within the current data center facilities and infrastructure. Reaching out to the industry allowed the SE RSC Support Services to gain knowledge of the most recent trends and best practices for designing data centers. Organizations such as Uptime Institute, Association for Computer Operations Management (AFCOM), Gartner Group, Corning Cable Systems as well as APC provided insight into the quickly emerging field of the “high-density” data center and how to build and prepare for the future.

Internally, CENTCOM facilities were suffering from many of the same problems as other IT organizations in the private sector. Issues such as server sprawl, increased uptime requirements, the deployment of blade servers, increased demand for data storage and an emerging service provider model were all factors that contributed to the problem. It became evident that a dramatic shift from the current mindset was necessary to move into the future.

**Solution**

The guidance was to create a new data center within current space by relocating personnel and reorganizing multiple areas. The SE RSC Support Services group proposed a plan to build a data center within a facility that had approximately 2,000 sq. ft of floor space available. After several weeks of careful examination it was determined that the project was feasible but the timeline and completion date of end of calendar year 2006 or January 2007 was going to be a major challenge if not impossible due to the upcoming holidays. The project under normal circumstances would have taken at least 6 months to complete. This was mostly due to the amount of demolition and outside electrical and mechanical work that was required.
Data Center

There are only a few major vendors in the industry that can provide a pre-engineered or mostly pre-engineered data center solution. APC has such a solution that utilizes a "building blocks" type approach to build custom data centers with pre-tested components.

The APC InfraStruXure® solution features components such as; racks, integrated hot and cold isles, cable management, uninterruptible power supply systems, environmental and power monitoring, power distribution equipment, in-row cooling and water distribution equipment that is all designed to work together. These subsystems work together efficiently and it can be rapidly deployed and installed by teams that understand the components so well that surprises during the roll-out are virtually eliminated.

The above mentioned components assembled in less than three weeks to provide 66 usable equipment racks within 2000 square feet of floor space.

The overall design layout is based on the Uptime Institute’s “Hot and Cold” isles design recommendation. Orienting the racks and rows with a front to front and back to back configuration allows for a much more efficient cooling design.

Cable Plant

The fiber-optic cable plant is a very important subsystem of the data center and deserves equal planning and attention. In a high security, multi-classification military environment a well designed cable plant can provide flexibility for network and storage requirements.

Historically, the cable plant is installed on an ad-hoc basis and therefore lacking in consistency and predictability. This outdated custom not only hinders the roll out of new systems it can be a major stumbling block during routine troubleshooting.

Many vendors offer quality products in this market but this project needed a vendor that could guarantee a solution that could not only be rapidly deployed but 100% recoverable. It was simply a waste of resources to deploy and terminate the necessary amount of fiber-optic cable to bring the new data center online for a 2-3 year project. Traditional methods of terminating fiber-optic cable would not only slow down the completion of the data center dramatically it would be extremely wasteful because cable being removed at the end of the project would essentially become scrap.

The solution was to partner with Corning Cable Systems to design a cable plant using factory-terminated “Plug and Play” cable. The factory-terminated (plug and play) solution consists of optical cable prepared in a controlled environment, terminated on both ends with Mechanical Transfer Plug (MTP) connectors and tested to form what is called a cable trunk. The MTP connector, a newer type of Multifiber Push On (MPO), is a 12-fiber push/pull connector similar in shape to an SC simplex connector, but with all 12 fibers in a single ferrule. Using 12-fiber MTP connectors on cable trunks provides high scalability in a compact cable size, thus reducing the size and quantity of cable trays needed. This solution due to its efficient size and manageability was an excellent choice for this project.

Environmental and Security Management

Two computerized systems for environmental monitoring and security were implemented.

The APC InfraStruXure Manager® was deployed to monitor electrical voltage and amperage down to the individual rack PDU and outlet. This solution also allows for active management of the In-Row cooling units.
The NetBotz® InfraStruxure Central® solution was installed as an early warning system to alert the user to temperature, humidity, air flow, water leakage, and loud audio events or anomalies. Video surveillance is also provided through nine cameras located in the data center. This system allows for real time management as well as trending and historical analysis of environmental data.

**Outside Plant and Power Upgrade (Electrical and Mechanical)**

**Electrical**

It was decided that the power for the data center should be isolated from the rest of the building. A power upgrade strictly for the data center project required a new, dedicated 480 volt three-phase transformer to be installed capable of providing 600 Amps of service. Electrical power enters through a breaker panel and then to an Automatic Transfer Switch (ATS). The ATS switches the power supply to a backup generator should primary power be disrupted. Power was then divided to independently supply data center equipment racks (3 zones with 23 useable racks each) and the cooling solution (a 70 ton chiller). Electrical input for the data center equipment is 240 kW, 3-phase power, equally divided over three zones. Power modules in each zone are used to condition the input power. Uninterruptible Power Supply (UPS) backup batteries are provided to maintain power during power outage until generator startup. Each zone uses 80 kW to power 23 usable racks. This equates to approximately 4 kW per rack, which is sufficient to power most racks of equipment.

**Mechanical**

The cooling solution was two fold; a Carrier AquaSnap® 70-ton capacity water chiller as well as an APC 15-ton capacity air conditioning unit. The water chiller provides chilled water to twelve in-row cooling units. The electronically controlled in-row cooling units pull hot air from behind the equipment racks to deliver cold air out the front. This provides the main cooling for the rack mounted equipment. The 15-ton air-conditioning unit in combination with an indoor air handler unit provides temperature and humidity control for the ambient air in the data center.

**Fire Suppression and Early Warning System**

The fire suppression system installed in the data center is a compressed gas system that, in the event of fire, floods the room with FE 25 chemical gas. This gas deprives the fire of the oxygen that it needs to spread as well as lowers the temperature dramatically. In addition, a VESDA system (Very Early Smoke Detection Apparatus) was installed to “sniff” the room air for smoke particles. This system can in effect detect a fire long before if ever starts. For instance, if a power supply starts to fail or a capacitor starts smoldering it would be detected long before the gas system is deployed. Not only is this added safety but it can prevent the unnecessary deployment of the gas which is quite expensive to refill.

**Anti-Static Floor System**

A raised floor system is normally recommended in most data center designs. It provides a cooling plenum to push air conditioning as well as an area to install electrical and network cabling. The APC InfraStruxure® solution utilizes all overhead power and cabling distribution so it makes a traditional raised floor almost unnecessary with the exception of providing anti-static projection.

For this project the raised access floor was neither possible nor cost effective due to a very low ceiling. It was however, necessary to provide an anti-static environment since server equipment would be present in the room. High-density anti-static flooring was used to meet this requirement. This material was applied to the bare concrete sub-floor. Special conductive adhesive was used to attach the tiles to the floor. Copper grounding strips were placed in the
adhesive and wired to electrical-ground. This floor system required a non-conductive wax to be applied and buffed in before the installation of the equipment racks.

**Generator Set**

A Caterpillar brand 400 kW electrical generator coupled with integral Diesel engine and fuel tank was selected to provide backup electrical power should the primary power be disrupted. It will be located as close to the data center as practical. Since the lead-time on fixed generators is several months a temporary/portable generator was secured until the permanent one is installed.

**Additional Sub-systems**

Other major subsystems engineered as part of the project that are not part of the APC InfraStruXure® System were; a 480V transformer, an Emerson Automatic Transfer Switch (ATS), a General Electric 120V transformer with breaker panels.

**Benefits**

**Advantages of each solution**

**Data Center**

The pre-engineered data center solution from APC is completely transportable and capable of being disassembled and reassembled in a new location at an estimated savings of over 1 million dollars to the customer due to reutilization of existing equipment. De-installation of the current data center components and reinstallation into the new facility will be a difficult but very doable task if planned properly. A pre-staged footprint of compatible equipment will be necessary to reduce downtime of equipment and minimize the disruption of services.

**Cable Plant**

The benefits of the “Plug and Play” fiber optic cable solution are speed of deployment, the insurance of a completely factory-tested system, and space savings. The largest benefit to this customer was that it could be 100% recovered and reutilized once the new data center was available. The time saved from the rapid deployment of a pre-terminated solution allowed the data center to come on line much faster than would have been possible with traditional termination methods. The cost savings from this solution is compounded by the number of times that the pre-terminated cable can be reutilized. It is estimated that this part of the solution will save approximately $200K in materials and labor the first time it is reutilized within the next data center project.

**Project Plan / Implementation**

By outsourcing the largest components of the data center the integration team was able to focus on site-preparation, schedule and over-all design objectives and requirements.

The project team implemented a “compressed schedule” in consultation with the prime contractor and coordination with the sub-contractors based on the objectives set forth in the initial plan.

The project duration lasted less than three months from the point of initial construction to completion and on-site inspection.

**Outsourcing and Partnerships**

The following represents the companies contributing to the success of the Data Center in order of how they were organized.

- Prime Contractor
APC (Data Center Solution)
- Ed Taylor Construction (Site Management)
  - Colwill Engineering (Electrical)
  - JA Green (Mechanical)
- Carrier (Water Chiller and distribution)
- Ocean Flooring (Anti-Static Flooring)
- Technology Support Systems (Demo and Drop Ceiling)
- United Fire (Gas Based Fire Suppression Solution)
- Lavendera Electric Company (Base Electrical)
- Chugauch Management Services (MacDill AFB Facilities Management)

Corning Cable Systems (Cable Plant Products Vendor)

Summary
Rapid data center design and deployment is not a simple task when trying to implement current industry best practices, minimizing cost as well as maximizing return on investment. That is why it is critical to research solution sets that are compatible with the organizations business objectives.

This project was a high-impact solution that will provide a fast-payback on the investment. For the next 2-3 years the SE RSC will be able to move forward with its mission of providing intelligence services to the region while accommodating growth and optimizing its current IT footprint. Providing IT services support to other regional commands such as SOCOM and SOUTHCOM can now be a reality. In addition to the current IT support provided to CENTCOM, there will be many opportunities in the coming months to provide support for new requirements; planned as well as unplanned.

It is also important to continually refer the original design objectives to ensure that the goals are being met and that the most important subsystems are getting the necessary attention.

This project initially set out to achieve the overall objectives of modularity, scalability as well as flexibility. Not only was this achieved in a timely manner, it was done so efficiently that it will forever change the methods in which this organization plans, deploys and manages data centers into the future.
Appendix

A. Services provided by other groups or companies

More than 90 different personnel worked on-site during the course of this project. The on-site portion of this construction project stretched from before Thanksgiving (2006) and extended to just after MLK day (2007).

Below is a list of the companies/organizations that were involved in the project and performed admirably. Most personnel were located in the Tampa, FL metro area. APC provided design guidance and oversight for the custom solution. APC also flew in personnel as needed for installation of the InfraStruxure® as well as the NetBotz® environmental monitoring solution. APC also provided 2 days of on-site technical training at the end of the project.

Companies/Organizations that Contributed to the data center project

1. SE RSC S2 Staff
2. GSA IT
3. L-3 Communications Titan Group
4. General Dynamics
5. APC
6. Ed Taylor Construction
7. Colwill Engineering
8. JA Green
9. Carrier HVAC
10. Technology Support Systems
11. United Fire
12. Lavendera Electric Company
13. Chugauch Management Services
14. Base CE
15. CENTCOM J2 RDIV Facilities
16. Ocean Flooring
17. Corning Cable Systems
18. Stellar Construction
19. He-Man Electric
B. Industry Standards, Codes, and Publications

1. ASHRAE – Thermal Guidelines for Data Processing Environments
2. BICSI 002 – Data Center Design and Implementation of Best Practices
3. Telecommunications Industry Standard (TIA)/Electronics Industry Alliance (EIA)-568 – Commercial Building Telecommunications Wiring Standard
4. TIA-942 – Telecommunications Infrastructure for Data Centers
5. National Electrical Code (NEC)
C. Data Center Design Plan

Design features: In-Row Cooling, Hot and Cold Isles, In-Row/Overhead Power distribution, and Overhead Cable Management and Integrated UPS.
D. Data Center Engineering Summary

1. Innovation
   a. Pre-Engineered Solution
   b. Outside Plant Installation (~2 to 3 months)
   c. Rapid Deployment Data Center Infrastructure (~2 to 3 weeks)
   d. Recoverable/ Reusable Components
   e. Single Prime Contractor for Project

2. Best Practices
   a. Overhead Power and Cable Management
   b. 50 Micron Fiber Optic Cable
   c. N+1 Design
   d. Gas-Based Fire Protection (Clean Agent)
   e. 208V Power for all equipment with 480V Main
   f. IEC Type Power Receptacles (International Cords)
   g. LC type Fiber-Optic Connectors
   h. Hot and Cold Aisles and Walkways

3. New Technologies
   a. Zone Based Power and UPS Distribution
   b. Redundant 3 Phase Power to the Cabinet
   c. Hot Air Containment Aisles
   d. Metered/ IP Managed Power Strips
   e. Pre-Terminated “Plug and Play” MTP Fiber-Optic Cable Solution
   f. Environmental Monitoring (in every cabinet)
   g. VESDA (Very Early Warning Fire Protection)
   h. In-Row Cooling (chilled water based)
   i. No Raised Floor Required (for this project)
   j. Field Maintainable Modular Power and UPS systems
   k. Chilled Water Distribution with Flexible Pipe