

Board of Trustees Agenda Item

Board Meeting Date: January 23, 2012

Title of Item: Analysis of Data Center Options - Lease versus Build

Background and Analysis:

District staff have prepared an analysis showing the advantages and disadvantages of leasing collocation space for hosting mission critical information systems versus building a new data center.

The original Measure E and C project plans included funding for the design and construction of a data center to replace the current data center located in building L-7 on the De Anza College campus. The L-7 data center does not have the required capacity to support future district needs including adequate space to host systems, hardening to withstand seismic events, sufficient office space for staff members, and efficient environmental control systems among many other aspects.

Following the Measure C project plan, the building architects (Cody, Anderson, & Wasney) developed a design for a new data center and an adjoining office building, which will host members of the Educational Technology Services department. Cost estimates for this first design exceeded the available budget even after value engineering efforts were applied. Subsequently, the architects produced a new design that will come close to meeting the requirements of a new data center and office building but also stays within budget. Because of the potential budget overrun on the first design and the fact that several other Measure C projects were short of funds, the district conducted an analysis to understand alternative options to building a new center.

This analysis covers the benefits and challenges of leasing collocation space versus building a new data center for hosting our information systems. Vice Chancellor Sherman will present the results of the analysis to date.

Recommendation: Information only

Submitted by:	Fred Sherman, Vice Chancellor of Technology, 6120
Additional contact names:	
Is backup provided?	Yes

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Data Center: Collocate versus Build Analysis **Foothill-De Anza Community College District** **January 17, 2012**

Executive Summary

The purpose of this document is to provide background for a recommendation of one of three options mentioned below for providing data center services to the district. We are still gathering information and plan to provide a recommendation at a later date.

Three options exist to provide data center services to the Foothill-De Anza Community College District:

1. Continue with the revised plan to build a Tier 1 data center (upgradable to Tier 3) with Measure E and C funds
2. Collocate with a Tier 1, 2, or 3 data center off site
3. Renovate the existing L7 data center to bring it up to acceptable standards

This document contains many technical terms associated with data center construction and their operation. An appendix is provided at the end of this document that lists critical terms and their meanings.

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Background

The district currently hosts a data center located at De Anza College in the L-Quad (building L7). This data center measures 1,400 square feet (actual floor space for servers) and includes a raised floor and a Halon system for fire suppression. Two air conditioning units provide cooling but have proven to be unreliable and break down periodically. Redundancy in supporting systems (electrical power supply, temperature conditioning, etc.) are minimal or non-existent and the building was not built to *essential services* standards. The roof has been repaired several times for leaks and the area around the data center is subject to flooding during rainy periods. Accordingly, the systems contained within the L7 data center are at risk of damage from multiple causes. The L7 data center currently hosts over 200 servers supporting the Banner administrative system, the email and calendaring systems, the Website for the district and many other mission critical systems. This space is also the main point of entry for telecommunications for the De Anza campus and hosts the Internet connection point for the Middlefield and the High Tech Centers. The space required for telecommunications equipment in L7 will increase due to the replacement of the existing telephone system with new voice over IP (VoIP) technology.



L7 Data Center

In the year 2000, the district began planning for the construction of a data center and an associated office building for ETS personnel as a Measure E Bond project, but most of the Measure E funding set aside for this project was eventually shifted away to support other building construction projects. As a follow on action to fulfill the need for a permanent data center / office building, the district set aside funds in Measure C for this same purpose. (The district also retained some residual Measure E funds to support this project as well.) In addition, the district designated other Measure C funds for the renovation and possible expansion of the District Office Building.

In June 2007 the district hired the architectural firm, Cody, Anderson, and Wasney (CAW), to develop a general plan for the design of these renovations and new construction projects. Also, pursuant to a lawsuit by a group known as the *Friends of the Griffin House*, the district directed CAW to develop possible options for the use of an adjacent, existing house (an early twentieth century Victorian) known

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locally as the “Griffin House”. After consideration of the options and finding no economically feasible way to use the Griffin House, the district decided to stabilize the building to arrest any further decay and instead build around the Griffin House. This analysis and the associated decision process consumed some of the available bond funds designated for the construction of the data center / office building as well as the renovation of the district office building.

In April / June 2009, CAW began work on the design of the data center with the associated office building and the renovation of the District Office Building. After a preliminary cost analysis, CAW indicated that insufficient funds existed to fully renovate the District Office Building and also build the Data Center / office building. (Both projects’ projected costs exceeded their budgets.) Accordingly, the district decided to allocate \$9.4M¹ of Measure E and C bond funding to the design and construction of the data center and \$1.7M of Measure C bond funding to the renovation of the District Office Building. While the amount of funds allocated to the data center was thought to be sufficient to meet project goals, the amount of funds designated to renovate the District Office Building was not sufficient. As a result program goals on the District Office Building renovation were subsequently reduced.

CAW developed the design for the data center working with user groups in a “value management (VM)” process to fit the program into the appropriated budget for the buildings. The proposed design resulted in a Tier 1 data center and a two-story office building. This design contained minimal room for growth but met the basic needs of the district.

However, when the general contractor, Hensel Phelps, was brought onto the project, they estimated that the cost of construction would exceed the CAW estimate by approximately \$6M. In response, CAW again began working with user groups in a follow-on *value management* process to redesign the buildings to fit within the district’s budget. Some redundancy of the data center’s supporting systems in the original design was eliminated to meet budget constraints. The resulting design was a Tier 1 data center with a single story office building that could be built within budget.

Table 1: Data Center / Office Building Allocated Construction Funds versus Estimated Construction Costs

Data Center / office building	District budget	CAW estimate	Hensel Phelps estimate
Original design	\$10.5m	\$11.7m*	\$18.0m
New VM design	\$10.5m**	\$10.5m	\$10.5m

*Initial CAW estimate was increased to \$16.3m after reconciliation with HP estimate.

**Funds available for construction may need to be reduced due to soft cost/relocation increases.

The shortage of bond funds to meet the intended program use of the data center, associated office building and the renovation of the existing District Office Building allows the district to re-examine past decisions and consider the following courses of action:

- Continue with the revised plan to build a Tier 1 data center / office building and renovate the District Office Building
- Collocate district information servers into a Tier 1, 2 or 3 data center off site, spend a greater amount of Measure C funds on the District Office Building renovation and build an ETS staff building
- Renovate the existing L7 data center to bring it up to acceptable standards, spend a greater amount of Measure C funds on the District Office Building renovation and build an ETS staff building

¹ At the kick-off meeting, a budget of \$10.1M was approved.

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Risks Associated with the Current L7 Data Center

The L7 Data Center contains many mission critical systems that are at risk of damage and disruption of services due to the design and state of repair of its supporting building subsystems.

Table 2: Some Essential Systems Hosted in the L7 Data Center

Systems	Associated Services
SendMail	Email
Meeting Maker	Calendar
Banner – EIS*	Administrative automation
SARS	Counseling appointments, Lab attendance tracking
PBX	Telephone
Phone mail	Phone messaging
Core switches / routers	Networking
CENIC gateway	Internet

*A disaster recovery site for the Banner system has been established in Carlsbad, California

Table 3: L7 Data Center Failure Modes

Event	Current status	Probability of service disruption during year [^]	Event severity Recovery times
Water intrusion	Roof recently leaked (and fixed) Flooding occurs around building annually	Low (10%)	High (days - weeks)
Earthquake	Building not built to essential services standards	Low (5%)	High (weeks)
Fire	Server room protected by Halon system	Low (5%)	Medium (days - weeks)
Power failure	Generator hookup exists No onsite generator 15 minutes of aux power available [#]	Medium (40%)	Medium (hours-days)
HVAC failure	Two units provide cooling No redundancy Frequent failures	High (50%)	Low (hours)

[^] The percentages / recovery times stated above are representational, but not based on any specific calculation

[#] The PBX has an eight-hour battery back up system

Notes:

- Probability that one or more events will happen annually: 76%
- Probability of one or more high severity events happening annually: 15%
- Having multiple systems damaged will result in longer recovery times

New Data Center Design

The goal is to build a Tier 3 data center to *essential services* standards, which provides redundancy and robustness to ensure IT operations in all but the most severe disaster events. The proposed FHDA data center was originally designed to Tier 1 and *essential services* standards with a redundant chiller system and the capability to upgrade to Tier 3 later as an add option. The current revised (value management) plan is build the data center to Tier 1 and *essential services* standards with the capability to upgrade to Tier 3 at a later time.

Some areas that were altered in the original design impacted:

- Redundancy
 - Elimination of the secondary (redundant) chiller system
- Efficiency
 - Changing from a water cooled to an air cooled chiller
 - Elimination of the chilled beam system (for internal office temperature control)
 - Elimination of the Variable Air Volume (VAV) HVAC (for the data center)
 - Reduction of the number of HVAC zones from 23 to 15 (in the office building)
- Growth
 - Elimination of the redundant portion of remaining chiller system, which was designed to accommodate growth in equipment needed for the data center
 - Setting aside procurement and installation of 18 cabinets designated for growth
 - Setting aside procurement and installation of the power infrastructure required for the 18 growth cabinets

As you can see in the table below, redundancy, which is an important component of data centers for fault tolerance, was planned into past and present designs primarily as a feature to be added at a later date when additional funding becomes available. Fault tolerance is achieved by including back up systems in the design that can take over the function of the primary system if it fails for any reason.

Table 4: Comparison of Original Design to Value Management Design

	Original Design	Revised Value Management Design	
	Was (N+1) redundancy in the design?	Is (N+1) redundancy in the design?	Can (N+1) redundancy be added later?
High bandwidth network feeds	No	No	Yes
Internet providers	No	No	Yes
Main electrical power feed	No	No	Yes
Back up generators	No	No	Yes
Uninterruptable power supplies (UPS)	No	No	Yes
Cooling systems (chillers, fans, HVAC)	Yes	No	Yes

Note: (1 + 1) redundancy currently exists for our deployment of Banner through the use of a “hot site” setup located in Carlsbad, California.

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Building / Leasing / Collocating a Data Center

The tradeoff between building, leasing or collocating a data center is a function of many factors, but for Foothill-De Anza Community College District, cost is a key driver.

A. BUILD - LEASE COST ANALYSIS

Teledata, a data center design firm employed by the CAW architects, ran a cost analysis of lease costs for a typical commercial collocation site located in the Silicon Valley area by obtaining cost estimates from five local collocation vendors. These costs were compared to the construction cost of the data center to produce a simple breakeven point reflecting the number of years to accumulate the equivalent amount in lease costs. Using the assumptions detailed below, the breakeven point is between 10 and 11 years.

Key assumptions:

- Will lease Tier 2 data center space
- Need 20 server cabinets (minimum for initial installation) in 600 sq ft
- Used commercial lease rates for Silicon Valley area facilities
- Did not include *managed services*, lost staff time due to travel, or staff travel costs
- Did not consider the *time value of money*
- Did not include any server growth rate

Analysis Results

- One time transition costs to lease: .. **\$526,947²**
- Monthly operating costs to lease: **\$59,200**
- Data center construction costs:..... **\$7,800,000³**
- Simple breakeven point: **10-11 years⁴**

Actions that would shorten the breakeven point (reduce the number of years):

- Use the cost of leasing a Tier 3 data center space. (This would be offset by including the cost of building to Tier 3 standards.)
- Include costs for managed services, lost staff time due to travel, leasing staff office space at collocation site, and staff travel costs
- Assume an annual growth rate for expanding data center servers and equipment⁵
- Include the increased cost to the ETS office building to include additional workspace if the data center is not built onsite.

Actions that would extend the breakeven point (increase the number of years):

- Include costs to build to Tier 3 standards. (This would be offset by including the cost of leasing to Tier 3 standards.)
- Lease data center space in low utility cost areas, perhaps out of state. (This may be offset by including staff travel costs and lost work time due to extended travel.)

² Refer to Table 5 below for a breakdown in one-time transition costs. Source: Teledata

³ Includes both hard and soft construction costs. Source: Art Heinrich

⁴ The breakeven is slightly over 10 years using the average of the five vendors' costs. It is almost 11 years using only the lowest cost vendor.

⁵ The breakeven point drops to less than 8 years if a 10% annual growth rate for the number of servers is included in the calculation.

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- Establish a more cost-effective collocation arrangement with another non-profit institution
- Include the utility costs of operating the (to be built) data center into the calculation
- Include the time value of money into the calculation
- Include costs to dispose of (or repurpose) facilities associated with an onsite data center and associated equipment at end of life or refurbish / renovate an onsite data center as needed due to aging

Table 5: Breakdown of One-Time Transition Costs

Area	Cost	Detail
Communications cabling / infrastructure	\$60,400	Network, fiber / copper, ladder rack
Cabinets / power strips	\$69,347	Server cabinet/Installation (2) Monitored power strips & installation and software
Electrical	\$47,200	Dedicated electrical harness installed
Network equipment / service providers	\$150,000	Allowance for additional network gear and installation of network circuits
Engineers	\$100,000	Allowance for outside engineers / contractors
Server room move	\$100,000	Allowance for moving equipment from old data center (L7) to leased collocation site
Total	\$526,947	

B. EXISTING COMMERCIAL COLLOCATION RELATIONSHIPS

Collocation either through a commercial vendor or through collaboration with another organization is an alternative to building a data center. The district already uses collocation and cloud services to manage some of its applications as indicated in the table below.

Table 6: Some Cloud / Collocation Services Used by the District

Organization	System	Vendor	Type
District	EIS Administrative System (disaster recovery)	ABTech (Carlsbad, CA)	Collocation with managed services
Foothill College	Web server	NTT Verio (San Jose)	Collocation
	Learning Management System	Etudes, Inc.	Cloud, hosted application
De Anza College	Community Education Administrative System	Augusoft (Minneapolis, MN)	Cloud, hosted application
	Web Server	NTT Verio (San Jose)	Collocation

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C. POSSIBLE COLLABORATIVE COLLOCATION RELATIONSHIPS

The district discussed possible joint arrangements or partnerships with several higher education organizations. While most of these organizations were interested in collaboration, they were not at a point where they could discuss specific terms and conditions including available space or cost models for hosting another institution's equipment (except CENIC). The one exception is Santa Clara County Office of Education.

San Joaquin Delta College Data Center

The San Joaquin Delta College recently built a data center that will have excess capacity. Their technical team is currently installing network electronics and will be moving their data center equipment into the building. Dave Sartain, their Director of Technical Services, will be developing a business plan for hosting partnerships and will contact us with further details when available.

CSU East Bay Data Center

The new CSU-EB data center is in the process of being constructed. The 1,600 square foot data center will have excess capacity for four to six cabinets when finished. The basic 4-story building containing the data center has been built and they are currently in the process of fitting out the interior. Estimated completion date was November 31st, 2011. The data center has a raised floor with hot and cold aisle containment. The data center building is located 400 yards from the Hayward fault. It is not known if the building was built to essential services standards. Rich Avila, network director, has not developed a business plan for leasing space but is amenable to further discussions. He would consider providing managed services utilizing their 3PAR SAN environment.

Amazon Leased Cloud Services through CENIC

CENIC has been working with Amazon in an arrangement to allow CENIC member institutions to obtain reduced costs and improved performance for the use of Amazon's compute and storage services, collectively called Amazon Web Services (AWS). The Amazon servers hosting these leased services are located on the East Coast although arrangements can be made to locate on West Coast servers at an increased cost. CENIC is asking its members for volunteers to pilot the business arrangement. No managed services are available through this offering.

San Mateo Community College District Data Center

San Mateo CCD was planning on building a new data center subject to the successful passage of a facilities bond, which came up for a vote in November and was not passed. The old center was built in the 1970s and their IT director, Eric Raznick, does not think it would be suitable for us. Eric expressed an interest in further discussions regarding the possibility of jointly building a data center that would be shared and located somewhere between the two districts but this is unlikely now that the bond did not pass.

Chabot - Los Positas Community College District Data Center

Chabot – Los Positas CCD has a relatively new data center with some excess room for growth. The Chief Information Officer, Jeannine Methe, is unsure if there would be enough excess capacity to host our servers. Also unknown is whether or not space would be available on a long-term basis. Jeannine is interested in further discussions.

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Santa Clara County Office of Education (SCCOE)

The Santa Clara County Office of Education is planning to renovate space to establish a 2,000 square foot Tier 1 data center in their offices at 1290 Ridder Park, Drive, San Jose (the SCCOE main facility). (Their offices are located outside of the FHDA district boundaries.) SCCOE requires 1,000 square feet of data center immediately and the rest will be used for growth needs. Dr. Kelly Calhoun, their CTO, is interested in discussions about a joint partnership along with the possibility of upgrading their data center to Tier 3 standards with joint investment. They could accommodate our needs by letting us renovate their existing data center area, after they have moved out at the end of August.

Key issues:

- Is the SCCOE office building built to *Essential Services* standards?
- Do they have Superintendent approval for FHDA to use part of their space?
- Do the details of their planned design meet our requirements?
- What kind of lease terms and governance structure can we arrange?
- Does this arrangement make sense from a cost analysis standpoint?

Discussions are continuing.

Other Opportunities

No local municipalities were identified who might have an interest in a collaborative effort with the district to build / lease a data center.

D. FUTURE TRENDS FOR DATA CENTERS

Several recent studies on *lease versus build* preferences regarding data centers indicate an interest by some organizations to move data center operations to collocation facilities. However, ~ 60% of survey respondents indicated an interest in building, relocating, or upgrading data centers, while only ~20% to 30% indicated an interest in moving to a collocation site. The surveys did not differentiate between managers' interests in moving either all or just some of their data center operations to collocation sites.

Table 7 Lease versus Build Preferences

Survey Result	Year	Study Name	Survey respondents
62% said they would handle demand for more data center facilities by consolidating servers 40% would build a new data center 29% would lease collocation space 60% will build a new data center or perform renovations and/or upgrades in the next 3 years.	2011	<i>Inaugural Uptime Institute Annual Data Center Industry Survey, May 2011</i> Uptime Institute Uptime A third-party research, education and consulting organization	525 data center owners and operators based mostly (71%) in North America
22.0% will utilize a co-location center to meet their increased space requirements 13.8% will use managed hosting services 30.0% will relocate to a new facility 32.6% will upgrade existing facilities	2010	<i>2009/2010 AFCOM Data Center Trends Survey Results & Analysis</i> AFCOM Assn for Data Center Management Professionals	436 data center sites from - Priv Industry 84.5% - Govt Agencies 8.1% - Colleges or Univ 7.4%

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Similarly, 15% to 35% of survey respondents indicated that they have or are planning to move into cloud computing. Only 4% of educational organizations have deployed ERP systems into the cloud.

Table 8 Adoption of Cloud Computing

Survey Result	Year	Study Name	Survey respondents
4.4% of institutions have moved their back-office ERP systems to the cloud >80 % have definitively elected not to move their back-office ERP systems to the cloud 6.5% are storing and archiving data in the cloud	2011	<i>Campus Computing Survey</i> , November 2010 Campus Computing Project (Kenneth Green)	496 Institutions - Public Universities - Private Universities - Community Colleges
20% <u>will</u> move IT workloads to the cloud. 5% are considering or implementing <u>public</u> cloud computing over the next 12 months. 42% are considering or implementing a <u>private</u> cloud option, with 27% choosing a hybrid method.	2011	<i>Inaugural Uptime Institute Annual Data Center Industry Survey</i> , May 2011 Uptime Institute Uptime A third-party research, education and consulting organization	525 data center owners and operators based mostly (71%) in North America
> 20% of companies considering cloud computing have actually implemented 50% of organizations say their staff is not ready to implement cloud computing	2011	2011 State of Cloud Survey, Symantec	5300 organizations in 38 countries, small to large enterprises
14.9% of all data centers have adopted cloud computing 46.3% have considered but never implemented cloud computing.	2010	<i>2009/2010 AFCOM Data Center Trends Survey Results & Analysis</i> AFCOM Assn for Data Center Management Professionals	436 data center sites from - Priv Industry 84.5% - Govt Agencies 8.1% - Colleges or Univ 7.4%

Options: Benefits and Challenges

Three options, which the district is considering for the lease versus build decision, are:

1. Continue with the revised plan to build a Tier 1 data center (upgradable to Tier 3)
2. Collocate with a Tier 1, 2, or 3 data center off site (commercial lease or joint partnership with a non-profit)
3. Renovate the existing L7 data center to bring it up to acceptable standards

The table indicates the benefits and challenges with each option.

Table 9: Benefits & Challenges of Collocate versus Build Options for District Data Center

Options	Pros (Benefits)	Cons (Challenges)
1) Build the data center	<p>Capital funding exists to build to <i>essential services</i> standard – upgradable to Tier 3 standards</p> <p>We own / control the asset</p> <p>Provides close proximity with offices (no travel by technicians needed)</p> <p>All ETS personnel (except for client teams) will be located together</p>	<p>Data center is located in seismically active area where increased likelihood of events exists (heightened risk factor)</p> <p>Data center is located in a high utility cost area</p> <p>Insufficient capital funds exist to immediately build to Tier 3 standards (if office building is also built). Additional funds are required to achieve Tier 3 standards.</p>
2) Collocate data center space / services	<p>May be able to locate in more seismically stable area with lower utility costs (lower disaster risk / lower operating costs)</p>	<p>Operating funds are not easily available</p> <p>Ongoing costs continue after breakeven point (10 – 11 years)</p> <p>Need for additional travel costs (time and money) to service equipment or require the hiring of personnel / services at collocation site (<i>managed services</i>)</p> <p>Requirement to convert current operations to <i>Lights out</i> operations (time, training, equipment acquisition issues)</p> <p>Obtaining collocation services from a vendor places the district at the mercy of the vendors with regard to cost escalation</p> <p>Sharing a jointly operated facility increases the complexity of operations affecting legal agreements regarding ownership, coordination for the security of each other's assets, and arrangements for allocating operating costs between the organizations</p>

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Options	Pros (Benefits)	Cons (Challenges)
3) Renovate the current data center (L7)	Less capital funds will be required for L7 renovation	L7 building cannot be renovated to meet <i>essential services</i> or Tier 3 standards (resulting in a low fault tolerance to disaster events or equipment failure) Limited growth potential due to constrained space Difficult to make L7 energy efficient Severely limited space at De Anza College for positioning onsite staff ETS staff dispersed across two campuses

Conclusions to date

Three options exist to provide data center services for the district:

1. Continue with the revised plan to build a Tier 1 data center
2. Collocate with a Tier 2 data center off site
3. Renovate the existing L7 data center to bring it up to acceptable standards

Option 1 (Build)

- The proposed new data center with the revised design can be built within the original budget.
- The build option offers the opportunity to collocate all ETS staff members (except for client teams) in one location.
- It will take ten to eleven years to reach the breakeven point when comparing the cost of building versus the cost of procuring a commercial lease for facilities.

Option 2 (Collocate)

- Moving to a collocation site will necessitate retraining the operations staff and acquiring new equipment to provide remote operations capability as well as possibly relocating some staff to the collocation site.
- Some ongoing staff resources will be expended in travel time between the campus and a collocation site on an ongoing basis
- Possibilities exist for establishing a partnership with another non-profit to reduce the costs of operating a data center. The Santa Clara County Office of Education's plan to build a data center offers the best opportunity of establishing a partnership to jointly build and operate a data center.
- Sharing a jointly operated facility increases the complexity of operations affecting legal agreements regarding ownership, coordination for the security of each other's assets, and arrangements for allocating operating costs between the organizations.
- Obtaining collocation services from a vendor places the district at the mercy of the vendors with regard to cost escalation. Applying leverage with the vendor to lower or maintain costs will be limited due to the expense, time, and risk of moving our equipment between sites (if we wanted to use the threat of relocating to another collocation site).

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Option 3 (Renovate existing L7 data center)

- The current L7 data center cannot be renovated to achieve Tier 3 essential services standards without a very large investment in capital funds.

Trends:

- Surveys of data center managers indicate strong interest in pursuing both collocation and construction of new data centers. More managers are building or improving data centers rather than using collocation to expand data center facilities.
- The use of cloud services to host critical systems (such as ERPs) by educational organizations is very low.
- No statistics are available on whether organizations are using collocation as a replacement for their existing data centers or as an additional facility to complement their existing data centers and expand their businesses.

Recommendations

To be developed after further research and analysis

Appendix A: Definitions

A. BUSINESS CONTINUITY

Business continuity is a practice of planning and implementing procedures along with supporting equipment and systems so that mission essential services and systems can continue to operate when a destructive or disruptive event (disaster) occurs, which would otherwise prevent continuous operations. In data center design, buildings are usually constructed to *essential services* standards and with redundant components for business continuity purposes.

B. CLOUD COMPUTING

Cloud computing is a type of service whereby an organization provides computing services through the hosting of facilities and systems (data center, networks, computers, operating systems, and / or applications) to a recipient organization. Cloud computing may be provided by vendors for a fee through their facilities or it may be provided by a central IT staff to its parent organization. One category of cloud computing is “infrastructure as a service (IaaS)” where an organization provides services through hosting the data center, networks, computers, and possibly operating systems for external or internal clients who install and run their applications on this infrastructure. IaaS can be an alternative to building a data center or leasing space at a collocation site.

According to the National Institute of Science and Technology (NIST), Cloud Computing has five essential features:

- On-demand self-service
- Broad network access
- Resource pooling
- Rapid elasticity
- Measured service

C. COLLOCATION CENTER

A collocation center (also called a colocation center or *colo*) is an offsite data center facility in which multiple (usually independent) organizations share space, utilities, services, and resources to provide data center services to their respective institutions. Collocation centers can be leased commercially or community managed.

D. ERP (ENTERPRISE RESOURCE PLANNING)

An ERP refers to the mission critical system that is used to automate the core business processes and functions of an organization. Our ERP system is Banner.

E. ESSENTIAL SERVICES CONSTRUCTION STANDARDS

Essential services are construction standards in which a building is built structurally strong so as to allow safe occupancy and use after a significant seismic event occurs.

F. FAULT TOLERANCE

Fault tolerance is the capability of a system to continue to function, albeit at a reduced but acceptable level, after experiencing a failure of one or more of its components.

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G. HVAC (HEATING, VENTILATION, AND AIR CONDITIONING)

HVAC is a unit or system of units that is employed to maintain temperature and air flow (e.g. environmental conditioning) for a building.

H. HOT SITE

A hot site is a remote, offsite location where a replication of a mission critical system and its essential supporting components are maintained and operable so that the primary system can be rapidly switched over to the replicated system in the event that the primary system is taken offline or becomes severely degraded in operations.

I. LIGHTS OUT DATA CENTER

The "lights-out" data center eliminates the need for direct access by personnel, except during infrequent occasions. All devices are accessed and managed remotely. Most operations are conducted through automated programs, systems and services.

Some *Lights Out* Data Center Technologies

- KVM over IP
- Remote power management
- Environmental monitoring
- Reliable Arrays of Independent Servers (RAIS)
- Virtualization

J. MANAGED SERVICES

Managed services is a term used to describe outsourcing of IT services such as monitoring and supporting computers, servers, network, and software applications. Data center managers often purchase managed services to handle issues associated with hardware / software maintenance and installations when leasing data center space from a collocation site.

K. N+1 / 1 + 1 REDUNDANCY

Components (N) have at least one independent backup component (+1). In N + 1 redundancy, backup components which may be turned on or off are nonetheless placed in a standby mode and must be switched in to replace a primary resource that might be disabled or functionally diminished in capability. "1 + 1" redundancy occurs when both the primary and backup systems are active, connected and simultaneously participating in supporting the system.

L. ROM

Rough order of magnitude (cost) estimate

M. TIER 1 THROUGH 4 DATA CENTER DESIGN STANDARDS

The Tier 1 to 4 data center design standards are a standardized methodology used to define the level of fault tolerance, the ability to operate through disasters and the capability to remain operational (uptime) of a data center. A *Tier 4* data center considered as the most fault tolerant, reliable, and able to continue operations during disasters.

Table 10: Data Center Design Standards

Tier 1	Non-redundant capacity components (single uplink and servers)
Tier 2	Redundant capacity components for power and cooling including UPS modules, chillers, heat rejection equipment, pumps, cooling units, and engine generators
Tier 3	<u>Concurrent maintenance enabled</u> : Dual-powered equipments and multiple uplinks (redundant delivery path for power and cooling; redundant control systems for the mechanical plant, start systems for engine generators, EPO controls, power sources for cooling equipment and pumps, isolation valves, etc.)
Tier 4	<u>Fault tolerant enabled</u> : All components are fully fault-tolerant and dual powered including uplinks, storage, chillers, HVAC systems, servers etc.

Redundant systems in Tier 4 architecture include:

- High bandwidth network feeds
- Electrical power feeds
- Back up generators
- Uninterruptable power supplies (UPS)
- Cooling systems (chillers, fans)

N. VALUE MANAGEMENT (VM)

In construction, value management is the application of analysis and techniques to modify a building design so that it provides the maximum value per cost (e.g. maximizes the benefit to cost tradeoff). Value management or value engineering is often used to re-scope a building design to fit within an available budget.