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In keeping with generally accepted government auditing standards and Auditor's Office policy, as authorized by city ordinance, the Audit Services Division has a responsibility to monitor and follow up on audit recommendations to ensure city agencies address audit findings through appropriate corrective action and to aid us in planning future audits.

Our original audit evaluated data centers operated by both the city and Denver International Airport. However, this follow-up report addresses only the 11 recommendations made to the city's Technology Services agency in that audit. The recommendations made to the airport include implementation dates that extend to 2021. As such, the airport recommendations are not included in this report and will be addressed at a later time.

In our first of two follow-up efforts for the “Data Centers” audit report issued in January 2019, we determined the Technology Services agency fully implemented some of the recommendations we made to it in the original audit report. However, despite the agencies' efforts, auditors determined that the risks associated with the audit team's initial findings have not been fully mitigated. As a result, the Audit Services Division may revisit these risk areas in future audits to ensure the city takes appropriate corrective action.

The Highlights page in this report provides background and summary information about the original audit and the completed follow-up effort. Following the Highlights page is a detailed implementation status update for each recommendation. We have communicated separately with Technology Services about the status of additional recommendations we reported confidentially because of their sensitive nature.

I would like to express our sincere appreciation to the Technology Services personnel who assisted us throughout the audit and the follow-up process. For any questions, please feel free to contact me at 720-913-5000.

Denver Auditor's Office

Timothy M. O'Brien, CPA
Auditor
Data Centers – Technology Services
September 2020

Objective
This audit evaluated the two data centers operated by the City and County of Denver’s Technology Services agency. The data centers were assessed for efficiency and effectiveness of operations against applicable standards to ensure the security and the operability of technology assets, such as equipment, facilities, and infrastructure.

Background
Data centers house critical information technology assets, including servers, routers, and other devices. Technology Services is responsible for a primary and a secondary data center. These two data centers use a mix of cloud-based and in-house technology solutions.

Technology Services provides all IT-related infrastructure and services to the city, including support for the data centers audited in this report. The General Services Department provides facility support, including maintenance and operation of city facilities that support Technology Services’ data centers.

REPORT HIGHLIGHTS

Highlights from Original Audit

Data Center Infrastructure Could Not Easily Adapt to Changes in Operations
- Environmental controls at one city data center did not provide consistent temperature and humidity for the data center to function at optimal performance.
- The existing data centers did not provide sufficient geographic diversity.
- Technology Services could not provide a complete and accurate inventory of data center hardware, applications, databases, and other equipment.

Data Center Operations Lacked Application Reviews, Cost Data, and Collaboration between Technology Services and Business Technologies
- No process was in place to review and approve the continuing use of software applications running in the data centers to ensure they still provided appropriate value.
- The Technology Services agency did not track the costs of application services, making it impossible to truly determine the cost of providing or changing these services.
- The Technology Services agency and the Business Technologies division did not share their data center management tools and knowledge, so they missed out on opportunities for cost-savings and efficiency.

Technology Services Did Not Employ Consistent Operational Standards at All Data Center Locations
- Technology Services had not adopted comprehensive data center operations and control frameworks to ensure consistent operations.
- The city's General Services Department operated without complete policies and procedures to provide facility services at Technology Services’ data centers.
- Employees sometimes made unauthorized changes in Technology Services’ data centers.

FULLY IMPLEMENTED 3
PARTIALLY IMPLEMENTED 7
NOT IMPLEMENTED 1
While the Technology Services agency implemented three recommendations made to it in the “Data Centers” audit report, seven recommendations were only partially implemented, and another has yet to be acted upon.

By fully implementing three of our recommendations, the Technology Services agency is now ensuring the city data centers are collaborating with other agencies to share tools and knowledge and are implementing standards to align with TIA-942, the Telecommunications Industry Association’s standard for data center quality. Additionally, Technology Services made a concerted effort to address the IT change-control process through both governance and training. These remediations by Technology Services help address the security risks associated with the city’s data centers.

However, risks remain that Technology Services will not address all access and security controls at the city data centers. This includes geographic diversity, inventory management, cost analysis, and policies and procedures for data center operations. Additionally, several vulnerable systems on the city network have still not been properly addressed.
FINDING 1 | Data Center Infrastructure Cannot Easily Adapt to Changes in Operations

Recommendation 1.1  Relocate Data Center (Technology Services) – The Technology Services agency should complete the replacement of its secondary data center with a suitable location.

AGENCY ACTION

Original target date for completion: December 2019

We interviewed Technology Services leadership and received further corroboration that the agency has a project to migrate the services of the city’s primary and secondary data centers. According to our review of project documentation, we determined Technology Services migrated most of the services to a hosted data center.

Project documentation included the current migration status of the two data centers, including data migration, equipment rental from the hosted data center, and physical infrastructure being laid throughout the city.

We found the overall data center migration project followed the city’s IT intake process and Technology Services leadership provided timely approvals for project intake documents. However, the city could not migrate certain services — such as mainframe servers — to the hosted data center at this time, and Technology Services had no formal solution for migrating the unsecure servers.

Therefore, we consider this recommendation partially implemented.

Recommendation 1.4  Develop Data Center Inventory Report (Technology Services) – The Technology Services agency should develop, as soon as possible, a readily available, easy-to-run report that provides a complete and accurate inventory of all data center hardware, software applications, databases, and underlying equipment.

AGENCY ACTION

Original target date for completion: June 2019
In its initial response in January 2019, the Technology Services agency identified the NetZoom tool as its data center inventory management solution. This was later confirmed by the information security manager who was acting as the sole administrator for the tool at the time.

The information security manager demonstrated the tool for us, showing a prepopulated database of infrastructure components that they could select from the list. We also noted the addition of a Virtual Private Network, or VPN, device and a visualization of the racks where infrastructure is located in the hosted data center.

While a solution has been implemented and progress has been made to inventory assets at the hosted data center, the process is not yet complete. There is currently no easy-to-run report providing a complete and accurate inventory of data center assets, because the migration of inventory to the hosted data center is not fully recognized by the system. This is dependent on the migration of data center services from the city-managed site to the hosted data center, as described in Recommendation 1.1. Therefore, we consider this recommendation partially implemented.

**Recommendation 1.5**

**Perform Periodic Review of Inventory (Technology Services)** – The Technology Services agency should develop as soon as possible a process to periodically assess the completeness and accuracy of data center inventory.

**NOT IMPLEMENTED**

**AGENCY ACTION**

**Original target date for completion: June 2019**

Technology Services purchased the NetZoom tool to help map out and provide a visual representation of the data centers. Technology Services officials informed us that adding, deleting, and modifying physical assets in NetZoom is performed manually as these assets are migrated over from the city data centers. This process includes cabling but does not include applications or services. Additionally, one individual is responsible for updating the tool, and no one reviews these entries. NetZoom has a user-friendly configuration wizard for data validation when inputting data center assets. It follows the Data Center Infrastructure Management framework, but this should not be viewed as a reliable control as it does not detect unauthorized access.

Technology Services officials said there are no other data center inventory tools available in the city-managed data centers, and a process to periodically assess the completeness and accuracy of the data center inventory has not been performed. Therefore, we consider this recommendation not implemented.
Recommendation 2.1

Perform Periodic Application Review (Technology Services) – Working with the Mayor’s Office, the Technology Services agency should enhance their existing process, as soon as possible, for reviewing the business justification and appropriateness of software applications. This review process should occur at least every three to five years, include all applications, and be done in consultation with application owners.

AGENCY ACTION

Original target date for completion: December 2019

Technology Services engaged with a third party to provide the foundation of an application review process based on industry best practices. The third party provided strategies allowing Technology Services to align agency goals and its technology portfolio, reduce the city’s risk profile by eliminating outdated and inefficient hardware and software, and improve application cost of ownership by replacing end-of-life IT assets. However, a complete inventory and a total cost of ownership is required, and these efforts are still in progress. Due to the COVID-19 pandemic, the project is on hold as key Technology Services staff members were no longer available.

We reviewed documentation showing the progress made in eliminating outdated hardware and software. We noted Technology Services was able to address the risk for some older services by purchasing extended support.

Although Technology Services has made significant efforts to address the recommendation, we found vulnerable systems have still not been remediated and still do not have a well-documented timeline for remediation.

Therefore, we consider this recommendation partially implemented.
**Recommendation 2.3**

**Track Data Center Costs (Technology Services)** – The Technology Services agency should track costs associated with providing data center support. These tracked costs should include:

- Personnel costs – including salaries and benefits;
- Building costs – including utilities, insurance and other direct facility costs;
- IT infrastructure costs – including hardware and supporting software, such as operating systems costs; and
- Application-specific costs – including licensing, specific hardware needs, and maintenance costs.

**AGENCY ACTION**

**Original target date for completion: December 2019**

Technology Services uses a data feed at the hosted data center’s customer portal to track costs. This web-based portal allows Technology Services officials to view the key costs of the services they have procured. We used the portal to verify cost trend analyses, internet service provider costs, and associated IT infrastructure costs.

Technology Services’ chief technology officer told us the hosted data center provider would eventually generate these metrics for the city periodically; however, there is no formal agreement to perform this function.

While Technology Services can obtain metrics in real time through the portal, the agency has not enacted a plan to leverage these financials or costs. Furthermore, costs cannot be properly evaluated until the migration to the hosted data center is complete.

Therefore, we consider this recommendation partially implemented.
Technology Services held collaborative discussions with the airport’s Business Technologies Division in April 2019, shortly after the audit report was published, and again in April 2020.

Discussions included addressing "lessons learned" and deliverables. While at least one of the deliverables was not achieved (i.e., meeting quarterly), there were, at a minimum, discussions centered around tool-sharing.

Our recommendation did not require meeting quarterly. Therefore, we consider this recommendation fully implemented.

**Recommendation 2.6**

**Track Energy Use (Technology Services)** – The city’s Technology Services agency should set up a process as soon as possible to track, at a minimum, total energy costs for each data center. In the long term, the agency should perform an analysis of energy costs down to the device-level starting in 2020.

**AGENCY ACTION**

**Original target date for completion: December 2019**

Similar to tracking financial costs associated with data center management, the NetZoom tool is also responsible for tracking energy costs for the city at the hosted data center. However, tracking the total energy costs for each data center no longer applies, because both city-managed data centers are migrating to the hosted data center.

NetZoom can track power consumption down to the outlet in the data center and can further parse everything in the associated rack. While there has been no formal progress on measuring everything down to the device level, the tool administrator showed us this capability. However, our recommendation did not require a completed analysis until the end of 2020.

Aside from tracking energy costs at the data center, auditors also saw how energy costs are tracked for network resource consumption. For example, if a user initiates a File Transfer Protocol data transfer to an external site, and it is not within the expected operations, a bandwidth threshold for that Local Area Network will alert the information security manager and all relevant network operations personnel.

Because device-level analysis is not yet occurring, the risk remains that Technology Services will miss opportunities for improving data center energy costs. Therefore, we consider this recommendation partially implemented.
Recommendation 3.1

Adopt Data Center Standards (Technology Services) – The Technology Services agency should adopt, as soon as possible, a set of comprehensive data center operating standards, such as the Telecommunications Industry Association’s standard for data center quality, called “TIA 942.”

AGENCY ACTION

Original target date for completion: December 2019

The Technology Services agency decided to transition both data centers to a hosted data center. The build-out for the hosted data center is not scheduled to be complete until December 2020. At that time, the city’s primary and secondary data centers will be migrated over.

In the interim, both of these data centers are still operating under the same standards identified in the original audit. However, in response to our recommendation, Technology Services purchased a license for the TIA-942 standard and is applying this standard to the relevant build-out portions at the hosted data center. For example, when performing the cable and wiring build-out at the hosted data center, Technology Services is leveraging and applying the cabling standards as specified in the TIA-942 standard. Therefore, we consider this recommendation fully implemented.

Recommendation 3.2

Update Existing Policies (Technology Services) – The Technology Services agency should work with the General Services Department to update, as soon as possible, the existing IT asset management policy related to problem management and maintenance. This updated policy should be based on the National Institute of Standards and Technology’s standard 800-53 and should address environmental and security control considerations, periodic testing, and problem resolution.

AGENCY ACTION

Original target date for completion: December 2019

PARTIALLY IMPLEMENTED
We found Technology Services has not created formal documentation as a result of this recommendation; rather, an informal verbal agreement has been in place due to the limited number of individuals and years of experience that the current staff has in managing a data center.

Additionally, Technology Services officials said the only other policies on data center management were the “Physical Security of Technology Systems” policy and the Data Center Management Standard. The policies contained information related to the physical security of the data centers; however, they did not include several key items (e.g., a physical risk assessment) and data center controls to extend beyond the scope of physical security. The Data Center Management Standard more accurately addressed the environmental controls related to the data centers.

The “Physical Security of Technology Systems” policy and the Data Center Management Standard were created after the implementation date and have not been formally approved by leadership. Additionally, there are no internal links for other employees to reference, giving the policies minimal value.

Therefore, we consider this recommendation partially implemented.

Recommendation 3.3

Create Procedures (Technology Services) – After implementing Recommendation 3.2, the Technology Services agency should work with the General Services Department to create procedures related to data center maintenance and problem management.

AGENCY ACTION

Original target date for completion: December 2019

The Technology Services agency created a data center routine checklist that outlines weekly, monthly, and annual maintenance at the city data centers. After reviewing this document, we determined it does not detail the specific procedures that should be performed. For example, one of the weekly checks is titled “generator status check,” but it does not provide the specific procedures that should be performed.

Additionally, even though Technology Services agreed to implement this recommendation in December 2019, this document was created during our follow-up work in April and May 2020, and it has not been formally approved by leadership. Additionally, there are no other sources of information for other employees to reference.

Therefore, we consider this recommendation partially implemented.
Recommendation 3.4

Prevent and Detect Unauthorized Changes to Systems (Technology Services) – As soon as possible, leadership of the Technology Services agency should issue a firm directive to agency personnel that no unauthorized changes to systems occur.

AGENCY ACTION

Original target date for completion: June 2019

In January 2019, Technology Services began periodically training relevant IT staff on adhering to an internal, standardized change process for stakeholders. The training material addressed all relevant areas of the change process and included references to supplementary internal documentation. For example, some training covered areas related to approved standard changes, election freezes, and management communications.

In addition to evaluating the training material, we assessed Technology Services’ requirements for adhering to the internal change process. We obtained a May 2019 letter from the chief information officer to Technology Services staff that required employees to abide by the process, and it included appropriate points of contact that could assist with more detailed questions about the internal change process.

Therefore, we consider this recommendation fully implemented.
Office of the Auditor

The Auditor of the City and County of Denver is independently elected by the citizens of Denver. He is responsible for examining and evaluating the operations of City agencies and contractors for the purpose of ensuring the proper and efficient use of City resources. He also provides other audit services and information to City Council, the Mayor, and the public to improve all aspects of Denver’s government.

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