New York Independent System Operator

Carman Road Data Center Study

October 15, 2010

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1. Executive Summary

As part of an ongoing commitment to maintaining reliable infrastructure and services for Data Center operations in support of the New York Independent System Operator reliability and market functions, KEMA, Inc. was engaged to review the adequacy of the Carman Road Data Center (DC) to support operations. The objective of this study is to review the current state of the Data Center at the Carman Road facility, including growth projections in the area of power consumption, platform expansion, and identified business evolution, and provide recommendations that can be used as an assessment of current adequacy and a roadmap for expansion. The study identifies risks associated with the current facility conditions based on known growth projects and industry best practices.

The NYISO has realized good value from the Carman Road Data Center. Over its forty-year life the Data Center has been expanded, augmented, and renovated as needs and technology have changed. Deficiencies of the center, compared to modern centers, have been reasonably worked around and the center has given the NYISO reliable service.

The Carman Road Data Center is not without problems, as described in Section 3 of this report. None of these issues, by themselves, are sufficient to initiate a project to replace the center. However, taken in total and recognizing the age of the building, consideration of a new Data Center is recommended.

Determining the critical time when the Carman Road Data Center can no longer satisfy the NYISO's needs is difficult. That moment must be identified some time in advance, at least eighteen months, to allow for the design and construction of a replacement. It is reasonable to expect that the Carman Road Data Center will remain useful over the next eighteen months, but sometime beyond that time, further work-arounds or replacement will become necessary.

Considering the age of the building, the numerous compromises made to achieve the current lifetime, and the ongoing compromises required to continue production use, KEMA recommends a decision to begin work to construct a new Data Center. This determination is based on engineering principles. But there are other viewpoints that reinforce the desirability of a new Data Center.

The Carman Road Data Center, as discussed in Section 3.3, is an inefficient design. While our estimate of the cost if this inefficiency is not enough to by itself justify a new facility - $100,000 to $200,000 per year – the saving of this money over the lifetime of a new Data Center can offset some of the construction cost. The sooner these benefits could be realized, the greater the payback.

There also is the value to the NYISO in developing “green”, or at least “greener”, facilities. Other organizations, such as Syracuse University, have constructed energy efficient data centers. Syracuse has constructed a Data Center that operates with effectively no power from the electricity grid. While operating off the grid may not be realistic for the NYISO, positioning the company as environmentally proactive is appropriate for this day and age.

Finally, the near-term plans for the IT infrastructure reinforce our findings. NYISO refreshes the IT infrastructure over multi-year cycles, targeted at three years. Three projects now underway could benefit from installation directly into a new Data Center (as opposed to installation into the existing center and subsequent movement to a new center):

- Replacement of the current-generation Ranger servers.
- Replacement of the tape silo data backup system.
- Replacement of the backbone networking hardware.
- DOE Smart Grid.

The benefits, although not quantified in this report, would include reduced costs (labor and shorter project cycles) by avoiding the work to relocate the new hardware from the existing center to the new and reduced risk of outages for the same reason.

In summary, while we cannot declare the state of the Carman Road Data Center to be in crisis, we recommend a decision to begin construction of a new data center. We believe a greater benefit will be realized the sooner this activity is started, in terms of realizing operating cost benefits, avoiding the stranded cost of partial solutions, and earlier mitigation of the risks endemic to the design compromises in the existing data center.

2. Background and Introduction

As part of an ongoing commitment to proactively pursuing long-term, reliable infrastructure services for Data Center operations in support of the New York Independent System Operator reliability and market functions, KEMA, Inc. was engaged to review the adequacy of the Carman Road Data Center (Data Center, or “DC”) to support operations. The objective of this study is to review the current state of the Data Center at the Carman Road facility, including growth projections in the area of power consumption, platform expansion, and identified business evolution, and provide recommendations that can be used as an assessment of current adequacy and a roadmap for expansion. The study is to identify risks associated with the current facility conditions based on known growth projects and industry best practices.

Methodology

The project commenced on 6 July, 2010. KEMA consultants met with the NYISO staff on July 13 to gather information and toured the Carman Road and Krey Blvd Data Centers. Telephone conversations and a second data gathering meeting supplemented the initial meeting.

With the initial data gathering and analysis complete, KEMA produced a draft of the report on 13 July 2010. The draft was reviewed by the NYISO, errors in fact corrected, and the findings discussed. The findings of this assignment remain entirely that of KEMA.

The delivered report represents the situation at the Carman Road Data Center as of the date of publication on the front cover.

2.1 Confidential Information

Material classified as Confidential Information and/or Critical Energy Infrastructure Information and subject to non-disclosure agreements between the NYISO and KEMA has been removed from this document.

3. Carman Road Data Center Assessment

The Carman Road Data Center is housed at the Primary Control Center on Carman Road in the town of Guilderland, NY. The main Carman Road facility was originally built as a control center in 1969. The predecessor of the NYISO – the New York Power Pool – occupied the building as their offices and control center from that date.

The original Data Center consisted of two rooms totaling approximately 3,000 square feet. The design was intended to house the two "sides" of redundant systems in different rooms that were, to the extent possible, physically, mechanically, and electrically independent of each other. Thus, an event, such as a fire or HVAC outage, in one room would not affect the other room. The design was fully utilized by the dual redundant mainframe systems for which it was initially intended. However, later regulatory requirements for an alternative site required location of one mainframe in a separate building. A separate local building was leased to house an alternative control center and backup computer system.

Offices for IT and engineering staff were located adjacent to the Data Center. This space was subsequently retrofitted to expand the Data Center, bringing the total space to 4,600 square feet. However, with the retrofit and the resulting two unequally-sized rooms, the security of locating redundant equipment in different rooms became less practical. (It should be noted that the "two-room" design concept has been implemented in only a small number of electric utility control rooms. Other practices, including backup or alternative Data Centers in separate buildings are more prevalent today.) Exhibit 3-1 is a plan view of the Data Center.

The layout and construction of the Data Center presents challenges to supporting the IT assets and operations of the NYISO. For the purposes of this study, the discussion of the center has been divided into:

- Problems from the layout of the center.
- Compromises made in the electrical and mechanical facilities.
- Inefficiency of the center's energy usage.
- Cyber and physical security.

3.1 Data Center Layout

While the NYISO has maintained the Data Center over its life and renovations have succeeded in keeping the center useful, several basic issues with the layout cannot be resolved.

Shallow raised floor height:

The space under the raised floor is used for several purposes:

- Signal cable runs. Most runs are carried in wire cable trays.
- Electrical cable runs. The distribution panels are located on the peripheral walls of the Data Center. The power cables run from the panels to each rack. Generally, each rack connects to two panels.
- Cold air supply to the equipment.

Modern data centers are constructed with 18” to 24” under floor space. The Carman Road Data Center has a depth of only 12”. While it may be possible to increase the under floor space, the ceiling height is also constrained and the renovation would be disruptive. The raised floor construction also lacks cross bracing. Thus the floor tiles contribute to the structural integrity of the floor. Where several adjacent tiles are removed, the floor distorts and replacement of the tiles can be difficult. In the extreme, the floor could collapse if sufficient tiles are removed. (The Data Center maintenance staff’s judgment is the mitigation for this risk.)

The structural weakness could be an issue if the extinguishing agent is discharged. The under floor discharge could loosen tiles, which could lead to integrity issues in the floor. It must be stressed that this issue is conjectural, but still a concern.

Constrained cable routing:

Beyond the potential structural issues, the constrained under floor space complicates cabling and cooling. (The cooling is discussed in Section 3.2). Over the 40-year life of the Data Center, cabling among the IT components has changed dramatically. The mainframe technology installed initially was largely a monolithic assembly, with limited cabling to other components in the Data Center. Technology changed over four decades, and the mainframes were replaced by distributed systems, with multiple servers, each networked with each other. New applications added more servers. Moreover, the networking hardware, routers, switches, firewalls, and fiber channel “brocade” switches, expanded to occupy significant rack space.

A typical server in the Carman Road Data Center today may have two power cables, eight Ethernet cables, and four fiber channel cables. The newest multi-processor “virtual” servers may have double the number of signal cables. The cables transit under the floor, largely in wire mesh cable trays. The Ethernet and fiber channel cables run from the equipment racks to the “network rows”; the power cables from the equipment rack to the distribution panels on the walls. As the floor space filled with more equipment, and copper and fiber networking cabling proliferated, the cable trays filled to capacity. Most of the Carman Road DC cable trays are filled, and Ethernet and power cables share space with fragile fiber channel cables.

Given that most cable trays are three to four inches deep in cables (effectively at capacity), it has become problematic to remove retired cables. The technicians much prefer to cut the retired cable ends and leave the cable in the tray. Thus, it is difficult to reclaim space in the trays.

Modern Data Centers utilize “structured” cable systems. Structured cabling simplifies cable runs by organizing the racks into “horizontal” rows. “Horizontal cross connect” (HC) patch panels in each row are connected to the network rows. This “vertical” cabling is permanently installed under floor. Structured cable system offers several advantages:

- Equipment can be cabled without pulling cables under the floor. The equipment is cabled from the enclosure to the HC via overhead cable trays. The cable is plugged into the HC patch panel that connects to an HC in the network row. Another overhead cable run then connects the equipment to the appropriate network hardware.
- Ethernet and fragile fiber channel cables can be segregated.
- When equipment is retired, there is no need to pull under floor cables. The overhead cables are removed and the under floor vertical cables can be reassigned.
- The under floor cables can be bundled and laid without expectation that individual cables will be removed or replaced. By including sufficient spare capacity, failed cables are simply left in place.
- By running the horizontal cables overhead, under floor congestion is reduced, facilitating cool air flow and power cable runs.

Exhibit 3-2 shows the NYISO Alternate Data Center arrangement at the Krey Control Center (KCC) with the components of the structure cabling system marked. (The drawings have been rotated to fit the page, thus the horizontal and vertical directions are rotated.) The utility of the structured cabling can be clearly identified by comparing Exhibit 3-2 with Exhibit 3-3, the current arrangement of the Krey Blvd Data Center. The significant expansion of the servers and storage (the right-most rows) is evident, and all of this expansion was accomplished without any changes to under floor signal cabling.

While a structured cable system could be retrofitted into the Carman Road DC, the aspect ratio (the ratio of room length to width) dramatically reduces the utility of the system by shortening the row length. The “L” shape of the center and the (physical) fire wall between the front and back rooms also works against the utility of a structured system. Finally, the work to install the system would be disruptive. In short, conversion of the Carman Road DC to structured cabling is impractical.

Layout and available space:

The preferred shape for a Data Center is a rectangle, approximately 50 feet wide. This dimension is set by the distance from the computer room air conditioning units to the center of an equipment row. Unless compensated for by design, a wider room could compromise cooling air flow under the floor when a CRAC is out of service. The dimensions and shape of the Carman Road Data Center produce compromises in the layout of equipment:

- The layout of racks in the two Data Centers (Carman Road vs. Krey Blvd) is entirely different. The opportunity for human error misidentifying equipment is increased.
- The spacing between rows is at a minimum in some areas. Minor "fender benders" are a fact of life.
- The placement of larger equipment, such as the tape silo, is dictated by the availability of space rather than considering best placement by function and HVAC, power, and signal cabling needs.
- The placement of new equipment is similarly compromised.
- Materials and parts are stored throughout the room rather than in cabinets or along the walls.

The Carman Road DC has sufficient floor space to support today's equipment complement. The future floor space needs at the NYISO are difficult to predict, but the following trends are evident:

- The floor space required for a given system is trending smaller. The current generation of the Ranger Energy Management System is housed in approximately six fewer enclosures than the previous generation.
- The smaller footprint for existing systems is, however, offset by the new functions and the staging of replacement systems. (Discussed below.)
- The floor space required for storage is increasing. This can be seen by comparing Exhibit 3-2 and Exhibit 3-3. The number of enclosures for the Storage Area Network and Network Attached Storage has nearly doubled.

- The Krey Blvd DC has become the "default" site for development and corporate systems. Given the tight quarters at the Carman Road Data Center and the availability of space at the Krey Data Center, it is simpler to install equipment at the Krey Blvd DC.

New functionality anticipated at the NYISO includes support for "Smart Grid". Smart Grid[1] refers to a suite of emerging technologies and some older capabilities that have become less expensive to implement and may offer improved payback. The space requirement for Smart Grid cannot be reasonably estimated without an implementation plan. Some of these capabilities will be hosted in new servers and will require additional storage. An expanded Web presence will also be likely. Without a definitive schedule from the NYISO, KEMA has assumed for this study an expansion requirement of no more than ten additional enclosures, including storage, are needed for the next years.

This expansion assumption estimate roughly offsets the floor space reclaimed by the replacement of the older Ranger system. However, a DC must be sized to accommodate not only the current implementation for any given functionality, but also the replacement for that hardware while it is being developed and tested. Most IT hardware in the DCs has a planned lifetime of three to four years. Some time before the end of the lifetime, new hardware is procured, configured, and tested. At the extreme, this might mean having double the floor space of the current generation hardware, minus some factor in expectation of a smaller footprint for new hardware. However, the system replacements are staggered such that only a portion of the systems are being replaced at any time. Thus, the requirement for 100% "spare" floor space can be significantly reduced. A factor of 30% open space is a reasonable minimum.

The Carman Road DC may meet a 30% minimum requirement for spare floor area. However, the open space is fragmented and the location for hardware may be, as stated earlier, determined by availability, not by functionality, mechanical, or electrical requirements.

Overall, the room dimensions are constraining and result in continuing compromises to the layout and operation of the Data Center.

3.2 Electrical and Mechanical Facilities

Both the cooling and electrical supply designs of the Carman Road DC are compromised.

[1] Refer to http://www.oe.energy.gov/smartgrid.htm for more information.

Computer Room Air Conditioners (CRACs):

The CRACs in the Carman Road DC have been replaced twice, and the resulting layout is not optimal. Referring to the Krey Blvd DC layout, the CRACS are placed in pairs, opposite each other along the long walls of the room. With any CRAC out of service, the opposing unit and adjacent units can supply the necessary cooling air. Within the Carman Road DC, the CRACs (labeled "Liebert") are not well located for backup. An outage of either of two "critical" units (as labeled on the drawing) produces a hot spot in the upper left corner of the room.

The hot spot condition is exacerbated by the limited under floor plenum space and the restrictions from cable trays (covered in Section 3.1). As the cable trays have filled, air flow is further compromised. Modern data centers are constructed with cold aisles, with cooling air vented from the floor through perforated tiles, alternative with hot aisles, where the exhaust from the equipment racks is returned to the CRACs overhead. The hot and cold aisles and the vented tiles can clearly be seen in Exhibit 3-3. In comparison, the Carman Road DC circulation design is less organized and more dictated by current conditions and equipment arrangements than by plan.

Power Distribution:

The power supply to each equipment enclosure originates at a wall-mounted panel. The cable travels through the wall in conduit and emerges under the raised floor where it is routed to the enclosure and connects to a power distribution panel within the enclosure. Most enclosures are fed from two sources (for redundancy).

The electrical distribution scheme is less problematic than other aspects of cabling in the Data Center. However, the power cables must compete for space under the floor and the fixed location of the wall distribution panels and the conduit in the walls limits flexibility. The restrictions on the distribution of power make it more difficult to balance the load across the circuits.

Modern centers use power distribution centers; essentially distribution panels housed in enclosures similar to the equipment enclosures. In the Krey Blvd. DC, the power distribution centers (PDCs) are located on the ends of every other row. The runs from the PDCs to the enclosures are relatively short, and the power cables do not compete for space with the data cables.

Power Supply:

The power supply to the Data Center is aligned with good industry practice with one exception: the uninterruptible power supply ("UPS", which includes batteries, chargers, and DC to AC converters) is located in an area with only handheld fire suppression; and the UPSs are accessible only after passage through other equipment areas. Thus, should a fire start near the UPS, extinguishing the fire before damage occurs would be unlikely.

While this design is not "best" practice, the lack of automatic extinguishing is compensated by the full-capability Alternate Data Center at Krey Blvd. Rather than citing this matter as a critical issue; we would recommend that it be corrected when other Carman Road renovation or development work is undertaken.

3.3 Energy Efficiency

The building energy efficiency industry has developed a rating scale for computer centers that is based on a Power Usage Effectiveness ("PUE") scale. PUE is calculated as the Total Facility Power divided by IT Equipment Power. Total Facility Power is the sum of all of the power used to operate the IT equipment and the total power required to cool the IT equipment, measured in kilowatts (kW). IT Equipment Power is measured at the Data Center power panels. The power required to cool the equipment is the sum of all of the power required for the CRAC units (Computer Room Air Conditioning) and all of the CRAC condensers behind the building.

The industry has observed that a facility with "average" energy efficiency has a PUE of 2.0. This means that it takes as much energy to cool the IT equipment as it does to operate the equipment. As the facility becomes less efficient the PUE number increases and the power required to cool the IT equipment becomes larger than the power to operate it. A well designed data center can achieve a PUE of 1.5 and is considered an efficient facility. Both Google and Microsoft have recently announced the construction of super efficient data centers with PUEs of 1.12.

The PUE for the "front room" of the Carman Road DC (the smaller room in the lower left of Exhibit 3-1) is 2.86, which is a very inefficient PUE. This room requires 74KW of energy to cool 39.8KW of IT equipment. The rear room has a PUE of 1.95, which is slightly better than the average data center. The room has 155KW of IT equipment, and requires 148.5KW of cooling. When the two rooms are taken together the PUE becomes 2.14. The combined rooms consume 222.5KW of cooling power and 198.4KW of equipment power. At an actual cost of $0.12 per kWHr, the Data Center is costing approximately $442,000 a year to operate and cool.

A new Data Center, built using good industry practices, could achieve a PUE of 1.5. If this new, more efficient center enclosed the same compliment of equipment as the existing center (198.4KW) it would require about 99KW of cooling. The cost of operating the new center would be $313,000 per year. This would be an annual savings of approximately $139,000 per year.

If the new Data Center was designed to include best available practices and innovative energy savings features, such as those used by Google and Microsoft, a PUE of 1.2 could be achieved. At this level of efficiency the annual savings could reach $200,000.

The energy efficiency of a Data Center is composed of many incremental elements. An important part of the equation is embedded in the room structure. The best cooling efficiency is achieved when the least energy is expended to move air. The physical design of the room strongly affects the distribution of cooling air in the room. Efficiency can be observed when the cold aisles are evenly cool and the warm aisles are evenly warm. When there are noticeable variations in the room temperature there is evidence of inefficient use of energy. The front room, and to a lesser extent the back room, suffer from severe limitations to even air flow. Both rooms have very shallow under floor (plenum) spaces. Deeper plenums allow for more even air distribution and more efficient cooling. The plenum space is also used for distributing data and power cables. The paths of the data cables tend to follow the orientation of the rows of the cabinets. In the case of the Carman Road DC the CRAC units are located against the walls and, except in one instance, the equipment racks are in rows parallel to those walls. As a consequence the data cables run perpendicular to the air flow. In some cases the bundles of cables are so thick as to block air flow completely. At least some of the factors that limit the efficiency of the Data Center are literally cast in concrete.

It must be noted that the PUE measurements were made on one particular day in August. We would expect to find seasonal variations in the cooling demand and thus variations in efficiency in differing weather. If the August 2010 snapshot is compared to the average, total building demand for August 2009, the Data Center accounts for nearly 75% of the Carman Road facility’s total power consumption. The power consumption for the Carman Road facility varied only 16% during the entire calendar year of 2009. As expected, the winter months produced higher power consumption. This leads to the conclusion that there is very little seasonal variation in Data Center cooling demand. The Data Center is not taking advantage of seasonal temperature variations nor is the remainder of the building making use of the considerable energy extracted from the Data Center, which could be captured to heat the Carman Road Control Center.

There is another cyclical factor worth considering. NYISO modernizes IT equipment across a three-year cycle. Realizing that the Data Center consumes approximately 75% of all of the power delivered, this cycle can be seen in the monthly power records for the last four years. Admittedly this record is for only a part of the entire cycle; however there was a peak in power consumption in the late first quarter of 2007. There is a trough in consumption in mid 2009. The total variation is about 35%. The next peak may occur in mid 2011. At that time the cost of operating the Data Center will increase. If all else remained the same, the projection savings of $139,000 mentioned above will also increase.

3.4 Physical and Cyber Security

Physical access to the Data Center, in fact access to and throughout the Carman Road Control Center, is aligned with good industry practice and meets all industry and government security requirements. KEMA is not aware of any changes to requirements that could not be satisfied by the existing Carman Road DC.

KEMA is currently auditing NYISO's cyber security procedures and practices under a separate contract. At this early stage of that work, we are not aware of any cyber security issues that can be attributed to shortcomings of the Carman Road Data Center. The authors of this report will review the final findings of cyber security audit and will issue an amendment to this report if issues are found with the Carman Road DC.

Exhibit 3-1, Carman Road Data Center Layout

Exhibit 3-2, Krey Blvd. Data Center Layout (April 2007)

Exhibit 3-3, Krey Blvd. Data Center (July 2010)

[Exhibits intentionally removed from this version.]

KEMA

4. Analysis and Recommendations

The NYISO has realized good value from the Carman Road Data Center. Over its forty-year life the Data Center has been expanded, augmented, and renovated as needs and technology have changed. Deficiencies of the center, compared to modern centers, have been reasonably worked around and the center has given the NYISO reliable service.

The Carman Road Data Center is not without problems, as described in Section 3 of this report. None of these issues, by themselves, are sufficient to initiate a project to replace the center. However, taken in total and recognizing the age of the building, consideration of a new data center is recommended.

Determining the critical time when the DC can no longer satisfy the NYISO's needs is difficult. That moment must be identified some time in advance, at least eighteen months, to allow for the design and construction of a replacement. It is reasonable to expect that the Carman Road Data Center will remain useful over the next eighteen months, but sometime beyond that time, further work-arounds or replacement will become necessary.

Considering the age of the building, the numerous compromises made to achieve the current lifetime, and the ongoing compromises required to continue production use, KEMA can endorse a decision to begin work to construct a new Data Center. This determination is based on engineering principles. But there are other viewpoints that reinforce the desirability of a new Data Center.

The Carman Road Data Center is, as discussed in Section 3.3, is an inefficient design. While our estimate of the cost if this inefficiency is not enough to by itself justify a new facility - $100,000 to $200,000 per year – the saving of this money over the lifetime of a new Data Center can offset some of the construction cost. The sooner these benefits could be realized, the greater the payback.

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Finally, the near-term plans for the IT infrastructure reinforce our findings. The NYISO, as discussed above, refreshes the IT infrastructure over multi-year cycles, targeted at three years. Three projects now underway could benefit from installation directly into a new Data Center (as opposed to installation into the existing center and subsequent movement to a new center):

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