Archival Storage Total Cost of Ownership Analysis

A detailed financial analysis comparing the use of magnetic disk, magnetic tape and optical technologies within an archival storage environment

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TCO ANALYSIS

Table of Contents

Table of Figures

1.0 Executive Summary

In the present climate of increasing regulations and the risk of crippling litigation, it is important for organizations to have secure, long-term access to valuable information. In developing a data archive strategy there are a range of storage technologies to choose from, each with its own strengths, weaknesses and costs.

The purpose of this Total Cost of Ownership (TCO) analysis is to compare and contrast the quantifiable acquisition and operating costs for a cross-section of different storage technologies used for archiving data. In order to develop a representative model for the analysis, an actual case scenario was used. The requirement was for a 12TB archive measured over 3 years of operation. The archive products selected for comparison were magnetic tape (AIT-3), magnetic disk (Centera) and three optical storage technologies: DVD, UDO and MO.

In order to avoid subjective interpretation of the TCO figures, only clearly quantifiable costs were included in the analysis. All costs used were list price US$ values and were proportionally adjusted to fairly compare similar 12TB configurations. The costs included in the analysis were hardware and software acquisition, media acquisition, hardware and software maintenance, floor space and the cost for power and cooling.

Figure 1 below provides a high level summary of the results of the TCO analysis. The body of the report documents the methods used in gathering these results and provides a detailed analysis of the final figures.

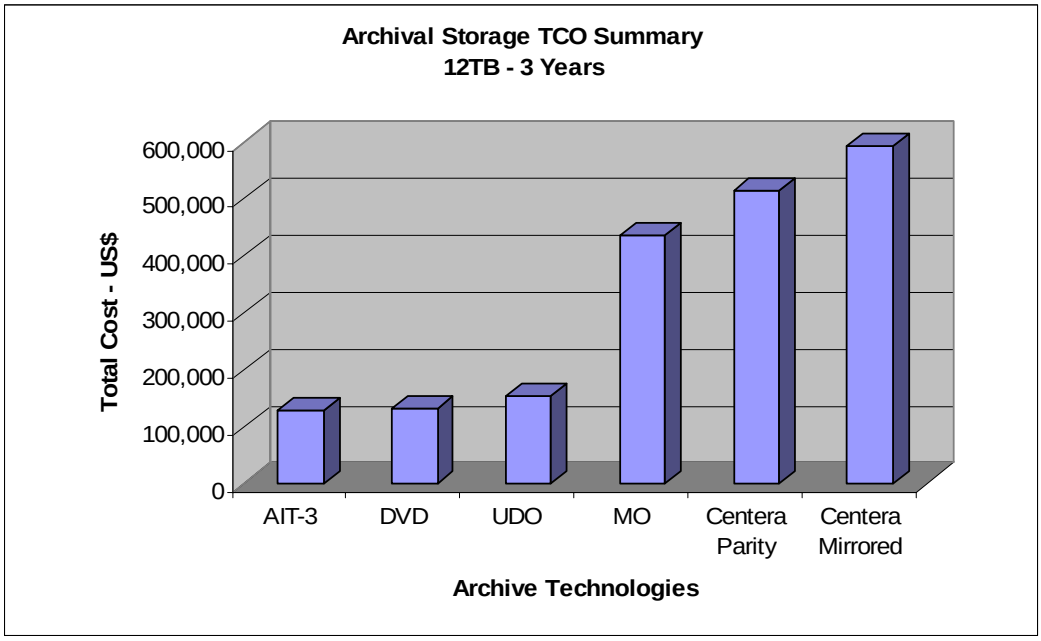

Figure 1 – Archival Storage TCO Summary

The results clearly show that the Total Cost of Ownership of AIT, DVD and UDO archives are very similar and are far lower when compared to MO and the Centera. Contemporary optical technologies such as DVD and UDO remain very price competitive with tape storage and are much less expensive than the Centera and MO configurations. The results also reveal that the annual maintenance and operating costs of the Centera system are greater than tape or optical library configurations.

The numbers gathered in this analysis do not account for all possible system and operating expenses, but do provide an accurate relative percentage for the selected technologies. The analysis strives to provide a factual starting point for readers looking to analyze the TCO of an archival storage environment and also touches on some of the additional business and technical considerations important in developing a successful and cost effective archive strategy.

2.0 Introduction

The demand for long-term record archives has increased sharply in recent years. Growth has been fuelled by new government regulations affecting data retention, the need to defend more effectively against litigation and the competitive imperative to maximize the value of organizational assets. These drivers have influenced large and small businesses across virtually every industry, as well as government and non-profit institutions.

Many organizations are now faced with the need to cost-effectively store and quickly retrieve large volumes of electronic content for years or decades. In many cases, the requirements of a long-term data archive have introduced completely new technical and operational considerations that can have serious consequences if not properly managed.

One area that has been frequently discussed, but seldom been properly quantified is the Total Cost of Ownership (TCO) for the acquisition, maintenance and operation of an electronic record archive. The purpose of this report is to identify and assess the most significant financial factors in a long-term record archive using common archival storage technologies: magnetic disk, magnetic tape and optical. This analysis does not attempt to capture all possible costs, but to identify the most significant quantifiable costs in order to provide an even-handed TCO comparison among the different technologies.

TCO is a very important consideration when selecting a technology for use in an archival storage strategy, but it is by no means the only determinant. While this report does touch on additional strategic considerations, the primary focus is to analyze the financial impact of different storage technologies in the context of a long-term data archive.

3.0 Archive Case Scenario

In order to provide a realistic TCO assessment, the analysis uses the actual archival storage requirements from the London office of a global financial institution. The organization has data archive requirements for the storage of stock trading transactions and customer financial records. The need to retain these records is driven by both internal corporate policies and governmental regulations that mandate the long-term retention of financial records.

The institution maintains their active records on protected, high performance, magnetic disk for 30 days before moving the records to an archive. Record access after 30 days is sufficiently infrequent as to warrant a more cost effective archival storage strategy that complies with their legal obligation for record retention.

Since this organization trades U.S. securities, one of the primary areas of concern is compliance with the Securities and Exchange Commission (SEC). SEC regulation 17a-4[1] governing broker-dealer transactions require record retention for up to 7 years and states that the archive media must use a "non-erasable, non-rewritable" format. This requirement for a non-alterable storage media is a critical component in establishing long-term data authenticity and appears frequently in archival storage regulations worldwide. As a result, the company requires an archive storage strategy that will meet very specific longevity and authenticity demands.

A total archive capacity of 12TB has been set as a target. With daily archive volumes averaging 8GB and factoring in yearly growth rates of 30-40%, the 12TB capacity is designed to meet their archive requirements for the next 3-5 years. They have thousands of networked users with a need to view historic records and have an average of 2,500 requests for archive data in a standard 8-hour working day.

This particular scenario was selected for the analysis since it provides significant archive volumes, definable access patterns and very specific retention periods as required by industry regulations. While different industry regulations and corporate policies can vary dramatically, data retention requirements are becoming ever more common for many organizations and this particular scenario represents a "typical" case study that is well suited for the analysis.

Figure 2 summarizes the archive attributes upon which the TCO analysis is based.

Case Scenario Requirements	
Required Archive Capacity	12TB
Typical Record Retention Period	7-10 years
Average Daily Archive Volume	8GB/day
Total Number of Records	> 6 million
Average Daily Archive Read Requests	2,500/day

Figure 2 – Case Scenario Requirements

As this is an actual case study, Section 11.0 provides a brief summary of this organization's final decision and the motivation behind their hardware choice.

[1] The SEC website is www.sec.gov. A full text of the SEC 17a-4 regulations can be found on www.law.uc.edu.

4.0 Selected Archive Technologies

The TCO analysis compares the most common archive storage technologies from industry leading manufacturers including: magnetic tape, magnetic disk and a range of optical storage technologies. All of the selected products are marketed by their manufacturers as long-term archival storage solutions. The analysis compares the latest generation of products available at the time this report was written.

4.1 Magnetic Tape Archive

Sony AIT tape was selected as the tape archive technology since it provides the best performance characteristics for archiving when compared with other tape technologies. AIT is a moderately priced professional class product with high capacity media. AIT has the ability to load and unload the tape without a full rewind operation through the use of a MIC chip on the media cartridge. This capability offers faster exchange times and higher random access performance. Quicker load, unload and seek times are particularly important for archive applications. In addition, AIT tapes are also available in a WORM (Write Once Read Many) emulation format. When a WORM tape is loaded in an AIT drive, the drive will not allow previously written data to be erased and rewritten. WORM media is an important requirement for archive environments where data authenticity is critical.

AIT-3 has an uncompressed media capacity of 100GB and a maximum compressed capacity of 260GB. The amount of achievable drive-based compression is very dependant on the size and type of files. Compression often provides little or no benefit for small and medium sized business records that may already be saved using some form of compression. With this in mind, the uncompressed 100GB media capacity has been used in this analysis.

4.2 Magnetic Disk Archive

With the continual decrease in the cost of magnetic disks, a number of specially designed magnetic disk archive products have entered the market. This analysis has chosen EMC's Centera product since it is exclusively targeted at the archival storage space. Centera offers specific features to meet archive requirements including WORM emulation. Similar to WORM emulation on tape, Centera uses a carefully controlled software interface to prevent previously written data from being erased and rewritten. WORM capability is a key feature for this scenario and for many archive environments.

It is important to note that this analysis has selected a magnetic disk solution specifically designed for archival storage. While there are many "low cost" RAID systems on the market, most do not offer the management and authentication features required in a long-term archive so would not offer an appropriate comparison.

4.3 Optical Archive

In the case of optical technology, three different options have been selected for the analysis: DVD, Magneto Optical (MO) and UDO (Ultra Density Optical). Optical technology is often used in archival applications since it offers very long media life and often true Write Once data recording, attributes that are important to many archives. 9.4GB DVD has traditionally been a low cost optical archive alternative. 9.1GB MO and 30GB UDO are targeted at the professional end of the archive market. Both MO and UDO were included in the analysis since the market is in transition between older generation red laser based MO technology and new generation blue laser UDO technology.

5.0 Archive Configurations

In order to meet the required 12TB archive capacity, the selected technologies are used as the foundation for a complete archive system. To achieve this, the tape and optical configurations make use of high capacity automated libraries from ADIC and Plasmon respectively. Figure 3 below details the specific configurations selected and the total usable capacity for each of the five technologies.

Magnetic	***Vendor***	***Product***	***Drive Count[2]***	***Media/Drive Capacity***	***Media Count***	***Usable System Capacity***
Tape (AIT-3)	ADIC[3]	Scalar 100	8	100GB	96	9.6TB
Disk	EMC	Centera Parity	64	320GB	-	11.2TB
Disk	EMC	Centera Mirrored	96	320GB	-	12.5TB
Optical						
DVD	Plasmon[4]	D1525	6	9.4GB	1,475	13.8TB
MO	Plasmon[5]	G638 x 2	4 (x2)	9.1GB	1,276	11.6TB
UDO	Plasmon[6]	G438	4	30GB	438	13.1TB

Figure 3 – Selected Archive Configurations

Figure 3 also illustrates that it was not possible to select configurations that precisely match the 12TB archive capacity. Instead, the analysis has chosen fully populated systems that most closely match the 12TB requirement and mathematical adjustments were made in the financial model to compensate for the difference in total archive capacity. Refer to the Capacity Adjustment Calculation Section 6.1 for a complete explanation.

It should also be noted that the Centera product has been listed with two possible disk configurations: Parity (Content Protection Parity or CPP) and Mirrored (Content Protection Mirroring or CPM). These two architectures afford different levels of data redundancy with a trade-off in system capacity. Choosing the most appropriate configuration for a given environment would require research that is beyond the scope of this TCO analysis. In order to be as impartial as possible and to avoid any incorrect assumptions, both configurations have been listed.

5.1 Drive Count for Tape and Optical

In order to satisfy 2,500 access requests each working day, the archive must have sufficient read bandwidth. Additionally, there must also be sufficient write bandwidth to accommodate the 8GB of daily archive volume. In the case of tape and optical, the ability to service these requests is dependent on the number of available drives and their performance. It has been assumed that a magnetic disk archive can accommodate this level of archive access without requiring any additional hardware or software.

The following table (Figure 4) calculates the average access for AIT, DVD, MO and UDO drives by accounting for all the steps in a full media exchange procedure. 2,500 requests per day equates to 313 requests per hour. The number of drives required to meet the access cycle for read operations is listed in the last row of the table. The AIT configuration requires a higher drive-media ratio to meet the same random access specification since load/unload and seek times are much slower than optical.

[2] Refer to section 5.1 for a full explanation of the drive count calculation.
[3] The AIT configuration uses Sony AIT-3 drives in an ADIC tape library.
[4] The DVD configuration uses Panasonic 9.4GB DVD multi drives in a Plasmon DVD library.
[5] The MO configuration uses Sony 9.1GB MO drives in a Plasmon optical library.
[6] The UDO configuration uses Plasmon 30GB UDO drives in a Plasmon optical library.

Drive / Library Specs.	*DVD*	*MO, UDO*	*AIT-3*[7]
Load Time	15 sec	5 sec	10 sec
Unload Time	3 sec	3 sec	10 sec
Average Seek Time	200 msec	35-50 msec	27 sec
Average Rewind Time	0 sec	0 sec	12 sec
Media Exchange Time	6 sec	6 sec	6 sec
Average Data Access	5 sec	5 sec	5 sec
Average Access Cycle	29 sec	19 sec	70 sec
Access Cycles per Hour	124 cycles	189 cycles	51 cycles
Drive Count for Read	3 drives	2 drives	6 drives

Figure 4 – Drive Access Cycles for Reading

All performance data listed in Figure 4 was taken directly from the drive and library specifications of each vendor. For the sake of the analysis, worse case random access is assumed which means that each access request will require loading a new piece of media. If access patterns are totally random, as they are with this scenario, the worse case load assumption should be reasonable. If access patterns are more predictable or if physically adjacent files are often accessed together, the need for media exchange could be reduced. Also in this scenario the files being accessed are small, requiring very little time to read the files once located. In environments where files are larger, the drives with the higher streaming data rates (i.e. tape) will realize improved performance.

In addition to the drives required to read data from the archive, one additional drive has been added to each automated library to support archive write requirements. A single tape or optical drive is sufficient to write the required 8GB of new data archived each day. One additional drive has also been added to each configuration for overall system redundancy in the event of drive failure. In the case of DVD, two spare drives have been added. This has been done because the Plasmon DVD library cannot accommodate an odd number of drives (typical for many DVD libraries) and because the duty cycle on DVD drives is far lower than that of MO, UDO or tape, making additional drive redundancy advisable. Figure 5 summarizes the total required drive count.

Drive Type	*Read Drive Count*	*Write Drive Count*	*Spare Drive Count*	*Total Drive Count*
AIT-3	6	1	1	8
DVD	3	1	2	6
MO	2	1	1	4
UDO	2	1	1	4

Figure 5 – Total Drive Count

5.2 Software Configurations

Interface and management software is a key component of all archive environments. In order to provide the most direct comparison, it is desirable to choose the same archival software product for as many of the technologies as possible.

For this analysis, the QStar HSM product was selected since it supports all of the tape and optical library configurations being considered. QStar HSM is a well-respected archival management and HSM application for enterprise environments and will fully meet the archival requirements of this scenario. A Windows based server has also been added to the tape and optical configurations since these libraries are SCSI based and will also require a server for connectivity and installation of the QStar software.

Given the differences in hardware and software configurations, it is not possible to provide an exact feature / function software match between the QStar functionality and Centera. The closest match with the QStar capabilities requires the combined use of three Centera software products: CentraStar, the CentraStar Compliance Plus Option and the Centera Universal Access software.

[7] Sony AIT specifications are based on performance gained from the use of the MIC. However, in practice very few software applications have implemented MIC support.

CentraStar is a required component and must be included with the hardware. The CentraStar Compliance Plus Option is necessary to emulate the native Write Once attribute of optical storage, which is a requirement for the customer scenario used in this report. The Centera Universal Access software provides a file system interface that allows 3rd party applications to read and write data to the Centera hardware. The Centera Universal Access is similar to that provided by Qstar's virtual file system.

Refer to Section 10.0 for more details on the Centera software configuration selected for this report.

6.0 TCO Component Analysis

The TCO analysis is based on quantifiable expenses for a 12TB data archive over the first three years of operation. Costs that could not be fully quantified, are not statistically significant or are subject to interpretation were not included. The cost components included in the analysis are:

- Hardware Acquisition
- Software Acquisition
- Initial Media Acquisition
- Hardware Maintenance
- Software Maintenance
- Floor Space
- Power and Cooling

A detailed spreadsheet of all figures and calculations can be found in Section 9.0. Section 10.0 provides additional details on the Centera hardware and software configuration. All figures are list prices in US$ taken directly from vendors' price lists. No special pricing or discounts have been used.

The financial model assumes full archive capacity from the first day of operation. While it is true that tape, disk and optical technology can all be implemented with smaller configurations and expanded over time, each scales in different ways. Consequently, it would have been too complex to fairly represent the differences in scalability and was not essential for the purposes of this analysis.

6.1 Capacity Adjustment Calculation

As shown in Figure 3, it was not practical to match all systems to a 12TB archive capacity. In order to provide an exact capacity match, it would have been necessary to select configurations that are larger than required and partially "depopulate" them to meet the 12TB target. This technique would be subject to manipulation and could put some systems at a significant financial disadvantage.

This analysis has, therefore, chosen to select fully populated systems as close to 12TB as possible, calculate the $/GB of each and adjust the overall system cost to match the 12TB target capacity. While this means that the adjusted system cost does not reflect an exact configuration, it provides a fair method of comparing relative costs of the different technologies. Figure 6 summarizes the actual system cost and the adjusted cost using the technique described above.

Archive Type	***System Capacity***	***Actual System Cost $***	***$ / GB***	***Adjusted System Cost at 12TB - $***
AIT-3 Library	9.6TB	103,573	10.79	129,466
DVD Library	13.8TB	151,967	11.01	132,145
UDO Library	13.1TB	167,732	12.80	153,648
MO Library	11.6TB	421,162	36.31	435,684
Centera CPP	11.2TB	479,540	44.82	513,793
Centera CPM	12.5TB	618,265	49.46	593,535

Figure 6 – Capacity Adjustment Calculation

6.2 Results Overview

Figure 7 summarizes the findings of the TCO analysis in a graphical format using adjusted system costs over three years of operation. Since the final numbers do not reflect all possible costs, the absolute values are not complete. However, the objective of the analysis is to offer an even-handed assessment of all major expenses and to provide an accurate relative cost for each of the selected configurations.

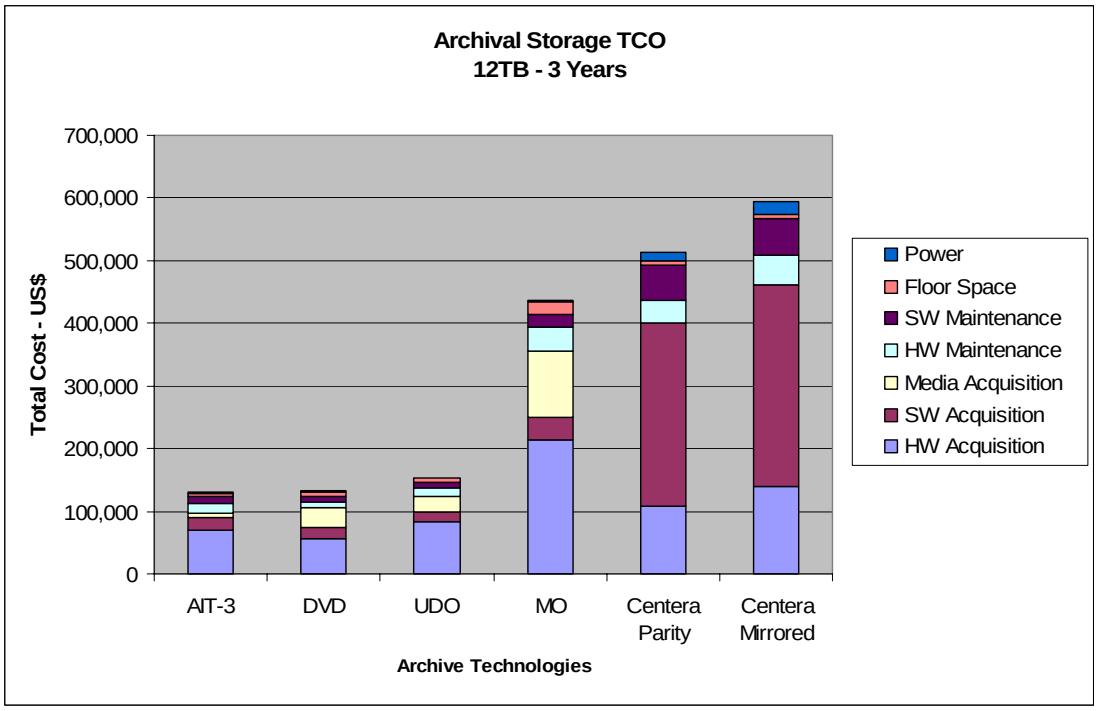

Figure 7 – Archival Storage TCO Detailed Summary

The results demonstrate that the TCO for a 12TB archive is lowest with AIT tape and DVD. The cost of these two configurations is virtually identical. The UDO archive comes in a close second at approximately 15% higher than AIT and DVD.

MO is significantly more expensive as a result of its lower volumetric density. The MO configuration required two libraries to achieve the 12TB configuration, making it much less cost effective across all of the components making up the TCO totals.

Centera is the most expensive of all the technology options. The Centera Mirrored configuration is 4.5 times the cost of an AIT and DVD alternative. Figure 8 provides a complete cost ratio analysis for each of the configurations so that relative cost for a given configuration can be more easily compared.

Archive Type	***AIT-3***	***DVD***	***UDO***	***MO***	***Centera CPP***	***Centera CPM***
AIT-3	1.00	1.02	1.19	3.37	3.97	4.58
DVD	0.89	1.00	1.16	3.30	3.89	4.49
UDO	0.84	0.86	1.00	2.84	3.34	3.86
MO	0.30	0.30	0.35	1.00	1.18	1.36
Centera CPP	0.25	0.26	0.30	0.85	1.00	1.16
Centera CPM	0.22	0.22	0.26	0.73	0.87	1.00

Figure 8 – Cost Ratio Analysis

Figure 9 is a summary of all the costs of the TCO components using the adjusted system cost over three years. Figure 10 provides a breakdown on the relative percentage of the individual TCO components also using adjusted system costs. The two summaries are useful in analyzing the distribution of costs across all configurations and are referenced in the subsequent sections.

Archive Type	*HW$*	*SW$*	*Media$*	*HW Maint$*	*SW Maint$*	*Floor Space$*	*Power$*	*Total$*
AIT-3	68,750	21,875	6,600	14,606	11,875	4,233	1,527	129,466
DVD	57,130	17,391	32,065	8,753	9,391	6,646	768	132,145
UDO	83,472	15,389	24,073	14,432	8,336	7,001	944	153,648
MO	212,814	37,241	105,600	38,671	20,110	19,116	2,131	435,684
Centera CPP	107,196	293,571	0	36,030	56,053	5,805	15,137	513,793
Centera CPM	139,632	321,120	0	48,424	58,812	5,201	20,345	593,535

Figure 9 – TCO Adjusted Component Costs

Archive Type	*HW%*	*SW%*	*Media%*	*HW Maint%*	*SW Maint%*	*Floor Space%*	*Power%*
AIT-3	53.10	16.90	5.10	11.28	9.17	3.27	1.18
DVD	43.23	13.16	24.27	6.62	7.11	5.03	0.58
UDO	54.33	10.02	15.67	9.39	5.43	4.56	0.61
MO	48.85	8.55	24.24	8.88	4.62	4.39	0.49
Centera CPP	20.86	57.14	0	7.01	10.91	1.13	2.95
Centera CPM	23.53	54.10	0	8.16	9.91	0.88	3.43

Figure 10 – TCO Adjusted Component Cost Percentages

6.3 Hardware and Software Acquisition

Hardware acquisition costs for the tape and optical libraries make up a similar percentage of the total system cost ranging from 43% to 53%. Not surprisingly, MO has the highest hardware cost at $212,814. This is due to the fact that a 12TB MO configuration required two optical libraries. The MO configuration would have appeared more competitive if the total required capacity had been lower than 12TB, requiring only a single library. The hardware percentage for Centera is considerably lower than the library configurations averaging 22%, but is more expensive in real terms than all but the MO configuration.

Regarding software acquisition, optical library configurations are similar, from 8.5% to 13%. The least expensive software was for the DVD and UDO configurations. MO has the lowest percentage due primarily to the higher overall system cost. The AIT tape configuration has a slightly higher percentage at nearly 17%. The most surprising software percentages are with Centera. Software accounts for more than 55% (on average) of the total system cost and is more than fifteen times the price of the other software. Centera software is by far the single most expensive component for any of the archive systems.

6.4 Media Acquisition

Since Centera does not make use of removable media, this component does not factor into overall percentages. This could partially explain why the hardware percentage on Centera is lower than that of the library configurations.

Due to the higher capacity of AIT tape, it offers the least expensive removable media at $6,600. The relative percentage of MO and DVD media is nearly identical at 24%, but MO media is the most expensive at just over $100,000. The high cost of the older MO media is another reason that it is less competitive than newer library solutions. It is interesting to note that the cost of UDO media for this 12TB configuration is actually less expensive than DVD media by approximately $8,000. This defies conventional wisdom that DVD offers the most affordable optical media. Part of the reason for this is that DVD media in a library requires the use of additional cost multi-disc magazines for protection and handling. The cost of these magazines increases the overall cost of the DVD media. Extra cost DVD magazines are common in automated libraries from most vendors so it is important to include their cost in this model.

6.5 Hardware and Software Maintenance

The Centera system has the highest actual cost and overall percentage for hardware and software maintenance than any of the other configurations. The model demonstrates that annual maintenance contracts on a Centera system average more than $33,000, far higher that that of the other technologies. These numbers are also slightly misleading because the first two years of hardware maintenance is included in the cost of a Centera system. This means that after year two the on-going cost of hardware maintenance will just jump sharply. This is an important consideration that should not be overlooked for any archival storage system designed to be operated for many years.

Hardware and software maintenance make up a much smaller percentage for the library configurations with a range of $6,000 to $9,000 a year for AIT, DVD and UDO. Average yearly maintenance on a 12TB MO system is roughly $20,000 with the major share being hardware.

6.6 Floor Space

In this model a cost of $3,235 per m^2 per year was used. While the cost of office space can vary dramatically from city to city, this estimate is representative for computer room space in a large North American city.

The cost of floor space turns out to be a relatively small and fairly equal expense for all the configurations with the exception of the MO. The two MO libraries occupy double the space so have a much larger floor space component. Overall, floor space is a modest cost that does not contribute significantly to the TCO analysis.

6.7 Power and Cooling

The cost of commercial power is set at $0.07/KWH. This figure provides a reasonable average for both US and European power rates. The model calculates cooling costs at 40% of power consumption. Figure 11 provides a summary for the figures used in calculating power and cooling cost over three years of operation.

While these figures are small for the automated libraries (averaging $350/year), they can make up a significant on-going operating cost for a Centera system (between $5,000 and $6,800/year). In some cities, power rates have increased dramatically over the last several years. California is a good example of sharp rises in power rates (much greater than the rate used in this model). The cost of power and cooling on a Centera system can easily exceed $10,000/year in areas where power rates are higher. Many companies are now looking for ways to reduce power consumption by eliminating power hungry equipment. The use of low power consumption libraries for archive data will have a distinct operational advantage where power costs are high or where power availability is limited.

Archive Type	*Power Watts*	*BTU/hr*	*Power $/hr*	*Cooling $/hr*	*Total $/hr*	*Total $/yr*	*Total 3 Years*	*Adjusted 3 Years*
AIT-3	415	1,418	0.0291	0.0174	0.0465	407	1,221	1,527
DVD	300	1,025	0.0210	0.0126	0.0336	294	883	768
UDO	350	1,196	0.0245	0.0147	0.0392	343	1,030	944
MO	700	2,392	0.0490	0.0294	0.0784	687	2,060	2,131
Centera CPP	4,800	16,400	0.3360	0.2016	0.5376	4,709	14,128	15,137
Centera CPM	7,200	24,600	0.5040	0.3024	0.8064	7,064	21,192	20,345

Figure 11 – Power Consumption Costs

7.0 Additional Considerations

This report has included only quantifiable costs in the calculation of TCO for the different storage technologies. However, there are a number of less quantifiable considerations that the authors of this report feel are important to note. These issues can have a significant impact on TCO calculations so may need to be factored in when building TCO models for specific corporate applications.

7.1 System Administration

The TCO model has not included the expense of system administration. Estimating the cost of data archive management can be subjective and is dependant on the skill sets of the IT organization. In addition, it can be reasonably demonstrated that the administration overhead for all the technology types considered is approximately the same (short-term and long-term). Some vendors have suggested that tape and optical library configurations require dramatically higher administration resource than magnetic disk based systems. This is simply not a valid assumption, as it cannot be substantiated by end user experience. For these reasons and since this report is tasked with identifying cost differences between the competing technologies, administration costs were not included.

7.2 Data Migration and Hardware Upgrades

Data archives must be designed to operate for years/decades, which means that data with long-term retention requirements will need to be migrated periodically from older to newer technologies. This TCO analysis accounts only for the first three years of operation and it can be assumed that no migration or hardware upgrades will be necessary during this period. Since tape, disk and optical technologies all have different media and system life spans, it is important to understand how frequently data migration and upgrades are required in order to ensure long-term data availability and to assess ongoing operating costs. Stable, long-life optical media offers a distinct advantage over tape and disk in terms of reducing migration frequency.

7.3 Tape Media Maintenance

When storing data on magnetic tape for extended periods of time media manufacturers and industry bodies often recommended that tape media be subjected to a maintenance program in order to ensure long-term data availability. Though the exact requirements for a tape maintenance program are up for debate, the requirement cannot be ignored when considering tape for a long-term archive.

Tapes that have not been accessed for an extended period should be “re-tensioned” and tape error rates monitored to identify ageing tapes that may require refreshing to new media. It is up to the individual organization to determine the value of their data and the frequency of management when using tape for long-term archival storage. There are both media and considerable administration costs associated with tape maintenance, in addition to incremental library resources needed for re-tension and refresh operations.

This type of media maintenance is not required for optical or redundant magnetic disk systems.

7.4 DVD Media Handling

Most DVD media used with automated libraries is bare, “un-cartridged” media. While this bare media is commonly housed in media magazines, it remains exposed to potential particle contamination and physical damage. As such, many users feel it necessary to make redundant copies of their valuable data. Redundant copies can be maintained on-line in the library or off-line and will have an impact on TCO calculations because they require extra media and administration. The effective capacity of the library is also reduced if redundant media are maintained on-line.

7.5 Data Authenticity and Audit Trails

Data authenticity can be a critical consideration for many archival storage environments and the use of WORM media is an important piece in the data authenticity "chain of trust". AIT, MO and Centera are all inherently rewritable, but offer WORM emulation implemented through firmware/software that prevents rewritable media from being overwritten. Only DVD and UDO phase change optical media provide true Write Once data recording. The use of true Write Once media can reduce the cost of audit trail management and should be considered "best case" for archive environments where data authenticity is a high priority.

7.6 Off-line Secondary Media Copies

Regardless of the stability of the media, it is important to retain more than one copy of all valuable information in order to protect against disasters or site failure. Often organizations look to store redundant data sets off-site in a protected vault to minimize cost. When using removable tape or optical media, it is a reasonably simple and cost effective process to make a second copy of media for storage in a vault.

When using a magnetic disk archive such as Centera, it is not possible to vault the magnetic disk. As a result, it is necessary to purchase tape or optical drives/libraries and software to create the second data copy for off-line vaulting. This adds a great deal of additional cost and complexity to the archive infrastructure. Alternatively, a second mirrored disk subsystem could be installed to perform remote replication. While this will meet requirements for protection against site failure, it is an extremely expensive strategy that can be very difficult to justify in environments where archive data is accessed infrequently.

7.7 Installation Considerations

The installation of automated libraries, magnetic disk subsystems and application software is a routine procedure for many IT managers. Proper planning and training will ensure a quick and successful installation process. In the case of Centera and other magnetic disk archive systems, it is important to mention two considerations that are somewhat out of the ordinary: the weight of the hardware and the power connection. As an example, fully populated Centera cabinet weight nearly 700kg (1500 lbs). Structural reinforcement may be necessary to ensure that the weight can be safely supported. In addition, the Centera power lead requires a heavy-duty electrical connection (L6-30R / IEC-309-332R6) for the demanding power requirements of the cabinet. This may require special electrical infrastructure before a disk based archive system can be installed.

8.0 TCO Analysis Summary

The figures provided in this Archival Storage TCO Analysis do not attempt to take into account all possible costs of a professional archive environment since many expenses are application or site specific. However, the analysis does address the most significant costs and seeks to provide a valid and representative ranking for each selected configuration.

The primary cost differences have less to do with magnetic vs. optical technology and more from their specific implementations. Indeed, the AIT-3 tape and the Centera solutions, both based on a magnetic storage, stand at extreme ends of the TCO spectrum. There is also a significant cost difference between the two optical configurations of DVD and MO. Overall, the AIT tape, DVD and UDO configurations offer a dramatically lower TCO proposition than MO and Centera and require much lower on-going operating expenses.

This report provides quantifiable insight into archive acquisition and maintenance costs, but it is also important to balance the financial analysis against other considerations. Business and technical issues such as regulatory compliance, data authenticity, media longevity and performance are equally valuable metrics and must be considered when evaluating archival storage strategies. Readers are encouraged to use the results of this report as a starting point for their own archival storage TCO evaluations.

Contacting the Authors

The authors of this report have made every effort to include accurate information and to fairly represent the findings of the analysis. They welcome your comments and suggestions and can be contacted at marketing@plasmon.co.uk.

9.0 TCO Summary Spreadsheet

Archival Storage TCO - 12TB over 3 Years US$ List Prices			AIT Scalar 100 8 AIT-3 Drs	DVD D1525 6 DVD Drs	UDO G438 4 UDO Drs	MO 2 x G638 8 MO Drs	Disk Centera CPP	Disk Centera CPM
Capacity in TB			**9.6**	**13.8**	**13.1**	**11.6**	**11.2**	**12.5**
Hardware Cost								
Storage Hardware			50,000	60,700	86,124	200,720	100,050	145,450
Server Hardware			5,000	5,000	5,000	5,000		
Total			55,000	65,700	91,124	205,720	100,050	145,450
% of Total Cost			*53.10*	*43.23*	*54.33*	*48.85*	*20.86*	*23.53*
Software Cost								
QStar HSM			17,500	20,000	16,800	36,000		
Centera SW Components							274,000	334,500
Total			17,500	20,000	16,800	36,000	274,000	334,500
% of Total Cost			16.90	13.16	10.02	8.55	57.14	54.10
Media Cost	**Unit Cost**	**Slot Count**						
100GB AIT3	55	96	5,280					
9.4GB DVD (w/ Magazines)	25	1,475		36,875				
30GB UDO	60	438			26,280			
9.1GB MO	80	1,276				102,080		
Total			5,280	36,875	26,280	102,080	0	0
% of Total Cost			*5.10*	*24.27*	*15.67*	*24.24*	*0.00*	*0.00*
Hardware Maintenance	**3 Years**		11,685	10,066	15,755	37,382	33,628	50,442
% of Total Cost			*11.28*	*6.62*	*9.39*	*8.88*	*7.01*	*8.16*
Software Maintenance	**3 Years**		9,500	10,800	9,100	19,440	52,316	61,263
% of Total Cost			*9.17*	*7.11*	*5.43*	*4.62*	*10.91*	*9.91*
Floor Space Cost	**m^2**	**Yearly $/m^2**						
Scalar 100 - AIT3	0.35	3,225	3,386					
D1525 - DVD	0.79	3,225		7,643				
G438 - UDO	0.79	3,225			7,643			
2 x G638 - MO	1.91	3,225				18,479		
Centera	0.56	3,225					5,418	5,418
Total			3,386	7,643	7,643	18,479	5,418	5,418
% of Total Cost			*3.27*	*5.03*	*4.56*	*4.39*	*1.13*	*0.88*
Power and Cooling			1,221	883	1,030	2,060	14,128	21,192
% of Total Cost			*1.18*	*0.58*	*0.61*	*0.49*	*2.95*	*3.43*
Actual Total Cost			103,573	151,967	167,732	421,162	479,540	618,265
Cost per GB			10.79	11.01	12.80	36.31	42.82	49.46
Adjusted to 12TB			129,466	132,145	153,648	435,684	513,793	593,535

Figure 12 – TCO Summary Spreadsheet

10.0 Centera Pricing Details

Centera Hardware and Software Pricing

US$ List Prices

	List Pricing US$	Centera Parity CPP	Centera Mirrored CPM
System Capacity in TB		11.2	12.5
Total Number of Nodes		16	24
Number of Access Nodes		4	4
Number of 8 Node Units		2	3
Hardware			
8 Node Cabinet	53,500	53,500	53,500
8 Additional Nodes	45,400	45,400	90,800
Power Cord	1,150	1,150	1,150
Total Hardware Cost		**100,050**	**145,450**
Software			
CentraStar / 8 Nodes (CPM)	78,300	0	234,900
CentraStar / 8 Nodes (CPP)	93,400	186,800	0
CentraStar Compliance Plus / 8 Nodes	12,400	24,800	37,200
Centera Universal Access Retention / Access Node	15,600	62,400	62,400
Total Software Cost		**274,000**	**334,500**
3 Year Hardware Maintenance			
8 Node Cabinet - Premium - Year 1, 2	2,675	10,700	16,050
8 Node Cabinet - Premium - Year 3	3,746	7,492	11,238
8 Additional Nodes - Premium - Year 1,2	2,270	9,080	13,620
8 Additional Nodes - Premium - Year 3	3,178	6,356	9,534
Total Hardware Maintenance Cost		**33,628**	**50,442**
3 Year Software Maintenance			
CentraStar / 8 Nodes (CPM) - Year 1, 2	0	0	0
CentraStar / 8 Nodes (CPM) - Year 3	5,481	0	16,443
CentraStar / 8 Nodes (CPP) - Year 1, 2	0	0	0
CentraStar / 8 Nodes (CPP) - Year 3	6,538	13,076	0
CentraStar Compliance Plus / 8 Nodes - Year 1-3	1,860	11,160	16,740
Centera Universal Access Retention / Access Node - Year 1-3	2,340	28,080	28,080
Total Software Maintenance Cost		**52,316**	**61,263**
Grand Total		**459,994**	**591,655**

Figure 13 – Centera Pricing Details

11.0 Case Scenario Results

The corporate scenario used in this analysis was an actual company that carefully analyzed their long-term data storage requirements in order to select the archive technology that best matched their needs. The technical and financial issues that were most important in their decision making process included:

- Satisfying archive capacity target
- Meeting performance and access pattern requirements
- Complying with SEC regulations for archival storage
- Scaling affordably with future archive growth
- Providing low TCO over many years of operation

In order to meet these requirements, the company selected a Plasmon G-Series optical library with 30GB UDO technology. This analysis confirms that UDO is able to comfortably meet the capacity and access pattern demands. The Plasmon G-Series library also provides internal scalability that can easily and affordably accommodates future archive growth.

UDO was an ideal choice for the SEC regulations since it clearly meets their definition of "non-rewritable, non-erasable" media. The SEC places a preference on the data authenticity qualities of optical storage by requiring that any system not using Write Once optical storage be subject to review by the SEC enforcement authorities. Both magnetic disk and tape archives would be subject to a potential audit by the SEC since they do not provide true Write Once data storage.

Financially, UDO also meets the company's needs. The initial investment for a UDO archive was very cost competitive, it offered unmatched media life with virtually zero on-going maintenance and extremely low operating costs. The backward compatible roadmap to higher capacity media makes UDO an even more compelling technology choice since this offers long-term support and investment protection.

While this company has requirements specific to the financial industry, their archival storage needs are typical of other organizations across a range of industries. For this company and for many others, UDO offers a professional and cost effective strategy for securely archiving valuable business records.