Enterprise Storage

Storage Economics

Identifying and Reducing Operating Expenses in the Storage Infrastructure

A White Paper

By David Merrill

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Executive Summary

Today's business environment continues to be a difficult one. Cost reductions are still in force, and IT continues to be a target for reducing costs while still required to deliver critical services. Some good news does exist though, in that there are cost-reduction activities that can yield real operating expense (OPEX) savings specific to the enterprise storage infrastructure. Due in part to several years of distributed systems growth, inefficiencies in storage/data deployment have created a conglomeration of distributed infrastructure that demands support from precious resources. Disaggregation of storage and data management must be addressed in order to reduce storage-related IT operating expenses.

Purchasing low-cost storage solutions does not equate to lowering operating expenses or reducing the total cost of storage ownership. Hitachi Data Systems consultants and IT analysts see trends where purchasing cheaper disk solutions to reduce short-term capital expense (CAPEX) can produce a negative long-term impact on OPEX. **Price does not equal cost**. Price per megabyte is a poor metric to use alone when making storage economic decisions. Centralized, networked storage that is managed in a consistent, structured manner is 30 percent less expensive to own when compared to direct attached storage (often dispersed throughout the enterprise) and distributed data management.

Enterprise, modular and locally attached disk will all continue to experience price erosion, but OPEX-sensitive architects and managers are looking with more interest at total solutions that can reduce ownership costs, while enabling the deployment of new solutions and strategies to support business requirements.

This paper describes where hidden, storage-related OPEX costs reside, how much potential cost savings are buried within the storage infrastructure, and the successful methods and activities used by IT departments around the world to "harvest" these savings. Storage economic analysis and OPEX-reduction initiatives combine to form a deterministic process to reduce the cost of enterprise storage ownership.

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Introduction

Today's economic pressures require a conscientious effort on the part of IT managers to look at all areas of the storage infrastructure for potential efficiency improvements and cost reductions. Within this infrastructure there are costs that can be identified, prioritized and recovered for the benefit of the business and operating budgets. In order to achieve these reduced costs, investments are often required (capital, people, processes).

Take, for example, the following question posed to the CFO or Budget IT Manager: "Will you spend money to save money?" The answer will most always be, "Yes!" But three key questions have to be answered before any spending can be authorized. These three questions become the CFO litmus test for economic viability of an IT investment:

1. How much investment is required to lower OPEX?
2. How fast will we recover this investment cost with a lower OPEX run-rate?
3. How much net savings will the organization realize with this investment?

These "how much, how fast, how much" questions apply not only to a storage investment, but also to almost any investment in today's difficult financial era. Investments in technology or operational efficiency are always balanced against their return on investment (ROI), their potential to enable new business, or their ability to establish a clear technical advantage. Storage economics demands this same scrutiny when looking at storage networks, storage consolidation, technology refresh, data protection schemes, and the like.

Storage volumes are growing at phenomenal rates, yet IT organizations cannot always justify ballooning storage budgets. *Storage consolidation solutions are now being adopted within mainstream IT organizations, because these organizations realize that a flexible, consolidated infrastructure can help manage the increased demands for data availability and evolving application requirements without breaking the budget.* IT organizations expect budget allocations for overall storage services, storage hardware, and software infrastructure to be constant year over year—a percentage of total IT budgets. If not tightly controlled, costs tend to increase because business requirements have become more complex.[1]

[1] "Enterprise Storage: Technology Adoption and Deployment Trends;" Sean Derrington; META Group; August 2002.

Price does not equal cost. Many storage decision-makers are seduced into thinking that low-price disk accomplishes their objective to lower the cost of storage ownership. In fact, purchasing inexpensive storage solutions most often leads to a higher total cost of ownership (TCO) over a three- to five-year horizon. Low-price disk does help with short-term CAPEX but will lead to higher OPEX costs in the longer term. With low-interest capital and many federal monetary policies encouraging capital spending (with depreciation incentives), CAPEX is not a near-term concern. Storage-related OPEX is paramount, and taking a macro view of costs is imperative to achieving favorable economic results within the IT infrastructure.

Storage Price Inelasticity of Demand

If price erosion on top of rising storage demand is not problematic enough, it is also worthwhile to understand that storage-related prices demonstrate inelastic trends relative to demand. In other words, vendors lowering their prices on unit costs of storage will tend not to increase demand for the product (see Table 1). This is because storage demand is driven by applications, business growth, data exploitation, and compliance laws—and not necessarily by lower prices.

Elasticity	**Demand is Price Elastic: $\lvert\eta_p\rvert > 1.0$**	**Demand is Price Inelastic: $\lvert\eta_p\rvert < 1.0$**
Price Reduction	Expenditures Increase	Expenditures Decrease
Price Increase	Expenditures Decrease	Expenditures Increase

Table 1: Price Elasticity of Demand Conditions.

If storage is price insensitive (or inelastic) and CAPEX reduction is not a critical exercise, then a new set of storage economic strategies is necessary. Price per megabyte is a poor *single* metric to use in storage economic decisions. The correct approach (and an industry best practice) is to take a strategic view of storage architectures and determine the best solutions based on TCO and OPEX minimization.

This paper outlines the basis for storage economic decision-making. Storage economics is much more than determining price-per-megabyte metrics or total cost of storage ownership. Rather, storage economics takes a broader view as to where costs may lie within the storage ecosystem, how much cost is contained there, how to extract these costs, and how to think strategically rather than tactically regarding storage deployment and architectural decisions.

Economic Measurements—TCO and ROI

A proper examination of storage economics requires consideration of two perspectives: *total cost of operational ownership (TCO)* and *return on storage investment (ROI).* The perspectives of TCO and ROI are similar in computation and development, but fundamentally different in the types of decisions for which they should be used. These terms are often interchanged or blended to mean the same thing (in economic terms), but they are distinct and different in their use within a storage economic framework.

Return on Investment

First, ROI is an effective method to use when proposing a new set of actions or activities to replace existing practices or technology. The status quo is often challenged; proactive activities are recommended that will yield a good return on investment. CEOs and other company executives often make decisions on investments relative to the ROI of each option. With a limited amount of cash to invest, a CEO can choose between a new factory, an executive jet, new product research or IT investments. Each of the investment options has to be defined as to its respective return on investment.

In the case of storage economics, a new storage request has to be considered in light of its ROI. If there are multiple technical solutions to the same storage problem (such as different topologies or protocols), each option will exhibit different returns on investment. Basic ROI results have to answer the three questions posed earlier: How much is the investment, how fast is its payback, and how much is the total or net savings on this investment.

ROI is crucial for demonstrating to management that even with enough incremental disk capacity to meet the basic company needs, the change to a new architecture or storage solution can provide positive ROI due to the OPEX reduction in many cost-sensitive areas. ROI analysis tends to be proactive in nature relative to the demand for change. ROI tends to be a justification method for OPEX-reduction activities.

Total Cost of Ownership

In the case of planned storage growth or expansion (reactive in nature relative to demand), TCO can be effective for calculating total lifecycle costs of competitive or comparative solutions. Total cost of ownership is exactly what the name implies—the total operating and purchase cost of an asset (such as storage). To determine TCO, several costs are accumulated that would be incurred over some number of years:

- Purchased elements from the vendor (hardware, software, installation, verification, migration)
- IT departmental costs for installation (new training, new room preparation)
- Write-off costs if the systems being replaced are not fully depreciated, or are not at the end of the lease life
- Year-on-year environmental costs, such as electricity, air conditioning, floor space
- Maintenance costs (after the warranty period) for hardware and software
- Ongoing labor costs, training, and vendor fees not otherwise covered.

TCO is most effective when performing a head-to-head comparison of two or more storage solutions (either vendor options or topology/architecture options). Best practices indicate that TCO requirements are included in all competitive bid situations, with the end customer establishing the parameters of the TCO cost models.

Since many people look at CAPEX cost as a one-time cost, they are fooled into thinking that the lowest purchase price is also the lowest TCO. This is not the case in most storage and data center environments. Storage purchase decision-makers should be looking at the TCO of competitive solutions, and not just at the lowest price per megabyte presented by vendors in the final negotiations.

ROI and TCO Commonalities

In calculating total ownership costs and OPEX-reduction options in an ROI exercise, there are several calculation methods that are common between both approaches. The cost calculation section later in this paper outlines the areas where costs should be applied in a TCO or ROI calculation methodology. Once defined and described, these same cost definitions can be used to compare and contrast different options, vendors, solutions, topologies, and protocols in a storage economics exercise.

Discovering OPEX Potential in the Storage Ecosystem

Recent IT trends for distributed servers, applications, storage and the Internet have propagated resources and infrastructure literally around the world. Current economic conditions beg for options to reduce IT spending, both now and in the future. Before any actions or calculations are attempted, it is worthwhile to determine how much storage OPEX potential exists, and what efforts are required to discover, harvest and reduce the actual storage costs.

Over the past several years, Hitachi Data Systems has conducted hundreds of storage ROI and TCO exercises around the world. This work has led to defining the following data point that can be used to justify a storage economic investigation:

On average, for every 12TB of usable disk capacity within the storage infrastructure, there is a $1M net OPEX potential.

It is a significant finding to be able to generalize or predict the amount of OPEX monies that currently lie within a storage infrastructure. Many situations generate $1M of OPEX savings with five or six terabytes of total storage, while some environments generate smaller savings. The $1M-to-12TB ratio is conservative, and generates the savings over a three-year term. This $1M is a net savings that impacts the department’s bottom line. The $1M is in US dollars, but similar ratios have held true with other currency denominations, after the proper conversion (for example, AUS$1M per 8TB).

It is important to understand the type of OPEX monies in the above statement. Later in this paper we will cover the types of saving categories that are possible with new storage architectures, but the $1M-to-12TB ratio generates savings from the following generalized categories:

- Waste reduction ~25%
- Outage time reduction ~20%
- Management labor effort ~15%
- Maintenance fees ~15%
- Environment ~ 10%
- Miscellaneous operational efficiency ~5%
- Other ~ 10%.

This single data point is often sufficient to initiate a more detailed storage economic analysis. The rest of this paper will outline a methodology that has been used effectively to quantify and qualify costing options and storage activities to reclaim and reduce storage-related OPEX.

Characterizing Storage OPEX Costs

Now that a target OPEX-reduction potential has been defined ($1M per 12TB), it is important to describe the type of money that is recoverable. There are multiple sources of OPEX-reduction monies within the storage infrastructure. Not all of these monies are the same, nor are they all treated with the same level of attention from company to company. Clearly, some of the savings may be seen as hard savings to one IT shop, and as soft savings to another. Not every category is commonly accepted between different companies, or between groups within a company, but there are multiple sources of savings to be determined. By presenting more modeling and costing conditions for consideration, the hit rate of a few conditions (four to six) is usually enough to develop a reasonable storage ROI analysis.

The primary exercise of any OPEX-reduction initiative is to first determine what categories or cost-reduction conditions are real and defendable within the enterprise. Once identified, there are concise, deterministic methods available to quantify cost differences; apply time values of money to the savings; and determine internal rates of return (IRR), payback or ROI, and net present value (NPV) of the future savings. These financial metrics are essential for financial justifications of new storage infrastructures.

In a 1998 Hitachi Data Systems white paper, 29 cost-saving conditions or use cases were outlined for return on investment for Storage Area Networks (SAN).[2] Over the years, some of the 29 cases have proven to be stronger than others in rationalizing storage consolidation, aggregation and storage networks. Through hundreds of ROI exercises and case studies, the following OPEX cost conditions have provided the most defendable and believable cost savings examples in moving to advanced storage architectures. Some of these options tend to produce soft currency savings, while others are commonly seen as generating hard currency (realizable) cost savings. Some modeling conditions are aggressive in nature, while others are very conservative.

Storage Administration Effectiveness. With pooled storage architecture, the number of terabytes per person being managed increases with an effectual central administration function. Fewer people can effectively manage and allocate storage using network-connected storage and larger, fewer storage pools. Improved data management processes and controls are usually evident. The net effect is that fewer people are needed to manage more storage in the future. Human resources remains the single highest data center cost[3] and so this becomes a key target for reducing current and future OPEX costs. Systems management effectiveness, enabled by an advanced storage architecture/strategy, is key to managing more with less. A five- to seven-fold improvement is not unusual to observe after a centralization activity is complete.

Improved Data Availability. Enterprise-class storage, added with highly available storage network topologies, can reduce the risk of unscheduled downtime. Higher data-path availability means less exposure to opportunity loss or cost as a result of an outage. SANs and newer-generation storage provide higher data storage uptime when compared to locally attached disk and SCSI connections. The ratings of the disk and network topology are converted into opportunity cost or opportunity loss calculations.

2 "Developing Return on Investment and Business Case Support for Storage Area Networks;" David Merrill; Hitachi Data Systems; 1998.
3 "Automated Network Storage Drives Business Value;" Sean Derrington; InforStor; January 2003.

Environmental Costs. Newer generations of storage systems take up less floor space and lower electric bills and A/C costs due to a lower kVA and BTU per gigabyte of storage capacity. The smaller footprint and reduced electrical costs generate real savings to the IT department. This case is usually a direct result of storage consolidation (fewer, larger storage systems).

Hardware Maintenance Costs. Aggregated storage hardware costs for maintenance can be lowered since maintenance is paid only on capacity that is needed and used (as opposed to paying maintenance on unused capacity).

Software Maintenance Costs. Many times, software licenses are based on total capacity or total number of storage frames (controllers). If this number can be reduced through consolidation, additional software savings from license fees and maintenance can be realized.

Scheduled Downtime Costs. With direct-attached storage, upgrades to microcode or capacity additions often require scheduled downtime, along with labor-intensive planning and installation. This labor and time effort is in addition to the business impact of the scheduled outage. New storage architectures allow storage provisioning and upgrades to be completed nondisruptively, thereby saving real business uptime, in addition to labor- and operating-cost savings.

Asset Utilization Improvement. Storage utilization increases as storage is aggregated and shared among a larger population of servers. Less storage waste is realized, and capacity-on-demand allows storage capacity to be purchased in the future (when it is cheaper). Improved storage utilization reduces future storage procurements, and can provide just-in-time storage provisioning. Improvements from 25- to 60-percent total disk capacity utilization are not uncommon.

Storage-only Server Reductions. Storage consolidation can reduce the number of Windows NT® and UNIX® servers that just serve CFIS- or NFS-mounted storage. It is estimated that 10 percent of the UNIX or Windows NT servers in a data center are used only for disk-access purposes. With SAN and NAS converged solutions, these servers can now be eliminated, or avoided in the future, and their related operating costs can also be eliminated.

Fibre Channel and Mainframe FICON™ Implementation. There are several technical and economic benefits of Fibre Channel and FICON, including increased data transfer rates, improved performance, an increase in the distance between CPU and storage, channel aggregation, and increased addressability. To the extent that these benefits can be costed and rolled up, justifications for fibre may be evident.

Backup Improvement. Storage networks can provide the necessary infrastructure (backup servers, media servers, Fibre Channel, high-speed connections) to improve backup windows, reduce the backup workload on servers, and generally improve recovery times (RTO) and recovery points (RPO). These improvements can lower the impact of backups and meet service level or quality of service (QoS) agreements with end users.

Disaster Recovery/Business Continuity Provisioning. The separation of storage from servers provides an opportunity to manage data and processing separately, and to also plan for recovery with better optimization of data. Data replication can be applied to storage to create multiple copies of critical data for other parts of the SAN. Most data center managers realize that catastrophic data loss is less likely to come from natural disasters, and more likely to come from more common events. Having plans in place for the high-probability events (with features like replication or snapshot copies) can be accomplished with target data planning.

Tape Reduction. Architecting a central storage solution allows for fewer, larger tape libraries or virtual tape archival systems to be implemented for the benefit of the storage community. Local tape drives, tape management, shipping costs and tape-handling costs can be reduced, as these functions are automated and possibly centralized on a new storage/tape architecture.

Development Time. Data replication, shadow volumes and snapshot techniques (enabled by advanced storage architectures) can provide very rapid access to development teams that need access to near-real-time production databases and information. Mirrors can be split, and copies made available to developers to test both code and performance on near-live data. Migration time is reduced, development time is positively impacted, and the need for developers to wait for test data is minimized.

These categories can become the foundation for identifying and proactively reducing costs within each condition. Some conditions are mutually exclusive, some are dependant on other conditions, and some are best used in a standalone rationalization exercise. Each has unique value; none are created equal. Qualifying, rating and ranking these cost categories are part of the OPEX-reduction exercise.

There is value in looking at the other OPEX-reduction categories outlined in this 1998 white paper, realizing that not every situation is the same, and more ideas for cost characterizations and reductions require additional effort and financial creativity. For a more comprehensive look at these 29 cases, please review this white paper on the Hitachi Data Systems website at http://www.hds.com/pdf/wp103_san_roi.pdf.

Activities/Options to Reduce Storage Infrastructure OPEX

Now that cost targets and the types of OPEX monies have been identified, the final activity is to determine what can be done to enable the changes necessary to reduce storage-related costs. The decision regarding specific actions to take will determine the investment or re-tooling costs necessary to impact the longer-term OPEX.

There are many proven methods, activities and initiatives that have been successfully used by IT departments around the world to reduce storage OPEX costs. Not all of these activities are equal, just as not all OPEX money categories are created equal. Once the type of OPEX monies is properly identified, the preference about money types will often lead to the course(s) of action necessary to reclaim these OPEX costs. For example, if space, electricity, hardware maintenance and lower labor costs are desired, then one of the primary activities should be a storage consolidation.

Figure 1 depicts the placement of activities relative to OPEX-reduction potential and against the effort or time required to implement the specific activity. The y-axis represents cost-reduction opportunities. The higher you move on this axis, the more operational costs are impacted. The x-axis represents several areas: storage maturity; investment required; time, labor and effort necessary; and so forth. Within the graphic there are three distinct bands where the various activities reside:

Band 1 (inner band) contains the OPEX cost-reduction activities that are most easily accomplished with proven results and demonstrable savings. These are the foundation activities that one should start with before moving to more advanced initiatives. These actions pick off low-hanging fruit, and tend to be where most of the $1M-per-12TB savings reside. These activities should be considered and acted upon first in any OPEX-reduction strategy.

Band 2 (middle band) contains projects and initiatives that go beyond basic infrastructure investment—activities that work to optimize processes, procedures, organizational alignment, and so forth. These efforts are common to (or scheduled by) more mature IT departments. This band may be seen as enabling more advanced strategies and OPEX-reduction strategies. For many IT departments, this effort is 12 to 18 months out, or after the activities in the first band have been achieved. Many of the savings from this area are considered to be soft savings, but IT organizations with best-in-class storage operations (and costs) have implemented and mastered these functions.

Band 3 (outer band) includes actions that are more distant in the future. Many IT planners are targeting these activities as the end goal (storage utility, for example). These actions may require a fundamental change in business methods or business/IT roles in order to implement. Hitachi Data Systems has found that some IT shops want to get to this financial end state, and therefore, turn to outsourcing to achieve this state. New technologies and storage developments will tend to appear in this layer first, when experience proves them to pass the OPEX test of time.

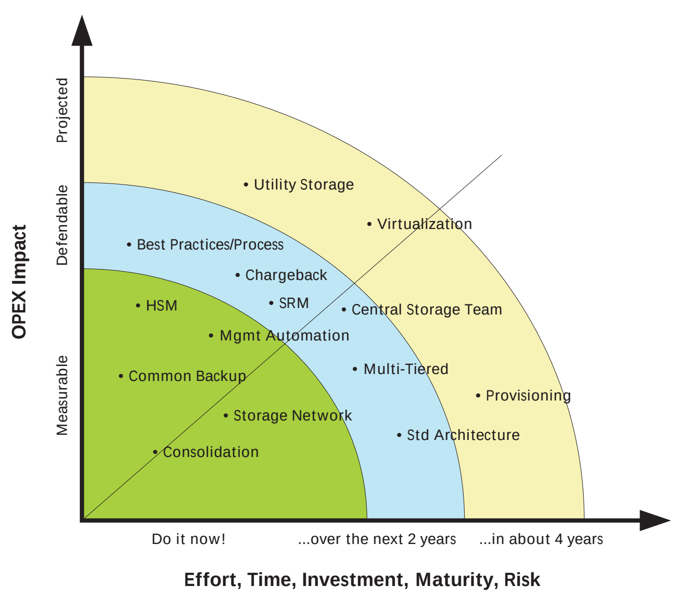

Figure 1: Relative OPEX Impact of Storage Improvement Initiatives.

A description of the activities and efforts (by band) are described below.

First Band

- *Storage Consolidation*. Fewer, larger storage systems that are easier to manage yield the simplest reduction of storage ownership costs. Overall storage utilization can increase with a central pool, and the overall staff management ratios (terabytes managed per administrator) will increase as compared to disaggregated storage pools or DAS. Most of the other activities and efforts listed here are facilitated by first achieving some level of consolidation of storage resources.
- *Storage Networks*. Separation of disk and servers is facilitated by a storage area network or SAN (FC, NAS, iSCSI, and the like). Many new functions, such as backup improvements and long-distance disaster recovery, are enabled through the SAN. A major benefit of networked storage is its potential to reduce storage costs. Networked storage is about 55 to 60 percent less expensive than the same-sized DAS environment (based on a 2TB system) due to improved disk utilization, centralized management, and reduced number of tape drives.[4]
- *Common Backup*. With a storage network in place and aggregated storage pools, advanced backup architectures (server-free, LAN-free) can be deployed.
- *Hierarchical Storage Management (HSM)*. Mainframe-style HSM methods can be implemented to move or migrate aged data onto different platform types available on the SAN or within the pool.
- *Storage Management Automation*. Common storage management functions can be applied to the simplified storage architecture. Many tools are available to assist storage administrators in allocating storage volumes; changing LUN sizes; enabling quotas; managing capacity plans, security, zoning, and backup jobs; and so forth. Improved management increases the terabyte-per-administrator yield for storage management (doing more with less) and improves overall storage utilization rates.

Second Band

- *Best Practices and Processes*. Logical or physical storage centralization allows for common practices and processes to be applied to storage. These include change control, version control, problem and help management, and capacity plans. Many Hitachi Data Systems customers use IT Information Library (ITIL) standards for IT operation definition and standardization.
- *Storage Chargeback*. Chargeback is an essential element to force end users to account for—and pay for—the storage resources utilized. Chargeback schemes drive proper behavior of storage locations (tiers) that are based on service levels and price points. With chargeback mechanisms, all data types will not be delivered and engineered in the same manner.
- *Storage Resource Management (SRM)*. Software and processes provide a management framework that allows all storage, SAN, and related infrastructure to be managed uniformly. SRM is in part the ability to monitor and report on storage but also includes management of the system(s) itself, the applications and storage devices, and the efficient backup and recovery of data.

[4] "The Storage Report—Customer Perspectives & Industry Evolution;" A Joint Industry Study by McKinsey & Company and Merrill Lynch's Technology Research Group; June 2001.

- *Centralized Storage Management Team*. Designing and deploying a specialized storage management team will establish a framework for skills development, operational optimization, improved operational methods, and proper metrics for managing storage resources.
- *Multi-tiered Storage Options*. Within the new storage architecture, multiple price and function points can be defined to provide a variety of storage options. Not all data is created equal, and multiple tiers can be used to house data in the appropriate location so as not to over-engineer solutions. (For example, users should not need 15,000RPM, RAID-1/0 high-performance disk connected with FC through a director for file/print data.) This becomes a prelude action for storage utility.
- *Building and Managing with Storage Architectures*. Consistent, structured, certified, and documented strategies tend to discourage rogue technologies and point solutions. Without a standard storage architecture, another island of optimization will arise with the SAN, and the total savings from these investments will be minimized. The storage architecture needs to include operational, technical and organizational architecture constructs.

Third Band

- *Storage Utility*. Providing computing resources as a utility, much like electricity, makes delivering a new business application as simple as plugging a lamp into a socket. The aim is to provide unlimited storage capacity in a way that makes it possible for the storage to be used and billed for any application. The financial benefit will be to limit CAPEX spending and drive a usage-based IT cost model for businesses.
- *Virtualization*. This relates to software, hardware and processes that can present any storage resource to any host resource.
- *Storage Provisioning*. Along with virtualization, storage provisioning will combine hardware, software and processes to enable storage resources that can be made available to hosts, without regard to vendors, platforms or protocols. Virtualization and provisioning take the next logical step to allocating storage resources that are driven by the SLAs and OLAs made with end users.

Triggers to Conducting an Economic Analysis

Now that we have described how much OPEX money potential may exist, the types of money that can be characterized, and the types of activities that can be used to harvest this money, any further motivation to act needs to come from the IT or finance departments. The following list of trigger events may help define conditions or situations where OPEX potential exists and where an in-depth economic analysis may be in order. If some (or many) of these trigger conditions apply, consider undertaking an economic analysis of the enterprise's storage environment. There could be enough OPEX potential to warrant a change in vendors, topologies, protocols, or operational practices/deployment.

- *The IT organization has lots of direct-attached storage (DAS) spread throughout the enterprise*. These storage resources are more difficult and expensive to manage. Advanced storage architectures can be a big benefit due to improved utilization, improved management, and better overall performance.
- *Storage outages exist*. Advanced storage hardware and software, when bundled with SANs and remote-site replication, can provide various levels of a fault-tolerant storage infrastructure.

- *IT plans and strategy include application and server consolidation.* Storage aggregation and consolidation are usually forerunners to server and application consolidation.
- *Many RAID storage systems are already in the data center (small- to medium-sized systems).* Just like the DAS condition, multiple RAID systems can still be consolidated into fewer, larger storage pools. This enables better management and uptime.
- *The IT department needs to reduce operating expenses now.* There is a need to drive out OPEX costs, reduce the storage charges levied against the end user, and/or generally do more with fewer resources.
- *Finance and IT work together.* This is becoming more and more common, where purchasing personnel, the CFO, and the budget staff get more involved with IT decisions. This is typically a sign that IT really wants to reduce costs.

Storage Economics Best Practices, Lessons Learned

After having completed hundreds of storage assessments and economic justifications during the past several years, Hitachi Data Systems has identified and documented best practices and lessons learned in storage economics. They are summarized below:

- Any storage economic analysis needs to be driven by a joint effort between the finance department and the IT group responsible for storage decisions.
- ROI savings have to be defendable and believable within the organization.
- A balanced team is essential for conducting an unbiased economic analysis. Best-in-class teams include technologists; operations, finance and end-customer advocates (who can provide a meaningful storage economic model); and vendor stakeholders.
- Separation of hard savings from soft savings provides credibility to storage justifications. Hard savings are typically those that can generate tangible financial variances that can be counted or taken out of a particular department's budget. Soft savings are those that are recognized and appreciated, but may not be defendable to the point that real monies are ever saved.
- Every business considers different hard and soft savings in TCO and ROI analysis, but not all conditions are ever equal. When IT and finance departments can agree to a wide range of cost containers to modeling and evaluating, the economic analysis is less biased in any functional area.
- Company finance officers (CFO, COO) need to drive the economic targets, IRR, payback goals, and so forth. These should not be driven by the IT department.
- Ask vendors to articulate and define economic value in real currency terms that can be applied to a particular business. The IT department should set the criteria and categories that are meaningful (hard savings), and not leave this to vendors.
- Economic factors need to be part of a long-term storage strategy. Storage economics should work in partnership with other storage qualities, such as availability, scalability, performance, manageability, and the like.
- Storage economic techniques are applicable in both good and bad economic times.
- Economic positioning needs to start early in strategy and architecture definitions, and not be left to tactical purchasing events alone.

- Review, revise and modify ROI and TCO calculations after the fact. Periodically review cost-reduction assumptions in order to provide consistency in storage and IT economic decisions. As time permits, validate theoretical ROI and TCO parameters with real/measured cost components.
- Identifying the economic hero(s) is essential to finding and reclaiming storage-related OPEX cost savings. The absence of the economic hero will lead to dead-end results that are never implemented (since there is no sponsor for the changes). If a cost saving does not have a stakeholder, it may not be perceived as real and will often be disallowed.
- Do not confuse ROI and TCO tools with the real intent of the economic messaging; any tool is a means to the end.
- Purchase price per megabyte is the wrong single metric to use in economic decisions for storage; this is also true of any part of the storage ecosystem (HBA, tape, networks, and so forth).
- If costs cannot be characterized, and owners for the costs identified, then an ROI activity will be a waste of time.
- In detailed ROI analysis, data collection of the current environment (capacity, costs, performance) is the most problematic element of the work.
- More than one economic perspective is often necessary. IT planners need to be flexible in CAPEX and OPEX categories and not limit the savings to one or two categories alone.
- Even with superior economic-savings potential, if the IT department is unable or unwilling to change operating parameters, processes, procedures, or vendors (as necessary), then economic motivators alone will be insufficient to enable a change.
- Do not allow vendors alone to define and characterize TCO and ROI variables and categories.

Appendix A: Glossary of Terms

Acronym	Definition
CAPEX	Capital Expense
CFO	Chief Financial Officer
CEO	Chief Executive Officer
COO	Chief Operating Officer
DAS	Direct Attached Storage
FC	Fibre Channel
HBA	Host Bus Adapter
HSM	Hierarchical Storage Management
IRR	Internal Rate of Return
ITIL	IT Information Library
NPV	Net Present Value
OLA	Operating Level Agreements
OPEX	Operating Expense
QoS	Quality of Service
ROI	Return on Investment
RPO	Recovery Point Objective
RTO	Recovery Time Objective
SAN	Storage Area Network
SLA	Service Level Agreements
SRM	Storage Resource Management
TCO	Total Cost of Ownership (or Operation)

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