Hitachi Data Systems

Economic Impact of Storage Virtualization

A storage economics discussion paper prepared for XYZ

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Introduction

HDS is pleased to present this discussion paper covering the economic benefits of virtualization for XYZ . XYZ is considering storage virtualization as a technology for operational and cost improvement. Some skepticism or questions on the operational benefits of virtualization needs to be addressed relative to the operations and file-types at . This paper will discuss the economic benefits of virtualization for XYZ , and more specifically the costs that can be targeted for reduction by employing this technology.

HDS works with several other large oil/gas customers with global operations and storage infrastructure environments that are very similar to XYZ . Great strides have been made with these clients to reduce unit cost of managed storage, as well as ancillary OPEX costs that contribute to, or are associated with, storage TCO. Although each client is different with the technologies and storage operation maturity, intelligent-controller-based virtualization and integrated tiered storage has been a fundamental strategy in new storage architectures with most all of these clients. The nature of the oil and gas industry is such that continuous improvements in ROA and TCO are essential for strategic planning and tactical implementations.

During some preliminary meetings with XYZ , it appears that the overall operational capability and relative maturity[1] of the storage organization positions virtualization as a strategy for improved operations, ROA, and lower storage TCO. Virtualization in an activity to be preceded by several storage improvement initiatives (organization optimization, consolidation, standard storage services), and usually requires a mature operating and management environment. Storage virtualization is an advanced activity that HDS has seen mature clients utilize to improve storage costs and to reduce OPEX (see appendix A). XYZ , from our limited expose and conversations to-date, clearly appears to be in position to take advantage of this architecture to drive new improvements.

Although this paper is focused on the economic impact of virtualization, there are perhaps other investments areas that could be done at XYZ to reduce CAPEX costs and reduce future OPEX costs. We have not had the opportunity for 'economic intimacy' at XYZ , but common cost reduction tasks that might also be considered at XYZ can be listed as follows:

- Disk-based backup
- Simple storage consolidation and tech refresh
- Data De-duplication
- Common storage services catalog
- Active Content Archive

Storage Virtualization and Economic Resources

This paper will not go through the technical and operational benefits of Storage Virtualization, nor will it outline the different technologies available to provide virtualization for the storage infrastructure. Other resources are available on these topics. We recommend the following sites for more information:

- IDC Paper http://www.hds.com/pdf/wp_idc_virtualization_benefits_091605.pdf
- ESG Report "The Future of Network-based Storage Intelligence"
- entrix Report

HDS has developed a full methodology for Storage Economics measurements, calculations, and strategies to reduce costs. The following BLOG site and BLOG library will provide additional information on these topics.

- Baseline paper storage econ http://www.hds.com/pdf/StorageEconomicsWHP-153.pdf
- Dave Merrill BLOG on Storage Economics http://blogs.hds.com/david/
- LFI Case Study http://blogs.hds.com/david/wp-content/wp_tiered_storage_241.pdf
- TagmaStore Paper http://blogs.hds.com/david/wp-content/wp_197_storage_econ_usp.pdf

[1] See Appendix C for the Storage Management Maturity Model as defined by SNIA

Mapping XYZ OPEX Costs to Virtualization Benefits

Before this paper was developed, HDS and engaged in a series of meetings and webinars to review the basic cost elements of the traditional storage infrastructures, and what cost content areas are of interest to XYZ . HDS' storage economics methods have been presented, along with the 32 types of storage ownership costs, and which ones may apply to XYZ . Out of the 32 types of areas that constitute storage TCO, XYZ had identified the following:

- XYZ is primary interested in defendable, significant savings in storage operations (hard costs)
- XYZ chose 18 of the 32 categories as high interest, hard costs from the HDS methodology
- Of the 18 types of cost reduction interests selected, defined
  - 7 are directly impacted by storage virtualization
  - 8 are indirectly related, where virtualization *enables* something else
  - 3 are not related directly to storage virtualization
- The other 14 costs are soft cost or not-applicable

This paper will take the approach to characterize the 7 general cost areas that would be impacted by a storage virtualization architecture. Below, all of the cost definitions have been summarized, but only the 7 hard costs directly related to virtualization will be discussed in this paper.

Strong Cost Reduction Cases for Virtualization

For XYZ , these 7 cost areas have direct, relevant savings from storage virtualization. These will be the areas that we focus on for ROI later in the paper.

1. **Storage Hardware Purchase Avoidance** - Some storage architectures are more likely to reduce future capital expenses due to better utilization of existing assets. Virtualization can improve aggregate utilization that tends to get fragmented or isolated on several, smaller (non-virtualized) arrays. Direct cost savings comes from
   - Better aggregate utilization and reduce stranded capacity
   - Reclamation of 20-40% for XYZ test cases

2. **Storage Software Purchase Avoidance** - Software control in a virtualized architecture is centralized to the center of storage intelligence (in the case of HDS' TagmaStore USP, this is done within the intelligent controller). This central control allows for the collapse or complete removal of software and operational intelligence on the subordinate arrays. Impact with virtualization are:
   - Change from capacity based license to controller based
   - Typical savings of 15-20% in purchased licenses
   - Tiered storage extends the savings when software expenses and licenses are applied to the right tier requiring the software functionality

3. **Software License Fee Avoidance** - When the software purchase cost is reduced, the recurring maintenance fees will also be reduced immediately. Reducing SW purchases by a centralized/intelligent controller will enable savings in monthly maintenance fees

4. **Data Center Floor space** - Storage virtualization will increase aggregate utilization, thus requiring fewer arrays to store the operational data. This reduction of arrays will provide savings in floor space, power and cooling costs in the data center. Asset utilization, Improved ROA and less waste will help reclaim/reduce cabinet, resulting in floor space reclamation in the short-term. Over time, better utilization will keep the TB/square foot at improved rates over what is available today

5. **Storage Electricity Costs** – This cost saving is associated with #4 in reducing environmental costs. The specifics of savings are:
   - Asset utilization, Improved ROA and less waste will help reclaim/reduce cabinets, resulting in less power for unnecessary controllers

  - Over time, better utilization will keep the kVA-per TB at improved rates over what is available today

6. **Storage Workload Labor, Re-provisioning & Remastering** - Without storage fragmentation, labor time necessary to load balancing, provisioning (hunting for free space), capacity planning is greatly reduced. This reduction is often seen at 20-80% of many common weekly management tasks. Cost Impact with Virtualization
   - Virtual pools allows for more flexibility in finding available LUNS (eLUNs) for last min allocations and provisioning
   - Tiered storage enables by virtualization will allow for data migration to lower tiers, and unforecast capacity to enter in at a lower tier and work the way up the stack
   - Significant labor savings are available for data migration and remastering, taking an 8 hour typical task down to minutes.
   - Performance, availability, QoS and SLA levels at the right tier, Dynamic tiered storage is dependant on a virtualized environment

7. **Disk Fragmentation, Utilization** - Aggregation and allocation from a common pool not only avoids future capital purchase for growth (see # 2 above), but reclaims current capacities stranded behind stand-alone arrays. Cost Impact with Virtualization
   - Better ROA
   - Less wasted space, reduce future CAPEX
   - Stranded capacity on each stand-alone frame is eliminated

Moderate Cost Cases for Virtualization

Not all the 32 types of money in the Storage Economics methodology are hard savings for XYZ . Virtualization is more of an enabler of the following types of money, and since these monies were seen as indirect or soft in nature, the total cost savings impact can be a qualifying impact (although in the paper not a quantifiable savings) within this analysis. XYZ may see these benefits as indirect savings.

8. **Hardware Maintenance Cost Avoidance** - Virtualization can help achieve higher levels of aggregate utilization, leading in a reduction of storage arrays on the floor. Improved utilization can often result in a 20-40% reduction of frames (in larger, multi-frame environments). The reduction of frames will reduce hardware maintenance costs for these arrays. Since XYZ tends to purchase storage with 5 years of included hardware maintenance, and depreciate the assets for 4 years, there will be only a few situations where an asset is in use long enough to be accruing hardware maintenance costs.

9. **Costs of Long Distance Circuits** – Improving the overall storage assets, will provide better insight and classification of data under storage. When bundled with tiered storage, data is stored and protected in the right tier of storage infrastructure. In large environments, this re-allocation of data can often reduce the TB of data needed to be replicated remotely, and thus reducing long distance circuits needed for data replication. Local snap copies can be done in lower tiered/virtualized arrays within the pool, often meeting RTO and RPO requirements without going off-site.

10. **Business Impact /Subsystems** – Virtualization in and of itself does not improve the subsystem availability. Each unit still has an inherent availability rating based on design, RAID protection, age, etc. Virtualization can provide the pool of storage with various service levels and protections (tiers). This will tend to be an indirect cost benefit of virtualization.

11. **Faster Recovery from Catastrophic Events –** This cost saving is similar to #9 above. Local snap copies can be done in lower tiered/virtualized arrays within the pool, often meeting RTO and RPO requirements while not going off-site. This is an indirect cost benefit for XYZ .

12. **Faster Recovery from non-Catastrophic Events** - This cost saving is similar to #9 above. Local snap copies can be done in lower tiered/virtualized arrays within the pool, often meeting RTO and

RPO requirements while not going off-site. Furthermore, disk-based backups can be elegantly engineered within the storage pool or on a tiered architecture. These disk backups can use lower tiers (often fully depreciated disk that has been virtualized. This would be an indirect cost benefit for XYZ .

13. **Data Security, Encryption** – this area would be an indirect Cost Impact with Virtualization in that security and encryption can be simplified with a single point-of-control for the entire store pool.

14. **Storage Downtime Impacted by Human Error** – Again, virtualization will simply operational control points for the entire storage pool. There if often a large reduction in the consoles or management points for the storage pool. The single point of management can be a blessing and a curse related to distributed/centralized management. Capacity-related slow-downs or outages will be reduced. If strong operational practices and processes (ITIL based) are in place, then the simplification and central command will reduce the number of storage outages blamed on human errors and operations.

15. **Cost of Tape Infrastructure** - disk-based backups can be elegantly engineered within the storage pool or on a tiered architecture that is enabled by storage virtualization. This effort would directly impact tape drives, media and media servers in the infrastructure.

Virtualization not Factored in these XYZ Cost Reduction Areas

The remaining categories are of interest to XYZ relative to OPEX cost reductions, but are not necessarily tied to implementing storage virtualization. Other investments and activities could be identified at a later date to demonstrate tactics and strategies to reduce these storage costs at XYZ .

- Staff time for Planned Outages
- Business Impact – Data Path
- Labor Costs through Off-shoring

Virtualization Cost Benefits not fully Embraced by XYZ

In addition to the costs savings where XYZ has interest, and where virtualization can enable financial benefits, there are additional types of money that can be reduced with storage virtualization. Even though XYZ did not place high priority on these types of OPEX costs, a virtualization architecture has been shown to reduce OPEX costs further in the areas of:

- Data migration cost, re-mastering
- Faster Provisioning of storage
- Simplified management, TB-per-FTE incremental improvement
- Investment protection of some older assets
- Reduction of Storage Network infrastructure

Virtualization Options with XYZ - Houston Storage

With the understanding of what type of cost reduction categories are important to XYZ , HDS next looked at 2 options for virtualization within the HDS storage pool in Houston. Option 1 is to virtualize (2) 9900 storage arrays that are used for Tier 1 storage. Option 2 is to virtualize (7) 9500 and AMS arrays behind a TagmaStore USP.

HDS tends to find that the best economic results come when more arrays, and older arrays can be included in a virtualization architecture. Numerically more, and older arrays help with the payback due to:

- Reducing the number of frames, thus impacting
  - License fees
  - Electricity, cooling and floor space
- Improving the data migration or data remastering costs

- Improving aggregate utilization. More arrays tend to demonstrate more stranded capacity that can be affected by a virtual pool concept
- Simplification of management labor
- Simplification of front-end SAN ports

We would expect that the ROI and payback from the Tier 2 storage to be superior given the total frame count, capacity and opportunity to impact the above points. A 2-1 virtualization scheme that is shown for Tier 1 would tend to provide economic benefits similar to consolidation or a tech refresh, and less savings due to storage virtualization.

XYZ Tier 1 Virtualized Architecture

The first use case for virtualization is the Tier 1 Storage in Houston. Currently there are (2) HDS 9900 arrays, and the proposal would introduce a single TagmaStore USP1100 as front-end to current capacity. The USP would also have 18.7TB of raw disk capacity within the frame. The Hitachi TagmaStore consolidates, virtualizes, and unifies data into one pool, scaling up to 332TB internal and 32PB external heterogeneous storage. The Universal Storage Platform leverages the third-generation Hitachi Universal Star Network™ crossbar switch architecture to delver high availability and performance, large-scale controller-based virtualization for ease-of-management, logical partitioning for application quality of service, storage-agnostic universal replication for business continuity, and a rich set of software tools.

Hitachi Virtual Partition Manager software enables the logical partitioning of ports, cache and disk (parity groups) into Private Virtual Storage Machines on the TagmaStore. Partitions allocate separate, dedicated, secure storage resources for specific users (departments, servers, applications, etc.). Administrators can be provided access to control resources and execute business continuity software within their assigned partitions, secured from affecting any other partitions. Partitions can be dynamically modified to meet quality of service requirements. Overall system priorities, disk space, and tiers of storage can be optimized for application QoS based on changing business needs

HiCommand Device Manager is a product specific to Hitachi storage systems that provides centralized management of distributed Hitachi environments. It also provides the device interface into Hitachi storage systems for the heterogeneous HiCommand Storage Services Manager and other third-party storage management tools. HiCommand Device Managers Provisioning Assistant is a value-added component that enables administrators to integrate and manage various models and types of storage systems as a single, virtual storage pool, allowing storage administrators to do more with less.

Hitachi Universal Volume Manager software provides the virtualization of a multi-tiered storage area network comprised of heterogeneous storage systems. It enables the operation of multiple storage systems connected to a TagmaStore Platform as if they were all in one storage system and provides common management tools and software. The shared storage pool comprised of external storage volumes can be used with storage system-based software for data migration and replication, as well as any host-based application. Combined with Hitachi Volume Migration software, Universal Volume Manager provides an automated data lifecycle management solution, across multiple tiers of storage.

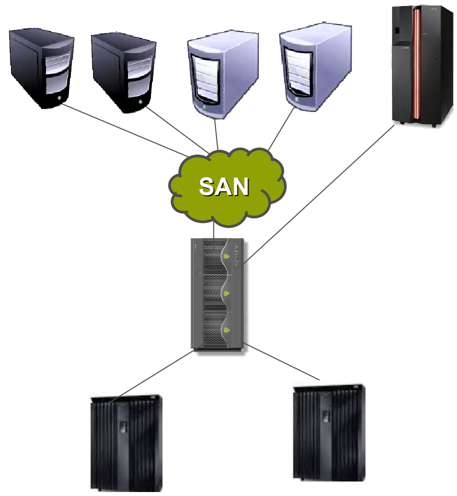

Figure 1 Tier 1 Virtualization Configuration

Technical and operational Basic Benefits

- USP to connect and virtualize (2) 9900 storage frames
- Stranded capacity reclaimed is 25 TB over a 5 year period
- Aggregate utilization increases from 70% - 80%
- Integrated tiered storage now with different classes of disk, fast migration and movement, to better accommodate changing storage needs
- Labor reduction, average of 7 hours/week for provisioning, load balancing, capacity plans
- SW license cost (recurring) reduction with software control now in the Tagma USP
- Floor space, power and cooling positively impacted by the removal (absorption) of the 9960 arrays into the virtualized storage pool

Economic Calculations for Tier 1 Virtualization

ROI calculations based on the hard cost categories XYZ has selected from the 32 types of costs

- Labor Effectiveness – 7 hours per week saved in common management and storage allocation tasks associated with file systems on these 2 systems. Labor for growth, allocation, load balancing etc. Labor costs for data migration and remastering is a savings of 8 hours per week.
- Electricity Savings – kVA ad BTU calculation on the frame count reduction. 1 frames phased-out over a 12 month period. kVA per TB increase easing DC space and power consumption issues
- Floor space savings – TB/square foot increases as more dense, efficient, high density drives are used to refresh older technology. Even though there is no financial impact with the reclamation of data center floor space, there is a quantifiable benefit of about 50 square feet.
- HW maintenance – will be impacted with the removal of the (1) frames absorbed into the virtualized storage pool
- SW license fees reduced as common software functions are now performed on the USP
- Utilization of assets (ROA) – CAPEX avoidance of 25TB, stranded capacity of approximately 35TB

	Year 1	Year 2	Year 3	Year 4	
Cash investment	($800,395)	$93,901	$4,401	$104,401	
Savings					*Use Case Totals*
Environmental savings	30,160	36,072	43,142	51,598	160,972
Hardware maintenance	0	21,600	21,600	48,000	91,200
Virtualization - Waste reduction	72,103	64,079	56,818	50,254	243,254
Purchase avoidance	0	0	0	0	0
Storage area management savings	92,950	94,809	96,705	98,639	383,103
Net cash flow	($590,082)	$325,561	$237,767	$346,020	
Cumulative cash flow	($590,082)	($264,521)	($26,754)	$319,265	
Total investment	$597,692				
Total savings	$916,957				
Client-supplied Internal Rate of Return	15.00%				
Calculated Internal Rate of Return	2.55%				
NPV of savings	$222,375				
ROI Method 1 - Simple ROI	38%	Savings / # of years / investment			

Figure 2 Tier 1 Virtualization ROI and Cash flow

Proposed Storage Architecture Return on Investment

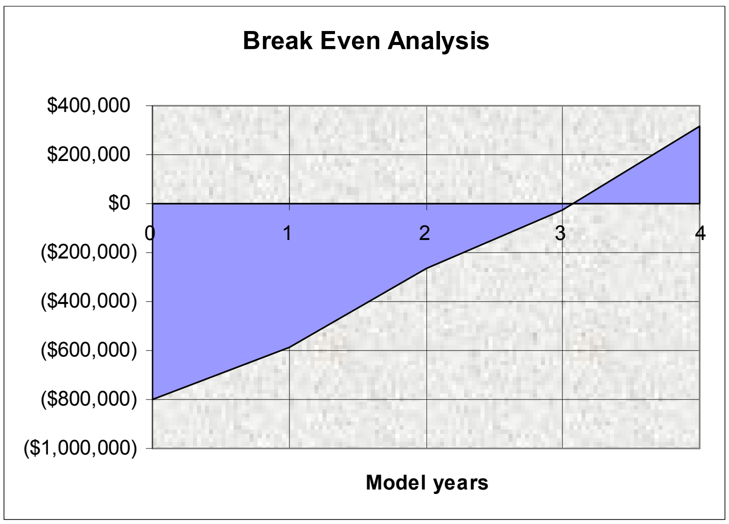

Figure 3 Payback Term - Tier 1 Virtualization

- Initial after-tax investment of $597,692
- Total Savings $916,957
- Payback in 37 months
- IRR of 2.55%
- ROI of 38% (Savings/ years/ Investment method)
- NPV of savings $222,375

XYZ Tier 2 Virtualized Architecture

The second case for virtualization at XYZ in Houston is with the Tier 2 storage. For this case a TagmaStore USP1100 would be put as a virtualization front-end to current capacity. The USP would connect and virtualize (4) 9500 storage frames and (3) AMS1000 arrays. Universal volume manager , Virtual partition manager and HiCommand are also included in the configuration.

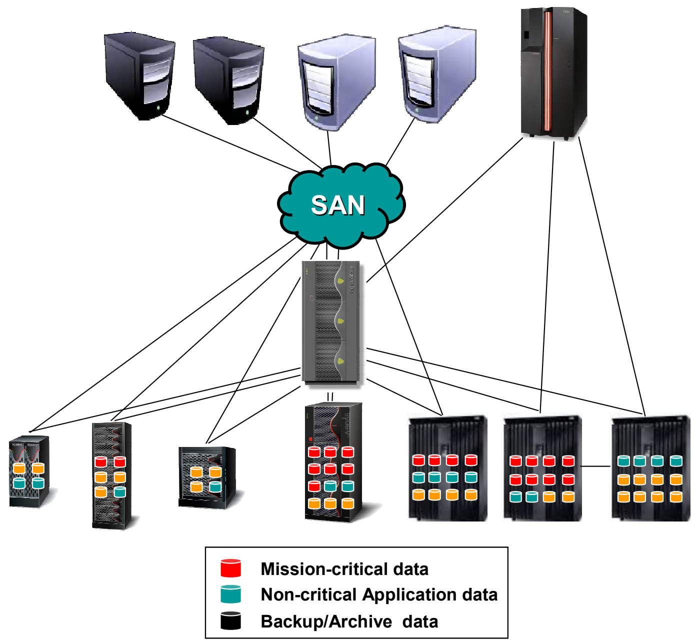

Table 1 Tier 2 Virtualization Configuration

Investment Summary

- USP 1100, 18TB raw internal FC disk
- Cost of growth, estimated, within the new virtualized architecture
- Device manager 19TB license
- Virtual partition manager for internal and external disk
- Universal volume manager 89 TB license

Technical and operational Basic Benefits

- USP to connect and virtualize (4) 9500 storage frames and (3) AMS1000 arrays
- Over time, the 9500 arrays will be absorbed into the reclaimed capacity of the AMS1000 arrays. This is a direct benefit of virtualization and non-disruptive data migration.
- Frame reduction from 8 to 4 over 12-18 months as 9500 data seamlessly migrated to TagmaStore USP internal and AMS 1000 external disk.
- Even with keeping the aggregate capacity growth at 30% CAGR, the purchasing demand curve will be ‘shallower’ since the utilization will be improved, and stranded capacities will be reduced.
- Stranded capacity reclaimed is 110 TB over a 5 year period. This represents less purchasing effort (time, materials) in addition to the CAPEX saved
- Aggregate utilization increases from 60% - 75% in the new virtualized environment
- Management points decrease from 3 or 4 to 1
- Integrated tiered storage now with different classes of disk, fast migration and movement, to better accommodate changing storage needs
- Labor reduction, by an estimated 20 hours per week for provisioning, load balancing, capacity planning
- SW license cost (recurring) reduction with software control now in the Tagma USP
- Floor space, power and cooling positively impacted by the removal (absorption) of the 9500 arrays into the virtualized storage pool
  - 108 sq. ft of data center space
  - 30,000 BTU
  - 9.32 kVA

			Install Date	Expiration	Raw	BTU	kVA
HOU150	9585	68090143	09/08/05	9/2010	43.4	5823	1.86
HOU150	9570V	65015584	05/05/04	5/2009	18	3327	1.06
HOU150	9570V	65016108	05/22/04	6/2009	25.3	3877	1.24
HOU150	9570				21	3563	1.14
HOUSTON	AMS1000	77010663	11/1/2006	11/2011	41.8	4206	1.34
HOUSTON	AMS1000		1/1/2007	11/2012	41.8	4206	1.34
HOUSTON	AMS1000		1/1/2007	11/2012	41.8	4206	1.34
					233.1	29208	9.32

Table 2 Tier 2 Storage Inventory - Houston

Economic Calculations for Tier 2 Virtualization

ROI calculations based on the hard cost categories XYZ has selected from the 32 types of costs

- Labor Effectiveness – 20 hours per week saved in common management and storage allocation tasks associated with file systems on these 7 systems. Labor for growth, allocation, load balancing etc. There is another 12-16 hours per week in data migration and data remastering cost avoidance over the next 2 years.
- Electricity Savings – kVA ad BTU calculation on the frame count reduction. 4 frames phased-out over a 12-18 month period. kVA per TB increase easing DC space and power consumption issues
- Floor space savings – TB/square foot increases as more dense, efficient, high density drives are used to refresh older technology, and although this is not a budget impact value for XYZ , the savings in floor space is significant.
- HW maintenance – will be impacted with the removal of the (4) frames absorbed into the virtualized storage pool for a savings of $204K over 4 years
- SW license fees reduced as common software functions are now performed on the USP. These savings are projected to be $180K
- Utilization of assets (ROA) – CAPEX avoidance of 110 TB, stranded capacity of approximately 63TB
- Capital avoidance for growth – Cost of capital avoidance for disk is $1.7M over 4 years. There is a marginal savings in front-end FC ports that may be realized due to the virtualization architecture, but this fabric collapse cannot be determined at this time until total throughput is defined.

	Year 1	Year 2	Year 3	Year 4	
Cash investment	($888,811)	($56,826)	($100,576)	$149,424	
Savings					*Use Case Totals*
Environmental savings	17,971	24,297	32,849	44,412	119,529
Hardware maintenance	0	42,000	111,264	51,264	204,528
MTS - Purchase avoidance effect	417,188	434,951	453,400	472,564	1,778,103
Software maintenance	34,000	34,000	70,000	42,387	180,387
Storage area management savings	195,910	199,828	203,825	207,901	807,464
Net cash flow	($223,743)	$678,250	$770,762	$967,953	
Cumulative cash flow	($223,743)	$454,507	$1,225,270	$2,193,222	
Total investment	$896,789				
Total savings	$3,090,012				
Client-supplied Internal Rate of Return	15.00%				
Calculated Internal Rate of Return	8.74%				
NPV of savings	$654,460				
ROI Method 1 - Simple ROI	86%	Savings / # of years / investment			

Figure 4 Tier 2 Virtualization ROI and Cash flow

Proposed Tier 2 Storage Architecture Return on Investment

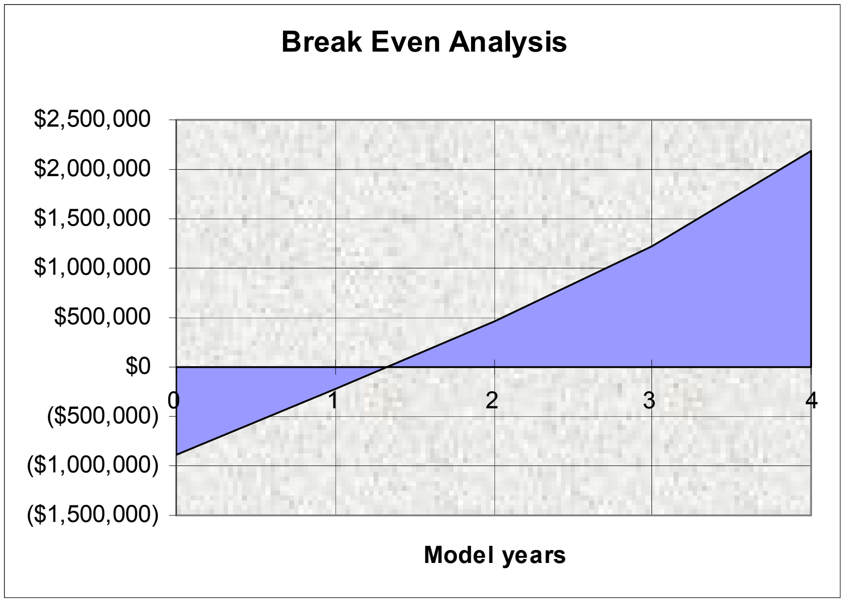

Figure 5 Payback Term - Tier 2 Virtualization

- Initial after-tax investment of $896,789
- Total Savings $3,090,012
- Payback in 15 months
- IRR of 8.74%
- ROI of 86% (Savings/ years/ Investment method)
- NPV of savings $654,460

Conclusions, Next Steps

The results of this informal work appears to show that XYZ can achieve good return on investment by employing storage virtualization architecture for environments where 4-5 older storage arrays can be included in the new storage pool. The Houston Tier 2 HDS environment appears to be a good sample size of an environment where savings can be realized.

Virtualization can provide the kind of savings that XYZ is interested in reducing, and where hard cost benefits can be realized in a relatively short time. Labor reduction, HW and SW maintenance reduction and avoiding future capital costs are all direct benefits for considering a storage virtualization. The age and geographic situation with several XYZ environments suggests that a pilot program should be considered and funded to prove the operational , technical and economic benefits of storage virtualization.

Virtualization Sweet Spot

As shown above the 2-1 virtualization does not behave economically as well as the 7-1 configuration. More system, older systems with lower utilization and stranded data do better with economic justifications. Houston Tier 2 demonstrates better ROI when compared to the Tier 1 storage in Houston. If XYZ can identify pools or pockets of medium-old systems of 4 or more storage arrays, a micro virtualization environment would demonstrate good to excellent cost savings.

Labor savings will improve as more points of management are collapsed into one. Many smaller systems each with storage management software (and recurring license fees) are a key criteria for identifying good candidate systems.

If the Houston Tier 1 and Tier 2 were to be integrated into a single instance pooled architecture, with tiered storage management software, extending the leverage of the USP and virtualization benefits would demonstrate a force-multiplying cost benefit impact for XYZ .

OPEX Cost Savings Beyond virtualization

Other things that XYZ may consider for OPEX reduction have been discussed briefly and may include:

- Active Archive
- Single virtualization with tiered storage
- De-duplication
- Thin provisioning

In order to make better recommendations for virtualization or other investment areas that XYZ should consider to reduce OPEX, HDS recommends a more formal, intimate Storage Economics Strategy Service. This engagement activity can help with a full discovery of assets, usage patterns, stranded capacities, labor efforts etc. This formal service would provide additional detail and insight far beyond this discussion paper, and may help with XYZ architecture and storage investment priorities.

Appendix A : HDS Storage Economics Methodology

HDS works with clients around the world to help define, locate and take action plans to reduce TCSO.

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.

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. The $1M-to-12TB ratio is conservative, and generates the savings over a three-year term.

Typical Tactical Plans Used to Reduce Storage OPEX

Over the past several years, HDS consultants have documented best-in-class activities and initiatives that IT departments have implemented in order to reduce cost, and lower TCSO. The description of the activities to reduce OPEX are summarized below.

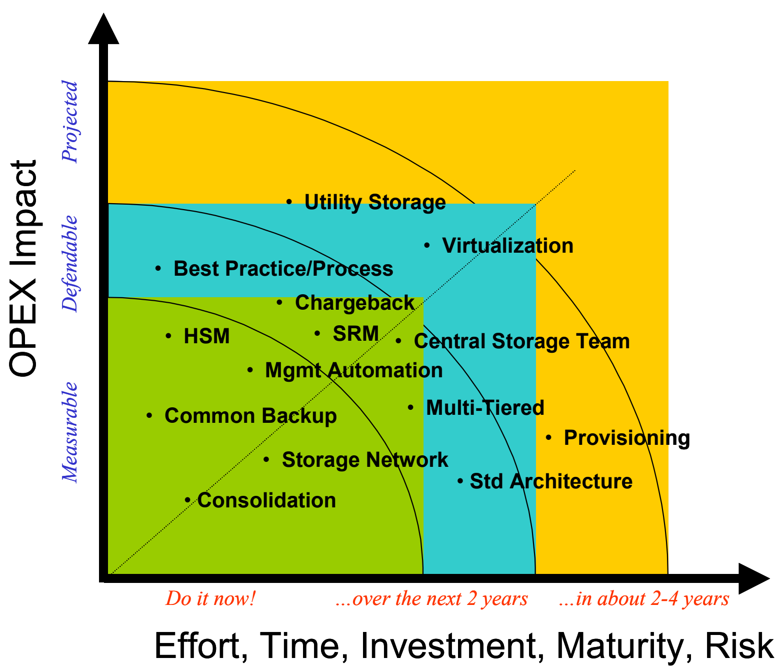

Figure 6 Range of Activities to Reduce Storage OPEX

Appendix B : Economic Model Assumptions

Economic Parameters	
Modeling Term	4 years
Depreciation Term	4 years
Depreciation	SLN, 0 Salvage Value
Marginal Tax Rate	42%
HW Maintenance	5 Years included
SW Maintenance	3 Years included
Current Labor Ratio 1-to	75 TB
CAGR– Tier1	15%
CAGR– Tier2	30%
CAGR – Tier3	50%
Storage Acquisition cost Tier1	$15/GB
Storage Acquisition cost Tier2	$7.50/GB
Storage Acquisition cost Tier2	$2.55/GB
File Systems Utilization Rate Tier 2	60%
File Systems Utilization Rate Tier 1	70%
Target utilization rate	80%
Storage mgmt burdened labor rate	$220,000
$/kWatt hour	$0.11
$/square foot DC space	No charge
Price Erosion of Tier1	15%
Price Erosion of Tier2	20%
Price Erosion of Tier3	30%
XYZ Target IRR	15%
Raw Capacity T1	103.6 TB
Usable Capacity T1	TBD
Raw Capacity T2	232 TB
Usable Capacity T2	TBD
Remastering costs per TB	8 hours
Target payback term	18-24 months
Fibre Channel Port cost	$2000/each

Appendix C: Storage Management Maturity Model