WHITE PAPER

Measuring the total cost of ownership of tape storage solutions

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1 Introduction

This paper presents a framework and financial methodology for deciding whether or not an enterprise should replace its current ("Status Quo") tape storage solution with a new ("Proposed") solution and the economics related to that decision.

The framework and methodology are explained by following an "illustrative business case" from beginning to end. This illustrative business case is analyzed into each of the elements ("value drivers") that contribute to the cost of the Status Quo and Proposed tape storage solutions. Aggregate analysis of the value drivers is then used to calculate the "discounted total cost of ownership savings," which is the difference in total cost of ownership between the Status Quo and Proposed solutions. Finally, we apply additional financial measures to further evaluate whether it is in the enterprise's financial interest to replace Status Quo with a Proposed tape storage solution.

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2 Illustrative business case assumptions

The illustrative business case assumes that Goodstuff Company (a fictitious company) currently operates three diverse tape libraries, which contain a total of 40 tape drives. The enterprise currently has 11,000 cartridges stored in slots within the three libraries. Five thousand more cartridges are kept at an offsite disaster recovery site. The libraries and drives have been purchased by Goodstuff.

The Proposed solution will totally replace the current libraries and drives with improved models, also to be purchased rather than leased. The tape drives that Goodstuff is purchasing have significant advantages in throughput, allowing Goodstuff to accomplish the same work load with only 25 tape drives as compared to the 40 currently installed. As an additional advantage, the new tape drives have double the data capacity of the older drives. This will allow Goodstuff to utilize significantly fewer cartridges than in the current tape storage solution, while also decreasing their need for additional cartridges to accommodate data growth.

Upon careful review of Goodstuff's cartridge growth patterns after the conversion to the new drive types, it was determined that Goodstuff's overall slot requirements can be dramatically reduced. This will allow Goodstuff to utilize only one library, rather than three. The new single library that Goodstuff will be deploying is much more space and power efficient than the existing environment.

Goodstuff believes that, overall, the new architecture will enhance the storage administrator's productivity because of its superior reliability, ease of capacity additions and ability to service on the fly. Additionally, the current staffing model has three full-time operators, one assigned to each library. After the transition, Goodstuff believes they will only need one operator, for the single Proposed library.

The cost of ownership of the Proposed and Status Quo tape storage solutions is measured over a prescribed number of years, known as the "financial planning horizon." The illustrative business case will be measured over three years. (An enterprise's financial planning horizon can be as short as one year or could extend to as many as seven or more years.)

3 Value drivers

Value drivers allow for the analysis of Status Quo and Proposed total cost of ownership in terms of modular elements. Each value driver can result in positive value (Proposed cost less than Status Quo) or negative value (Proposed cost greater than Status Quo).

Value drivers are organized into four major categories: infrastructure costs, storage management staffing, application performance and business risk mitigation.

"Infrastructure costs" include easily measurable cash outlays, such as those for storage hardware, hardware maintenance and software. It also includes some less easily measurable costs, like the price for data center space and power and miscellaneous implementation costs. "Storage management staffing" compares the staff effort needed to manage the Status Quo and Proposed storage solutions. "Application performance" compares the costs of under-performance in terms of availability, reliability and response time. "Business risk mitigation" compares the potential costs associated with threatening incidences, such as the need for data recovery following a disaster.

The complete structure of tape storage value drivers is as follows:

- Infrastructure costs
  - Hardware
  - Media
  - Offline cartridge storage
  - Hardware maintenance
  - Software acquisition and maintenance
  - Environmental costs
  - Wide area network
  - Other implementation costs
- Storage management staffing
  - Storage architect productivity
  - Storage administrator productivity
  - Operator productivity
- Application performance
  - Unscheduled downtime
  - Scheduled downtime
  - Data recovery speed
  - Backup window duration
  - Batch tape processing time
  - Transaction response time
- Business risk mitigation
  - Backup reliability
  - Disaster recovery

For any tape storage business case, these 19 value drivers will fall into three categories, depending on the perspective of the enterprise and the purpose of the tape storage solution:

- "Hard" costs are those that are deemed to be tangible and measurable and are typically identifiable in the enterprise's budget. Infrastructure costs are mostly hard. Operator productivity, based on the number of tape library operators, might also be measurable enough to be considered hard.
- "Soft" costs have an important bearing on the tape storage solution but are not identifiable in a budget. Enterprises usually view application performance and business risk mitigation costs as soft.
- Those not included under hard or soft costs.

An example of each value driver will now be presented in the context of the illustrative business case. To avoid a false sense of precision, all dollar amounts are rounded to the nearest $1,000.

3.1 Hardware

This value driver measures the costs of acquiring the storage hardware, along with financial repercussions of disposing the current hardware. The cost structure depends on whether the Status Quo and Proposed hardware are leased or purchased.

In the illustrative business case, both the Status Quo and Proposed libraries and drives are purchased. (See Table 1.) The Proposed investment is the hardware purchase price, offset by resale value of the current hardware. Storage hardware usually loses a material part of its resale value immediately upon delivery, with further declining value due to technological obsolescence, depending on the age of the equipment. In case the current hardware is re-used elsewhere within the enterprise, the "resale" value would reflect the value of this alternative use.

Hardware purchase comparisons

Hardware (purchase) assumptions			**Status Quo**	**Proposed**
A Purchase price (after discount) for 1 new library				$450,000
B Purchase price (after discount) for 25 new drives				$500,000
C Resale value of 3 current libraries				$100,000
D Resale value of 40 current drives				$150,000
Cash flow	**Investment**	**Year 1**	**Year 2**	**Year 3**
Status Quo cost		$0	$0	$0
Proposed cost	$700,000	$0	$0	$0
Excess cost of Status Quo	**-$700,000**	**$0**	**$0**	**$0**
Formulas used				
Proposed investment = A + B - C - D				

Table 1.

As a variant to our illustrative business case, consider one in which both the Status Quo and Proposed libraries and drives are leased rather than purchased. (See Table 2.) Here, the Proposed investment would be the lease termination fees of the current hardware. Lease termination fees may approximate the total (with a small discount factor) of the remaining lease payments.

Both the Status Quo and Proposed annual costs reflect hardware lease payments. Our business case would benefit from the fact that fewer libraries and drives are leased in the Proposed solution.

3.2 Media

The annual purchase cost of new cartridges, as data grows and worn cartridges are recycled, represents a major cost item of tape storage solutions. This cost is influenced by four major factors: the unit cost of cartridges (declining over time), the data capacity per cartridge, the cartridge percent utilization and data growth. Generally, the Proposed new solution will have a higher cost per cartridge, which is more than offset by improved cartridge capacity and utilization leading to fewer purchased cartridges. Utilization can be strongly influenced by a virtual tape solution component, which is not reflected in this illustrative business case. (See Table 3.)

After this initial conversion investment, the Proposed solution shows significantly less media cost, because more data is stored on each cartridge and fewer new cartridges need to be purchased to accommodate data growth.

Hardware lease comparisons

Hardware (lease) assumptions			**Status Quo**	**Proposed**
A Annual lease cost for 3 current libraries			$180,000	
B Annual lease cost for 40 current drives			$200,000	
C Annual lease price (after discount) for 1 new library				$140,000
D Annual lease price (after discount) for 25 new drives				$180,000
E Lease termination fees for 3 current libraries				$90,000
F Lease termination fees for 40 current drives				$80,000
Cash flow	**Investment**	**Year 1**	**Year 2**	**Year 3**
Status Quo cost		$380,000	$380,000	$380,000
Proposed cost	$170,000	$320,000	$320,000	$320,000
Excess cost of Status Quo	**-$170,000**	**$60,000**	**$60,000**	**$60,000**
Formulas used				
Status Quo Years 1–3 = A + B				
Proposed investment = E + F				
Proposed Years 1–3 = C + D				

Table 2.

Media comparisons

Media assumptions		Status Quo	Proposed
A	Current number of cartridges (online and offline)	16,000	
B	Native cartridge capacity	20 GB	40 GB
C	Average cartridge utilization	50%	50%
D	Average utilized cartridge capacity	10 GB	20 GB
E	Initial number of cartridges (online and offline)	16,000	8,000
F	Data stored on tape	160 TB	160 TB
G	Cartridges purchased for initial conversion		8,000
H	Data growth	50%	50%
I	Recycling of worn cartridges	10%	10%
J	Additional cartridge purchases in Year 1	9,600	4,800
K	Discounted price per cartridge	$70	$90
L	Assumed annual cartridge price decline	10%	10%

Cash flow	Investment	Year 1	Year 2	Year 3
Status Quo cartridges purchased		9,600	15,360	24,576
Status Quo price per cartridge	$70	$67	$60	$54
Status Quo cost		$640,000	$920,000	$1,320,000
Proposed cartridges purchased	8,000	4,800	7,680	12,288
Proposed price per cartridge	$90	$86	$77	$69
Proposed cost	$720,000	$410,000	$590,000	$850,000
Excess cost of Status Quo	**-$720,000**	**$230,000**	**$330,000**	**$470,000**

Formulas used

D = B x C

E(Proposed) = A(Status Quo) x D(Status Quo) / D(Proposed)

F = D x E [The Status Quo and Proposed solutions store the same amount of data]

G(Proposed) = E(Proposed)

J = E x (H + I)

Cartridges purchased in Year 1 = J

Cartridges purchased in Years 2–3 = Cartridges purchased in prior year x (1 + H + I)

Price per cartridge in Year 1 = K x (1 - L / 2)

Price per cartridge in Years 2–3 = Price per cartridge in prior year x (1 - L)

Table 3.

The example above assumed a "worst case" purchase of enough Proposed cartridges to convert all data from current cartridges, before the new library is installed. In fact, current cartridges can sometimes be reformatted as the new media. In other cases, the customer might decide against an initial conversion and write on the Proposed cartridges only when new data is created during normal processing.

The following example (see Table 4) illustrates the case where media is re-usable in the next generation of the tape drive, leading to reduced Proposed purchases in the near term. In this example, every two current Status Quo cartridges are converted into one Proposed cartridge before the Proposed library goes into operation, leaving half the Status Quo cartridges available to fulfill future growth requirements.

3.3 Offline cartridge storage

Tape cartridges, and the data they hold, are often removed from the library and stored either locally in the data center ("offline") or offsite ("vaulted"), as in our illustrative business case. There are two kinds of cost associated with both offline and vaulted storage — the cost of moving the cartridges to and back from the storage facility, and the cost of actually storing them.

In our example (see Table 5), the greater capacity of the Proposed cartridges leads to a smaller number that need to be moved and stored offline. Using a library as a disaster recovery site, which is not the situation in the illustrative business case, could also reduce offline cartridge storage costs.

3.4 Hardware maintenance

This value driver compares the Status Quo and Proposed hardware maintenance costs, over the financial horizon. In our illustrative business case, the Proposed hardware maintenance cost is less than Status Quo, because fewer libraries and drives are required. (See Table 6.)

Most storage hardware vendors offer premium (24 x 7) as well as "Next Day" maintenance — the latter costing perhaps half the former.

Most storage hardware vendors also provide an initial warranty period, usually 12 months, during which maintenance is provided at either no cost or reduced cost. 24 x 7 maintenance, as in the illustrative business case, is provided during the warranty period at a "warranty uplift" cost equal to the difference between 24 x 7 and Next Day maintenance costs. In case the enterprise had opted for Next Day maintenance, there would have been no cost in Year 1 of the Proposed solution, instead of $35,000.

In this example, we have elected not to escalate the maintenance costs anticipated in future years.

Media re-used comparisons

Cash flow	Investment	Year 1	Year 2	Year 3
Status Quo cartridges purchased		9,600	15,360	24,576
Status Quo price per cartridge	$70	$67	$60	$54
Status Quo cost		$640,000	$920,000	$1,320,000
Proposed cartridge demand		4,800	7,680	12,288
Proposed cartridge excess inventory (at year end)	8,000*	3,200	0	0
Proposed cartridges purchased	0	0	4,480	12,888
Proposed price per cartridge	$90	$86	$77	$69
Proposed cost	$0	$0	$345,000	$850,000
Excess cost of Status Quo	**$0**	**$640,000**	**$575,000**	**$470,000**

**After the 16,000 Status Quo cartridges were converted into 8,000 Proposed cartridges, 8,000 cartridges remained as excess inventory available to satisfy future growth.*
Table 4.

Offline cartridge storage comparisons

Offline cartridge storage assumptions		Status Quo	Proposed
A Number of cartridges (online and offline)		16,000	8,000
B Total number of cartridges stored online		11,000	6,000
C Number of cartridges stored offline		5,000	2,000
D Monthly cost per cartridge stored offline		$0.50	$0.50
E Annual cost of storing cartridges		$30,000	$12,000
F Monthly number of cartridges moved offline and back		10,000	4,000
G Cost per moved cartridge		$0.50	$0.50
H Annual cost of moving cartridges		$60,000	$24,000
I Data growth		50%	50%
Cash flow	**Year 1**	**Year 2**	**Year 3**
Status Quo cost	$90,000	$135,000	$203,000
Proposed cost	$36,000	$54,000	$81,000
Excess cost of Status Quo	**$54,000**	**$81,000**	**$122,000**
Formulas used			
C = A - B			
E = C x D x 12 months per year			
H = F x G x 12 months per year			
Year 1 = E + H			
Years 2–3 = Prior year x (1 + I)			

Table 5.

Hardware maintenance comparisons

Hardware maintenance assumptions		Status Quo	Proposed
A Monthly 24 x 7 maintenance price (after discount) for all libraries, after the warranty period		$5,000	$2,000
B Library warranty period			12 months
C Monthly 24 x 7 maintenance price (after discount) for all libraries, during the warranty period			$900
D Number of drives		40	25
E Monthly 24 x 7 maintenance price (after discount) per drive, after the warranty period		$160	$180
F Drive warranty period			12 months
G Monthly 24 x 7 maintenance price (after discount) per drive, during the warranty period			$80
Cash flow	**Year 1**	**Year 2**	**Year 3**
Status Quo cost	$137,000	$137,000	$137,000
Proposed cost	$35,000	$78,000	$78,000
Excess cost of Status Quo	**$102,000**	**$59,000**	**$59,000**
Formulas used			
Status Quo = 12 months x (A + (D x E))			
Proposed Year 1 = 12 months x (C + (D x G))			
Proposed Years 2–3 = 12 months x (A + (D x E))			

Table 6.

3.5 Software acquisition and maintenance

This value driver reflects the up-front software acquisition cost for the Proposed library and annual software maintenance costs for both Status Quo and Proposed libraries. In the illustrative business case, the new Proposed library requires acquisition of a software suite to optimize its operation. (See Table 7.)

3.6 Environmental costs

Certain enterprises are exceedingly concerned with the cost of data center space. For others, this is an inconsequential issue. In our example, the single Proposed library occupies significantly less data center space than the three Status Quo libraries. (See Table 8.)

Usually, power and cooling are smaller issues than space. Again, the single Proposed library uses less electricity than the three Status Quo libraries. Power consumed by tape drives is considered too insignificant for inclusion in this example.

3.7 Wide area network

In the illustrative business case, Status Quo and Proposed libraries are connected to servers via a local area network (LAN) and therefore they incur no wide area network (WAN) communication costs. If the Proposed solution had introduced a new disaster recovery library, then this WAN cost would have been included.

Software acquisition and maintenance comparisons

Software assumptions			**Status Quo**	**Proposed**
A Library software acquisition cost				$20,000
B Monthly software maintenance cost for all libraries			$2,500	$1,500
Cash flow	**Investment**	**Year 1**	**Year 2**	**Year 3**
Status Quo cost		$30,000	$30,000	$30,000
Proposed cost	$20,000	$18,000	$18,000	$18,000
Excess cost of Status Quo	**-$20,000**	**$12,000**	**$12,000**	**$12,000**
Formulas used				
Years 1–3 = 12 months x B				

Table 7.

Environmental comparisons

Environmental cost assumptions	**Status Quo**	**Proposed**
A Square feet of raised floor space for all libraries, including service clearance room	900	150
B Cost per square foot per month	$20	$20
C Annual cost of floor space	$216,000	$36,000
D Monthly power requirement for all libraries, kWhs	4,000	2,000
E Power cost per kWh	$0.25	$0.25
F Annual power cost	$12,000	$6,000
G Cooling as % of power cost	50%	50%
H Annual cooling cost	$6,000	$3,000

Cash flow	**Year 1**	**Year 2**	**Year 3**
Status Quo cost	$234,000	$234,000	$234,000
Proposed cost	$45,000	$45,000	$45,000
Excess cost of Status Quo	**$189,000**	**$189,000**	**$189,000**
Formulas used			
C = A x B x 12 months			
F = D x E x 12 months			
H = F x G			
Years 1–3 = C + F + H			

Table 8.

Virtual tape solutions can reduce WAN costs by reducing actual traffic to and from a remote library and by reducing maximum bandwidth by smoothing otherwise "bursty" communication.

WAN costs have two major components. The first includes the costs of telecommunications hardware on the enterprise premises. The second includes the costs incurred with telecommunications carriers, such as those for a T1 connection.

3.8 Other implementation costs

This value driver serves as a "catch-all" for miscellaneous, up-front implementation costs of the Proposed storage solution, which are often overlooked or ignored. The activities of preparation and due diligence measure the time and cost needed by the enterprise's storage architects to evaluate the Proposed solution, visit user sites, prepare management presentations and plan for implementation.

Installation disruption measures the cost of not being able to run applications while the libraries are being replaced. To eliminate installation disruption and reduce implementation risk, many enterprises perform parallel operation, where the current and proposed libraries operate simultaneously for some period of time. The cost of parallel operation is not shown in this example. (See Table 9.)

3.9 Storage architect productivity

A storage architect sets policies, evaluates solutions and vendors and designs storage solutions.

Other implementation costs

Other implementation cost assumptions			**Status Quo**	**Proposed**
A Work months for preparation and due diligence				2.0
B Preparation and due diligence cost per month				$10,000
C Number of administrators trained				12
D Training classes per administrator				2.0
E Cost per training class				$500
F Current cartridges converted to Proposed				16,000
G Conversion cost per cartridge				$4.00
H Freight for delivering Proposed library				$3,000
I De-installation of current libraries				$2,000
J Installation of Proposed library				$11,000
K Hours of installation disruption				20
L Cost per hour of scheduled downtime				$1,000
Cash flow	**Investment**	**Year 1**	**Year 2**	**Year 3**
Preparation and due diligence	$20,000			
Training	$12,000			
Cartridge conversion	$64,000			
Library installation	$16,000			
Installation disruption	$20,000			
Proposed cost	$132,000			
Excess cost of Status Quo	**-$132,000**			
Formulas used				
Preparation and due diligence = A x B				
Training = C x D x E				
Cartridge conversion = F x G				
Library installation = H + I + J				
Installation disruption = K x L				

Table 9.

This value driver quantifies the difference in storage architect staffing costs between the Status Quo and Proposed solutions. Certain storage solutions have superior library interoperability, library consolidation capability, drive support/certification, ability of virtual tape to isolate applications from technology changes and other features that improve storage architect productivity.

In the illustrative business case, we assume that the enterprise currently has 2.5 full-time equivalent staff members (FTEs) performing tape storage architect activities. This could be two people working full time plus one person half time, or five individuals each devoting half their time to architect activities. The Proposed solution requires only 2.0 storage architects, for a productivity savings of 0.5 FTEs. (See Table 10.) Because of its library consolidation capability, the Proposed solution was more effective (90 percent versus 50 percent) at enabling storage architect productivity.

In the storage management staffing examples (value drivers 9, 10 and 11), we have conservatively elected to show the same benefit in Years 2 and 3, as Year 1. In fact, the benefit

Storage architect productivity comparisons

Storage architect productivity assumptions		**Status Quo**	**Proposed**
A Full-time equivalent storage architects (FTEs)		2.5	
B Potential productivity improvement with Proposed solution			50%
C Solution effectiveness at enabling storage architect productivity		50%	90%
D FTEs needed		2.5	2.0
E Annual storage architect fully-burdened salary		$120,000	$120,000
Cash flow	**Year 1**	**Year 2**	**Year 3**
Status Quo cost	$300,000	$300,000	$300,000
Proposed cost	$240,000	$240,000	$240,000
Excess cost of Status Quo	**$60,000**	**$60,000**	**$60,000**
Formulas used			
D(Proposed) = A x {1 - B x [C(Proposed) - C(Status Quo)]}			
Cost = D x E			

Table 10.

Storage administrator productivity comparisons

Storage administrator productivity assumptions		**Status Quo**	**Proposed**
A Full-time equivalent storage administrators (FTEs)		10.0	
B Potential productivity improvement with Proposed solution			50%
C Solution effectiveness at enabling storage administrator productivity		70%	90%
D FTEs needed		10.0	9.0
E Productivity ramp-up, months per FTE			2.0
F Annual storage administrator fully-burdened salary		$80,000	$80,000
G Productivity ramp-up cost			$60,000
Cash flow	**Year 1**	**Year 2**	**Year 3**
Status Quo cost	$800,000	$800,000	$800,000
Proposed cost	$780,000	$720,000	$720,000
Excess cost of Status Quo	**$20,000**	**$80,000**	**$80,000**
Formulas used			
D(Proposed) = A x {1 - B x [C(Proposed) - C(Status Quo)]}			
G = D x E x F / 12 months x 50% productivity loss			
Year 1 = (D x F) + G			
Years 2–3 = D x F			

Table 11.

could increase as the data grows and/or salaries increase. This effect might be offset by the enterprise's expectation that better hardware and software tools will allow the same staff to manage more data, regardless of the solution.

3.10 Storage administrator productivity

Activities of a storage administrator include the following:

- Install hardware
- Test system
- Write backup/recovery scripts
- Update/maintain software/scripts/agents
- Install software and/or agents
- Order hardware
- Perform capacity planning: hardware, software, media
- Order software
- Update/maintain hardware

This value driver quantifies the difference in storage administrator staffing costs between the Status Quo and Proposed solutions. Certain libraries have superior reliability, ease of adding capacity, ability to service on the fly and other features that improve administrator productivity.

In the illustrative business case, we assume that the enterprise currently has 10.0 FTEs performing tape storage administrator activities. The Proposed solution requires only 9.0 storage administrators, for a productivity savings of 1.0 FTEs. The Proposed solution was more effective enabling storage administrator productivity (90 percent versus 70 percent), because of its superior reliability, ease of adding capacity and ability to service on the fly. (See Table 11.)

The Proposed solution was penalized for two months of ramp-up time, during which the 9.0 storage administrators were only 50 percent productive while mastering the new storage technology.

3.11 Operator productivity

Operators run backup and recovery tasks.

In the illustrative business case, we assume that the enterprise currently has 3.0 operators. The Proposed solution requires only 1.0 operator, for a productivity savings of 2.0 FTEs. The Proposed solution reduced the need for operators by consolidating three libraries into one. (See Table 12.)

The Proposed solution was slightly penalized for three months of operator ramp-up time, during which the operator was only 50 percent productive while mastering the new storage technology.

Operator productivity comparisons

Operator productivity assumptions		**Status Quo**	**Proposed**
A Full time equivalent operators (FTEs)		3.0	
B Number of libraries		3	1
C FTEs needed		3.0	1.0
D Productivity ramp-up, months per FTE			3.0
E Annual operator fully-burdened salary		$40,000	$40,000
F Productivity ramp-up cost		$80,000	$5,000
Cash flow	**Year 1**	**Year 2**	**Year 3**
Status Quo cost	$120,000	$120,000	$120,000
Proposed cost	$45,000	$40,000	$40,000
Excess cost of Status Quo	**$75,000**	**$80,000**	**$80,000**
Formulas used			
C(Proposed) = A x B(Proposed) / B(Status Quo)			
F = C x D x E / 12 months x 50% productivity loss			
Year 1 = (C x E) + F			
Years 2–3 = C x E			

Table 12.

3.12 Unscheduled downtime

In our illustrative business case, the tape libraries are scheduled to operate 24 hours per day, 365 days per year, which equals 8,760 annual hours. A major benefit of the Proposed library is its enhanced reliability, mostly due to redundant robots and power supply. Improved reliability leads to less unscheduled downtime. Each enterprise has a unique cost of unscheduled application downtime, often related to lost revenue, impaired customer reputation and costly workarounds.

When the library fails, the entire tape storage system is unavailable, affecting all its users and applications. When an individual tape drive fails, there is a lesser cost of unscheduled downtime for a single user. In our example, we are not claiming a reliability improvement for the Proposed drives. (See Table 13.) However, there are more Status Quo drives that might fail, leading to more hours of unscheduled drive downtime and higher cost of ownership.

In the application performance examples (value drivers 12, 13, 14, 15, 16 and 17), we have conservatively elected to show the same benefit in Years 2 and 3, as in Year 1. In fact, the benefit could increase as the enterprise's revenue and cost of downtime grow.

3.13 Scheduled downtime

This value driver quantifies the reduced cost of scheduled downtime from the Status Quo to the Proposed solution, recognizing that some libraries require time consuming

Unscheduled downtime comparisons

Unscheduled downtime assumptions		**Status Quo**	**Proposed**
A Annual hours of operation		8,760	8,760
B Library reliability		99.00%	99.99%
C Unscheduled system downtime hours per year		88	1
D Cost per hour of unscheduled system downtime		$10,000	$10,000
E Tape drive reliability		99.90%	99.90%
F Number of tape drives		40	25
G Unscheduled tape drive downtime hours per year		350	219
H Cost per hour of unscheduled drive downtime		$100	$100
Cash flow	**Year 1**	**Year 2**	**Year 3**
Status Quo cost	$915,000	$915,000	$915,000
Proposed cost	$32,000	$32,000	$32,000
Excess cost of Status Quo	**$883,000**	**$883,000**	**$883,000**
Formulas used			
C = A x (1 - B)			
G = A x (1 - E) x F			
Cost = (C x D) + (G x H)			

Table 13.

Scheduled downtime comparisons

Scheduled downtime assumptions		**Status Quo**	**Proposed**
A Annual scheduled downtime hours		100	10
B Cost per hour of scheduled system downtime		$2,000	$2,000
Cash flow	**Year 1**	**Year 2**	**Year 3**
Status Quo cost	$200,000	$200,000	$200,000
Proposed cost	$20,000	$20,000	$20,000
Excess cost of Status Quo	**$180,000**	**$180,000**	**$180,000**
Formulas used			
Cost = A x B			

Table 14.

scheduled downtime to perform routine maintenance. The Proposed library has less scheduled downtime, because it is designed to be "serviced on the fly" and allows capacity increases with little or no interruption to operation.

Each enterprise has a unique cost of scheduled tape storage downtime that is generally less than the cost of unscheduled downtime. The cost of scheduled downtime would be greatest for a 24 x 7 operating environment. (See Table 14.)

3.14 Data recovery speed

This value driver quantifies the reduced cost of elapsed data recovery time from the Status Quo to the Proposed solution. Because the Proposed solution uses tape drives with twice the throughput speed, data can be restored more quickly when recovery is needed, reducing the amount and cost of unscheduled application downtime. (See Table 15.)

3.15 Backup window duration

In our illustrative business case, the faster Proposed tape drives allow data to be backed up faster. This benefit of Proposed over Status Quo can be realized in several ways:

- The enterprise reduces its current backup window thereby reducing unscheduled downtime and gaining the benefit of more revenue or other application value. This is the quantification method actually used in the example.
- The enterprise incurs less risk of failing to complete backups within the proscribed window, incurring less cost of lost data when restoration is necessary.
- The enterprise takes advantage of room within the backup window to add new applications. (See Table 16.)

Data recovery speed comparisons

Data recovery speed assumptions		**Status Quo**	**Proposed**
A Annual number of recovery incidences		20	20
B Average recovery time, hours		2	1
C Annual unscheduled downtime during application recovery, hours		40	20
D Cost per hour of unscheduled downtime		$10,000	$10,000
Cash flow	**Year 1**	**Year 2**	**Year 3**
Status Quo cost	$400,000	$400,000	$400,000
Proposed cost	$200,000	$200,000	$200,000
Excess cost of Status Quo	**$200,000**	**$200,000**	**$200,000**
Formulas used			
C = A x B			
Cost = C x D			

Table 15.

Backup window duration comparisons

Backup window duration assumptions		**Status Quo**	**Proposed**
A Backup window, hours per day		4	3
B Backup frequency, days per year		365	365
C Application unavailability, hours per year		1,460	1,095
D Cost per hour of scheduled downtime		$2,000	$2,000
Cash flow	**Year 1**	**Year 2**	**Year 3**
Status Quo cost	$2,920,000	$2,920,000	$2,920,000
Proposed cost	$2,190,000	$2,190,000	$2,190,000
Excess cost of Status Quo	**$730,000**	**$730,000**	**$730,000**
Formulas used			
C = A x B			
Cost = C x D			

Table 16.

3.16 Batch tape processing time

Some enterprises have mainframe legacy applications that use tape as an intermediate and final storage medium, rather than as a backup medium for disk.

The faster tape drives introduced by our Proposed solution will help the enterprise complete its tape processing applications in less time. The calculation is based on an assumed cost per hour charged by the data center performing the tape processing. (See Table 17.)

Other interpretations of this value driver are:

- The enterprise is currently pressuring its 24-hour or shorter processing schedule, and faster tape processing will allow deferral of costly hardware upgrades.
- The enterprise can add new valuable applications to its processing schedule.

Batch tape processing time comparisons

Batch tape processing time assumptions		**Status Quo**	**Proposed**
A Tape processing time, hours per day		8	6
B Tape processing, days per year		365	365
C Tape processing time, hours per year		2,920	2,190
D Cost per hour of tape processing		$200	$200
Cash flow	**Year 1**	**Year 2**	**Year 3**
Status Quo cost	$584,000	$584,000	$584,000
Proposed cost	$438,000	$438,000	$438,000
Excess cost of Status Quo	**$146,000**	**$146,000**	**$146,000**
Formulas used			
C = A x B			
Cost = C x D			

Table 17.

Transaction response time comparisons

Transaction response time assumptions		**Status Quo**	**Proposed**
A Average tape application usage, hours per day per user		8	8
B Information requests per hour per user		10	10
C Average response time per request (in seconds)		60	20
D User hours per day awaiting response		1.33	0.44
E Annual fully-burdened user salary plus benefits		$40,000	$40,000
F Productivity loss awaiting response		25%	25%
G Annual tape responsiveness cost per user		$1,667	$556
H Number of tape application users		100	100
Cash flow	**Year 1**	**Year 2**	**Year 3**
Status Quo cost	$167,000	$167,000	$167,000
Proposed cost	$56,000	$56,000	$56,000
Excess cost of Status Quo	**$111,000**	**$111,000**	**$111,000**
Formulas used			
D = A x B x C / 3,600 seconds per hour			
G = D / 8 work hours per day x E x F			
Cost = G x H			

Table 18.

3.17 Transaction response time

Some enterprises use tape storage as a fast access archive. The users, for example, might be at a call center retrieving customer data and providing customer service. Since the Proposed solution has a faster average access time, information is retrieved faster and users have less waiting time for the application to respond.

In this example, the benefit of faster response time is quantified in terms of less lost user productivity. (See Table 18.) It assumes that each user loses 25 percent productivity while waiting for response, and can still be 75 percent productive doing something else while waiting. In fact, slow response could result in poor customer service, incurring an even greater cost.

3.18 Backup reliability

This value driver quantifies the reduced cost of unreliable backups from the Status Quo to the Proposed solution. In the event that recovery is needed, unsuccessful backups lead to costly irrecoverable data loss. Storage solutions with greater reliability and cartridges with greater durability improve the likelihood that backups will be successful.

Our illustrative business case assumes that the Proposed library is more reliable, increasing successful backups from 70 percent to 90 percent. (See Table 19.)

In the business risk mitigation examples (value drivers 18 and 19), we have conservatively elected to show the same benefit in Years 2 and 3, as Year 1. In fact, the benefit could increase as the enterprise's revenue, cost of irrecoverable data and cost of disaster downtime grows.

Backup reliability comparisons

Backup reliability assumptions		**Status Quo**	**Proposed**
A Successful backups		70%	90%
B Annual restorations		20	20
C Annual unsuccessful restorations		6	2
D Average application processing hours since previous successful backup		8	8
E Cost per hour of irrecoverable data		$10,000	$10,000
Cash flow	**Year 1**	**Year 2**	**Year 3**
Status Quo cost	$480,000	$480,000	$480,000
Proposed cost	$160,000	$160,000	$160,000
Excess cost of Status Quo	**$320,000**	**$320,000**	**$320,000**
Formulas used			
C = (1 - A) x B			
Cost = C x D x E			

Table 19.

3.19 Disaster recovery

This value driver quantifies the reduced cost of recovering from potential disasters. Storage solutions with greater reliability and throughput can recover information more quickly following a disaster, thereby getting the enterprise back into operation sooner. The cost of disaster downtime is usually greater than unscheduled downtime, because all business applications are affected and for a greater length of time.

Our illustrative business case assumes that the Proposed library is more reliable, and that the Proposed tape drives are faster than the Status Quo solution. (See Table 20.)

4 Financial measurement

After reviewing all the potential value drivers, we must decide which ones to include in the final business case. We then aggregate the excess cost of Status Quo from each selected value driver and calculate the total cash flows for the up-front investment and for each year of the financial horizon.

We are now ready for financial measurement, which is based on the total lines in Table 21.

4.1 Investment

The investment in the Proposed tape storage solution is $1,572,000.

4.2 Cost of capital

Each enterprise has a unique cost of capital (see Glossary) or "discount rate" used to calculate the "present value" of future cash flows. For our illustrative business case, let us assume that the enterprise's cost of capital is 8 percent.

Disaster recovery comparisons

Disaster recovery assumptions		**Status Quo**	**Proposed**
A Hours to recover from a disaster		25	10
B Cost per hour of disaster downtime		$100,000	$100,000
C Cost of a disaster		$2,500,000	$1,000,000
D Probability of a disaster within one year		3.0%	3.0%
Cash flow	**Year 1**	**Year 2**	**Year 3**
Status Quo cost	$75,000	$75,000	$75,000
Proposed cost	$30,000	$30,000	$30,000
Excess cost of Status Quo	**$45,000**	**$45,000**	**$45,000**
Formulas used			
C = A x B			
Cost = C x D			

Table 20.

Excess cost of Status Quo

Excess cost of Status Quo	**Investment**	**Year 1**	**Year 2**	**Year 3**
Hardware	-$700,000	$0	$0	$0
Media	-$720,000	$230,000	$330,000	$470,000
Offline cartridge storage		$54,000	$81,000	$122,000
Hardware maintenance		$102,000	$59,000	$59,000
Software	-$20,000	$12,000	$12,000	$12,000
Environmental		$189,000	$189,000	$189,000
Other implementation costs	-$132,000			
Operator productivity		$75,000	$80,000	$80,000
Unscheduled downtime		$883,000	$883,000	$883,000
Backup reliability		$320,000	$320,000	$320,000
Total	**-$1,572,000**	**$1,865,000**	**$1,954,000**	**$2,135,000**

Table 21.

4.3 Discounted total cost of ownership savings

"Discounted total cost of ownership savings" is the primary financial measure applied to our financial decision. The calculation of this measure is based upon the net present value (NPV) of future cash flows. (See Table 22.)

While the investment of $1,572,000 is cash today, the Years 1–3 are future cash flows. These future cash flows can be converted to their "present value" using the 8 percent cost of capital. As shown in this table, $1,694,832 invested with 8 percent compounded interest rate would grow to $2,135,000 in Year 3.

Discounted total cost of ownership savings

	Future value	Present value (8% cost of capital)
Investment		-$1,572,000
Year 1	$1,865,000	$1,726,852
Year 2	$1,954,000	$1,675,240
Year 3	$2,135,000	$1,694,832
Net present value		$3,524,924

Table 22.

The discounted total cost of ownership savings offered by the Proposed solution is $3,524,924.

For Excel users, the formula "= -1572000+NPV(8%,1865000,1954000,2135000)" would calculate this same answer.

At this point, we will calculate some additional financial measures that may be of interest to some enterprises.

4.4 Net present value of benefits

The net present value in the table above was calculated as the total of the Investment plus the present value of each future year. Net present value of benefits is simply the total present value of the future years, ignoring the investment.

The net present value of benefits offered by the Proposed solution is $5,096,924.

4.5 Return on investment (ROI)

Return on Investment is simply the net present value of benefits ($5,096,924) divided by the investment ($1,572,000).

The return on investment offered by the Proposed solution is 324 percent.

4.6 Internal rate of return (IRR)

Internal rate of return (see Glossary) equals the cost of capital at which the net present value would be zero.

The internal rate of return offered by the Proposed solution is 109 percent.

For Excel users, the formula "=IRR(Range,.1)" calculates to 109 percent when range is:

-$1,572,000 $1,865,000 $1,954,000 $2,135,000

Within the formula, .1 represents an initial "guess" at the result the formula "= -1572000+NPV(109%,1865000,1954000,2135000)" would calculate to $0.

4.7 Cumulative cash flow

Cumulative cash flow measures the difference in cash position between the Proposed and Status Quo solutions. (See Table 23.)

Cumulative cash flow

	Cumulative cash flow at beginning of year	Cash flow during the year
Year 1	-$1,572,000	$1,865,000
Year 2	$293,000	$1,954,000
Year 3	$2,247,000	$2,135,000
Year 4	$4,382,000	

Table 23.

At the beginning of Year 1, the Proposed solution is "in the hole" for $1,572,000 because of the initial investment in hardware, media, software and other implementation costs. By the end of Year 1, which is the beginning of Year 2, the Proposed solution has climbed out of the hole into positive territory. At this point, cumulative cash flow is $293,000.

4.8 Payback

Payback is simply the number of months, from the beginning of Year 1, it takes for the cumulative cash flow to climb back to $0. Since we began Year 1 at -$1,572,000 and ended at $293,000, we assume that $0 was crossed approximately 10 months into Year 1.

The payback offered by the Proposed solution is 10 months.

For Excel users, the formula "= 12-293000/1865000x12" calculates this result.

4.9 Cost of delay

Deferring the savings offered by a project, results in a penalty related to both the magnitude of those savings and the enterprise's cost of capital. If the enterprise were to delay the project for a full year, the cost of delay ($282,000) would equal cost of capital (8%) x discounted total cost of ownership savings ($3,524,924).

If, unlike the illustrative business case, the enterprise were leasing current equipment, the cost of delay would be offset by the reduced lease termination penalties introduced by the delay.

The cost of 3-month delay of the Proposed solution is approximately $70,000 (3/12 x $282,000).

5 Glossary

The following Glossary is in two sections: Financial glossary terms and Storage glossary terms.

5.1 Financial glossary terms

The following terms apply in general to financial evaluation of projects and are used within the storage value tool (SVT) as well.

Cash flow: Cash flows can be visualized as money that an enterprise must spend, either up front or in future years, to provide a storage solution. For example, money spent to acquire a new storage device is a cash outflow. Revenue improvement, due to less application downtime, is a cash inflow.

Cost of capital: Cost of capital is the minimum required rate of return, or discount rate, a new project investment must offer to be attractive. It is called this because the required return is what the firm must earn on its capital investment in a project just to break even. It can thus be interpreted as the opportunity cost associated with the enterprise's capital investment, defined as the most valuable alternative if the investment is not undertaken. When evaluating a potential investment, enterprises use their unique cost of capital to discount future cash flows.

In academic terms, cost of capital is typically derived from an enterprise's weighted average cost of capital, or WACC. WACC measures weighted average after tax costs of debt financing and required market return on equity. Some enterprises will use WACC as their standard cost of capital value, but it is not uncommon to use a higher or lower rate to adjust for an increase or decrease in project-specific risk. A typical cost of capital in today's low interest rate environment might be might be 7 percent to 10 percent.

Cost of 3-month delay: Cost of 3-month delay is defined as the cost of deferring realization of the net present value, less any reduced lease termination fees, in the event the project is delayed. The cost of deferring the net present value for a full year would equal the cost of capital times net present value of Proposed solution, and a 3-month deferral would cost one fourth of this figure.

Discounted cash flows: Discounted cash flows apply the cost of capital to future cash flows and convert them to present value using the concept "time value of money."

Time value of money refers to the fact that a dollar in hand today is worth more than a dollar promised at some time in the future. On a practical level, one reason for this is that you could earn interest while you waited — so a dollar today would grow to more than a dollar later. The trade-off between money now and money later thus depends on, among other things, the rate you can earn by investing and the overall rate of inflation.

Financial planning horizon: Financial planning horizon is the number of years over which the enterprise chooses to evaluate the investment in a new storage solution. An enterprise's financial planning horizon can be as short as one year or extend to as many as seven or more years.

Full-time equivalents (FTEs): Equals the fractional number of full-time employees (working 40 hours per week) that would be required to perform a certain function. Thus, if two storage management staff members each spend 60 percent of their time performing storage architect activities, the enterprise has 1.2 storage architect FTEs.

Fully-burdened salary: Annual salary plus employee-related overhead costs that include benefits, office space, travel expenses, etc. A typical enterprise might have overhead costs of 35 percent.

Internal rate of return (IRR): IRR is the discount rate at which the net present value (NPV) would equal zero. For example, the NPV might be $5,000 with cost of capital set at 8 percent, but $0 with cost of capital set at 25 percent. In this case, IRR = 25%. Most enterprises will set a basic hurdle rate, greater than the cost of capital, and expect all projects to have an IRR exceeding that hurdle rate.

Investment: Investments represent the up-front cash outflows (net of proceeds from de-acquiring current hardware) that a company must make to undertake a project. Typical investments for storage solutions are hardware, media and software purchase. Other costs that are considered part of the overall investment amount include implementation costs such as installation, freight, installation disruption, parallel operation, preparation and due diligence, storage administrator training and de-installation fees. These costs are typically overlooked when defining an investment amount.

Net present value (NPV): The net present value equals the investment (expressed as a negative cash flow) plus the net present value of benefits.

Net present value of benefits: The net present value of benefits equals the present value of benefits over the financial horizon.

Non-discounted cash flows: Non-discounted cash flows would simply be the arithmetic sum of the investment plus the future cash flows, without considering the cost of capital.

Payback: The number of months, following installation of a solution, at which the cumulative cash flow climbs back to zero. After reaching this point, cumulative cash flow will be positive going forward. For example, if the Proposed investment is $100,000, and the Year 1 Status Quo less Proposed cash outflow is $100,000 as well, then the payback would be 12 months.

Present value (PV): Present value is calculated by discounting future cash flows over the financial planning horizon.

Return on investment (ROI): Return on investment equals the net present value of benefits divided by the Investment.

Total cost of ownership (TCO): An enterprise's total cost of a storage solution typically includes costs such as hardware/software acquisition and maintenance, floor space and power, media purchases and storage, implementation of new technology and storage management staffing. Total cost of ownership also includes performance and risk mitigation issues such as unscheduled downtime, scheduled downtime, data recovery speed, backup window duration, batch tape processing time, transaction response time, backup reliability and disaster recovery speed.

TCO of future years are usually measured in terms of their present value.

5.2 Storage glossary terms

The following terms apply to tape storage solutions and are used within the storage value tool (SVT).

Average recovery time: This is the average time to recover from a recovery incident.

Backup window duration: The amount of time during each 24-hour period, normally at night, required by an enterprise to suspend application operation in order to back up its data on tape.

Installation disruption: Installation disruption is the cost of not being able to operate applications while a new storage solution is being installed.

Native capacity: Native capacity is the maximum amount of data that a tape cartridge can hold.

Parallel operation: Parallel operation is the excess cost of operating the current and new storage solution at the same time.

Preparation and due diligence: Cost of evaluating a new storage solution, evaluating vendors, visiting user sites, preparing management presentations and architecting the implementation.

Productivity loss awaiting response: This loss is the degree to which a tape user (perhaps at a credit card call center) loses productivity while waiting for data to be retrieved from tape and is displayed on a video screen for further action.

Productivity ramp-up: Productivity ramp-up is the period of time during which storage administrators or operators perform at less than 100 percent efficiency while becoming familiarized with a new storage solution.

Recovery incident: Each recovery incident represents an occasion when an enterprise needs to restore data from backup storage. Recovery incidents can be caused by human error, software failure, hardware failure or natural disaster.

Reliability: Reliability is the percent of time that a library, drive or virtual tape solution is expected to operate without unscheduled downtime.

Successful backups: Successful backups are the percent of backups that are successfully completed, so that the backed up data can be restored, if necessary.

System availability: System availability is the percent of time that the storage solution as a whole is expected to operate without unscheduled downtime.

Tape utilization: Tape utilization is the average percent of a tape cartridge's native capacity that contains useful data. Some enterprises, particularly those utilizing a virtual tape solution, may have a tape utilization of 90 percent or even greater. Other enterprises, particularly those in a mainframe environment, may have a tape utilization of less than 50 percent.

Utilized capacity: Utilized capacity is the average actual amount of data that a tape cartridge holds (= native capacity x tape utilization).

Vaulting: Tape cartridges may be stored online in library slots, offline at remote locations or offline on the premises. Storing data at such offline storage locations is referred to as "vaulting."

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