A report on PC Server Backup Technology

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The tape of things to come

The small business networking sector has seen tremendous growth in disk storage capacities over the past few years and represents an area of huge potential for tape drive manufacturers as administrators look for the best solution for data backup. Many companies are looking to implement a full client / server environment and vendors have been quick to see the opportunities here by offering a range of entry-level servers. However, even here storage is growing at an unprecedented rate with the majority of blue chip manufacturers supplying their latest PC servers with low-cost IDE solutions starting at nothing less than 40GB.

Demand shows every sign of accelerating as revealed by a report produced in 2002 by the hard disk manufacturer Seagate. This shows market research on storage trends conducted by Dataquest identifying the most common capacity in the year 2002 to be in the region of 40-49GB with this jumping to 100-199GB during 2003. Rapid development of hard disk technology is also a key driving force with capacities doubling every year since 1997.

With such huge amounts of valuable data now being stored on PC servers it is essential it is protected - and that means backing it up. Tape is the only solution for securing server-side data but the predicted increases in storage over the next few years makes it all the more important that a number of criteria are taken into account when selecting the best tape format for the job.

Storage capacity – the media must have sufficient space to handle current and future server storage. Backup should be able to function unattended and if a job has to span multiple tapes it has failed to provide a simple, easily managed solution.

Performance – the tape drive should be fast enough to secure all server data during a period that does not affect business operations. It must also be able to deliver a manageable backup window when storage requirements increase in the future.

Costs – a general rule at this level of backup is that the tape drive should not cost more than the server it is securing. Small businesses on a strict budget can not afford to double their IT expenditure to implement backup. Many will simply find alternative means or not bother at all if cost is prohibitive.

Expansion – An important feature is the ability to keep in step with backup requirements and be able to upgrade to higher capacities and faster drives when appropriate. Being forced to migrate to a new format will be costly and difficult to manage as support staff will need to maintain legacy drives and media for many years to ensure archived data can be retrieved.

At the small to medium business (SMB) sector, the DDS format has traditionally been a top choice for PC Server backup with IDC reporting an installed base of 9 million units worldwide. However, DDS was dramatically shelved in 2001 when the three co-developers - Sony, Hewlett Packard and Seagate, announced that this format would not be developed beyond DDS-4. This move left a huge market for DDS replacement technologies and Hewlett Packard responded at the beginning of 2003 by announcing the DAT72 format which it says was as a result of genuine customer demand. Clearly, the DDS replacement is a huge market to tap into and there is certainly no lack of choice with the AIT, VXA, SLR and ValuSmart formats all aiming to take their share of the spoils. Sony has positioned the AIT-1 format as a DDS-3 replacement and the AIT-2 as a successor to DDS-4 and the aim of this report is to take a closer look at AIT as a viable alternative to DDS and see how it stacks up against other formats competing for a piece of this market. The report will provide an overview of the different technologies currently available plus the features and benefits of each format and run a full performance benchtest on seven of the main competing formats.

Technology Overview

Helical scan Vs Linear recording

When it comes to selecting a tape format there are two competing technologies on offer – linear and helical scan recording. Each has its pros and cons so it's worth looking a little closer at each one to see what is on offer.

Source : IDC

Linear

Implemented in DLT1 and SLR drives, linear recording writes data in parallel tracks that run along the length of the tape. As the drive reaches the end of the tape it reverses direction and writes the next set of tracks creating a serpentine pattern. The write head is flanked on either side by read heads allowing data that has just been written to be verified in either direction.

The most common way to boost capacity and performance of linear recording devices is to add more tracks, lengthen the tape, decrease track width and write to multiple tracks simultaneously. Thin-film manufacturing processes allow more read/write channels to be easily added to the head but the latter two methods require increasingly higher degrees of accuracy while the tape is in motion and the standard solution is to use a servo system. Extra tracks are written to the tape during the manufacturing process and used by the head to track any tape wander. The drawback of this system is that the servo tracks are occupying space that could be used for extra storage.

A key feature of linear recording is the simple method used to load and tension the tape resulting in a comparatively short and uncomplicated tape path with minimal contact with other components. However, as the head is not moving relative to the media, tape motion is comparatively high with the SLR7 media for example moving at speeds of approximately 105ips (inches per second). Tape tension is greater with linear drives exerting pressures of between 80-100gms which will result in increased head wear. Also, due to the dual directional tape motion of linear recording, media is currently limited to MP (metal particle) technology which is already over ten years old. AMP (advanced metal powder) technology has made huge improvements in storage capacities for linear recording devices but this is only implemented in the enterprise-level SuperDLT drives.

Helical

While linear recording is the prevalent tape technology at the enterprise level of the backup market, helical scanning has the edge at the entry and medium levels. Implemented in the DDS, DAT72, AIT and VXA drives, it employs a cylindrical head which rotates at high speed at an angle to the tape direction allowing it to record data in tracks placed diagonally across the tape. Multiple read and write heads make up the drum and are placed on opposite sides to each other. As each track is written it can be verified by the following read head and any errors that occur on a track are automatically re-written by the next write head.

Performance and capacity can be improved by increasing the number of tracks, making them narrower, speeding up tape movement and drum rotation and adding more read/write heads. The first two solutions can be implemented easily and a high relative tape speed can be also be achieved whilst actual tape movement is comparatively low – 2cms/sec in the case of AIT.

A drawback of helical scanning is the complex tape path and multiple capstans needed to load and position the tape. However, a low tape tension of less than 10gms is required and the media doesn't touch the head in AIT and VXA drives as it is protected by an air gap between the tape and the drum surface. The AME (advanced metal evaporated) media used by AIT and VXA drives also offers advantages as this technology allows capacity to be increased comparatively easily. The columnar structure of the recording layer in AME also dictates that tape motion can only be in one direction with the bonus that it reduces wear on the media.

Format reviews

AIT

Although it uses similar helical scanning and 8mm AME tape technologies to Exabyte's VXA format, Sony's AIT (advanced intelligent tape) also offers a unique feature called MIC (memory in cartridge) which consists of a 64Kbit EEPROM (electrically erasable programmable read only memory) chip mounted in each cartridge. MIC aims to reduce the time spent by the drive in searching for data as it stores information that is normally found on the first segments of the tape. All AIT drives use ALDC (adaptive lossless data compression) techniques similar to those offered in Exabyte's enterprise-class Mammoth drives. It delivers a higher maximum compression ration of 2.6:1 although this is unlikely to have a great impact on capacity and performance as very little of today's business data can be compressed to these levels. It is clear from the performance tests that there is nothing to touch both the AIT90e and AIT130e for speed in this class with the drives taking first and third places overall for the backup, verification and restore tests. Both drives also returned some of the fastest times for the single file restore test. Storage costs are higher than average but capacity is impressive with even the AIT-1 cartridges offering a native 35Gb of storage. Positioned as a DDS-4 replacement, the AIT130e puts forward a compelling argument. It is much faster than Exabyte's budget-priced VXA-1, compares very favourably with HP's DLT VS80 and costs substantially less than the SLR100. Another key feature of the AIT format is Sony also now offers IDE versions of the AIT-1 and AIT-2 based drives which deliver the same impressive performance and capacities but at an even more cost-effective price.

DDS

Originally developed by Sony and Hewlett Packard from the DAT (digital audio tape) audio recording technology, DDS has been one of the most popular choices for backup at the workstation and PC Server level. Helical scanning is the preferred recording technology but the smaller 4mm format presents severe limitations for future development. Tape handling has also been an issue in DDS drives as the media actually makes contact with the surface of the recording drum resulting in higher levels of wear.

Introduced in 1999, the DDS-4 based SureStore DAT40e brought an impressive capacity increase to a native 20GB and introduced a three-fold performance boost over DDS-3. It still offers a competitive backup and restore performance as the speed tests showed it was faster than the DLT1 and VXA based drives and it delivered the fastest times of all for the single file restore test.Storage costs are extremely good but this drive's biggest weakness is the low native 20GB native capacity. It is clear from the tests that the DDS-3 based SureStore DAT24e is no longer a sensible choice for securing high volumes of data. Its top speed of 63MB/min was beaten soundly by all the other formats in this test and a native capacity of 12GB is far too small. A low unit price and unbeatably low storage costs make it a suitable candidate for personal backup but securing today's PC Servers is realistically beyond its capabilities. There is the option to upgrade to DDS-4 but there seems little point in investing in this technology when there are better alternatives on the market.

SLR

Tandberg Data's SLR range of tape drives are built on a solid foundation as the company has developed its linear recording drives over a long period of time. This linear recording format has been developed solely by Tandberg Data and the company re-vamped its tape drive range during 1999 bringing all the various products under the single SLR (scaleable linear recording) brand name. A key feature of the SLR7 and SLR100 drives is they both use Overland Data's VR_ (variable rate randomizer) technology. Implemented on a chip, it uses a variant of PRML (partial response maximum likelihood), which allows capacity and speed to be increased without changing the media or drive design. The SLR100 delivered very good results in the performance tests with average speeds close to 6Mbytes/sec for backup and restore operations although times for the single file retrieval were some of the slowest. The SLR100 offers some of the lowest storage costs but as a DDS-4 replacement, it is not a good choice simply because of its very high unit price, which is similar to that of the VS160. The SLR7 is Tandberg Data's budget offering and is pitched squarely at the DDS-4 market. To reduce costs it doesn't have the servo system employed by the SLR100 and its only uses a dual-channel head. It offers the same transfer rates as DDS-4 drives but performance testing showed that not only was it was capable of delivering marginally better speeds that the quoted native transfer rates but these were consistent across backup, verification and restore tasks.

The SLR7 has a strong future as it benefits from a well-established product line that extends up to and beyond the SLR100 as Tandberg Data has also recently released the next generation SLR140. The only drawback for the SLR7 is simply the initial costs. Unlike the similarly priced VS80 and AIT130e tape drives, the SLR7 doesn't offer any performance or capacity improvements over the DDS-4 format limiting its appeal as a replacement.

DLT1 / DLT ValuSmart (VS)

Used by Hewlett Packard's StorageWorks dlt VS80, the DLT1 format was introduced at the end of 1999 by Benchmark Tape Systems and advertised as combining the capacity of DLT8000 with the performance of DLT7000. The company also claimed it would cost the same as DDS-4 but it failed to deliver on this promise as the DLT1-based drives such as the dlt VS80 cost substantially more and performance is not as impressive as it cannot match the DDS- 4 for backup and restore speed. Benchmark created this format by licensing Quantum's original DLT technology and modifying it to create a new tape drive. A two-channel, magneto-resistive head replaced the DLT4000 ferrite head while four tape rollers were used instead of six and a soft-load mechanism replaced the large manual locking lever. Manufacturing costs were reduced further by using a thin steel mounting plate for the drive mechanics. Benchmark then re-designed the drive and came up with the ValuSmart Tape 80 in 2001 which reduced drive height allowing it to fit into a 5 _" standard expansion bay. This format has proved popular enough that Quantum reacquired the technology but the second generation VS160 only materialised at the beginning of 2003 after a three year wait. It does deliver an impressive performance boost to the native transfer rate by increasing this to 8MB/sec and doubles storage capacity to 80GB but a price tag of over £2,000 makes this too expensive to consider for PC Server backup as the drive costs on average over twice that of the server it is designed to protect. Furthermore, there could also be a lengthy wait for the next generation – VS320.

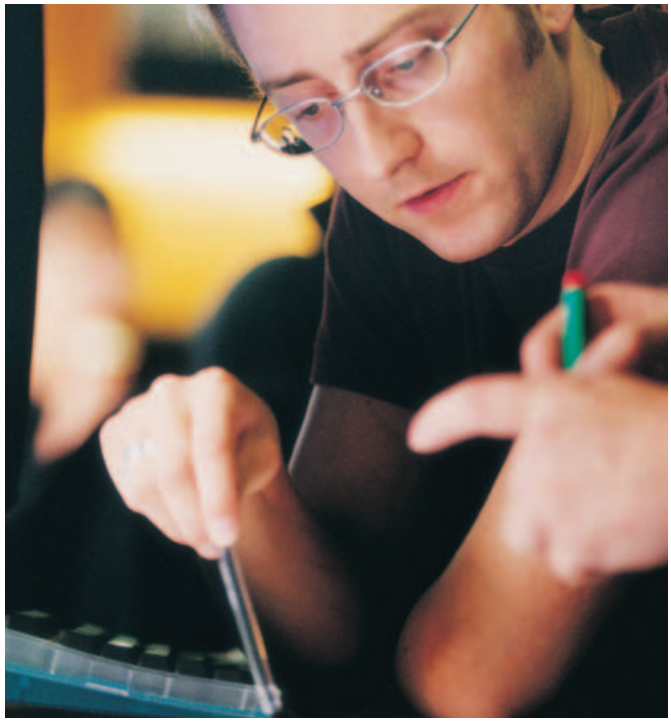
DAT72

Announced by Hewlett Packard at the beginning of 2003, the DAT72 format aims to continue where DDS left off. It does offer some significant improvements over DDS but it is unique as this is the very first time a new tape format generation has not delivered a performance improvement so all you get is the same 3MB/sec native transfer rates of DDS-4. Hewlett Packard has ensured it is read and write backward compatible with DDS-3 and DDS-4 media so some investment can be retained but the lack of either a performance increase or a clear indication of future development makes DAT72 less appealing as a long-term solution. Sony has not participated in this development and one reason it gave for discontinuing DDS was that the physical size of the compact 4mm media left little room for expansion. To overcome these limitations Hewlett Packard modified the head geometry of DDS-4 to allow track density to be improved. Tape thickness was also reduced allowing the media length of DDS-4 cartridges to be increased from 155 metres to 170 metres resulting in an increase in native capacity to 36GB. Overall, the DAT72 is not a confident step forward and only offers a limited number of improvements. The absence of a performance boost is worrying and at the time of testing Hewlett Packard and Seagate had yet to deliver a product roadmap so there is no guarantee that there will be any future generations.

VXA

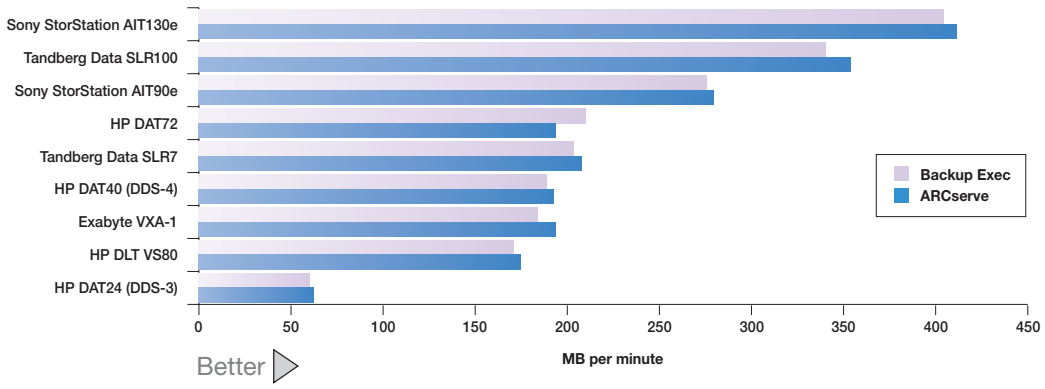
Used solely by the VXA-1 drive from Exabyte, the VXA format uses the same 8mm helical scanning technology and AME media as AIT. However, one of its main aims is to provide reliable data restoration and it uses three unique technologies to achieve this – discrete packet format (DPF), variable speed operation (VSO) and overscan operation (OSO). DPF breaks data down into packets before writing them to the tape and allows packets to arrive at different times in the data buffer and still be efficiently reassembled into their original order. VSO allows the drive to adjust tape speed to match the data flow so it can maintain a constant speed to reduce tape and drive component wear. During write operations, OSO is used to scan the data and rewrite it if an error is detected. Despite these advances, results from the performance tests showed that while the VXA-1 matched the DAT40e drive during backup operations, speed dropped during the verification and restore tests. The single file restore times were also slow with the VXA-1 taking nearly twice as long to locate and reinstate the test data. On price the VXA-1 compares very well with Sony's StorStation AIT90e and offers lower media costs. A storage capacity of 33GB also looks particularly good and Exabyte also offers lower cost 12Gb and 20Gb cartridges. Exabyte's VXA-1 is a strong contender as both a DDS-3 and DDS-4 replacement as it is competitively priced coming in at a similar cost to the AIT90e. It doesn't offer any performance improvements over DDS-4 but VXA does deliver a high storage capacity and low storage costs and teams these up with an innovative packet writing technology. Furthermore, as with the ValuSmart format, development has been very slow as although the VXA-1 was introduced in 1999, the VXA-2 only appeared at the end of 2002.
However, the price for VXA-2 is on a par with DDS-4 making it a better alternative than ValuSmart as a suitable replacement.
Exabyte is committed to keeping the next generation at a similar price point although this could entail another three year wait meaning the next VXA generation may not appear until 2006.

Testing scenario

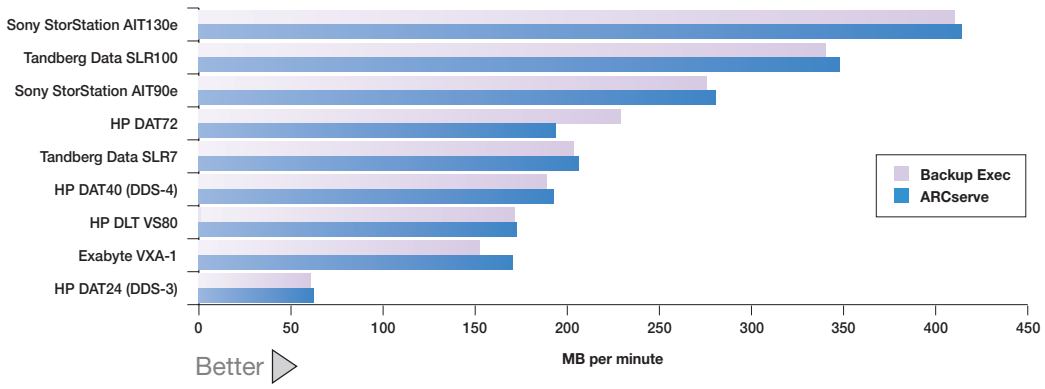


For testing purposes a Viglen LX245 workgroup server was chosen and this came equipped with a pair of 2.2GHz Intel Xeon processors backed up by 512Mb of DDR memory. Storage was dealt with by a Mylex AcceleRAID 170 Ultra160 RAID controller card and a triplet of 18.4Gb Ultra160 Fujitsu hard disks configured in a RAID 5 array. To ensure there would be no bus contention a separate Adaptec 39160 Ultra160 PCI controller card was used for the tape drives. The server was installed with Windows 2000 Server/SP2 while the backup software came courtesy of Computer Associates ARCserve 2000/SP3 and Veritas' Backup Exec 8.6. A 7.2Gb data collection representative of the average small business or departmental server was used for testing and comprised 22,328 files which included Word documents, Excel spreadsheets, Access and SQL databases along with PowerPoint presentations plus video clips, sound files, C++ source program files, ZIP archives and movie MPGs. Each drive was asked to secure the test data and then check it using ARCserve's tape to disk verification and Backup Exec's tape readability test. All data was then restored to a separate directory on the test server. Single file restoration was also tested by asking each drive to restore one file that was located approximately halfway down the backup tape.

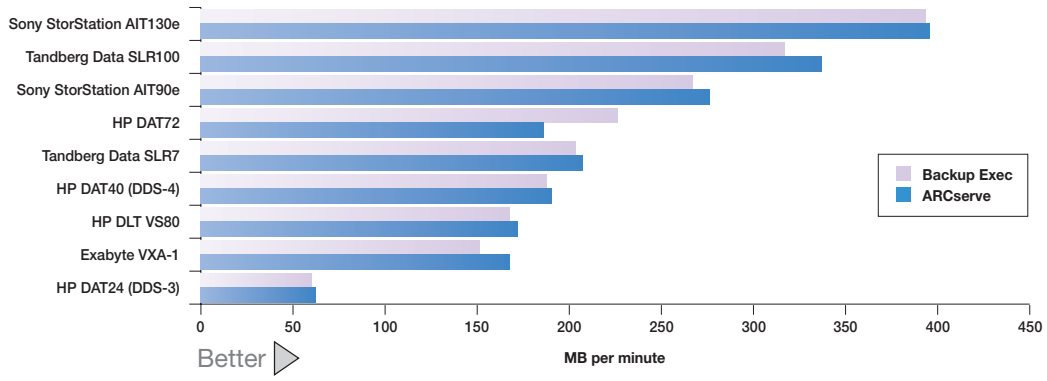
Backup



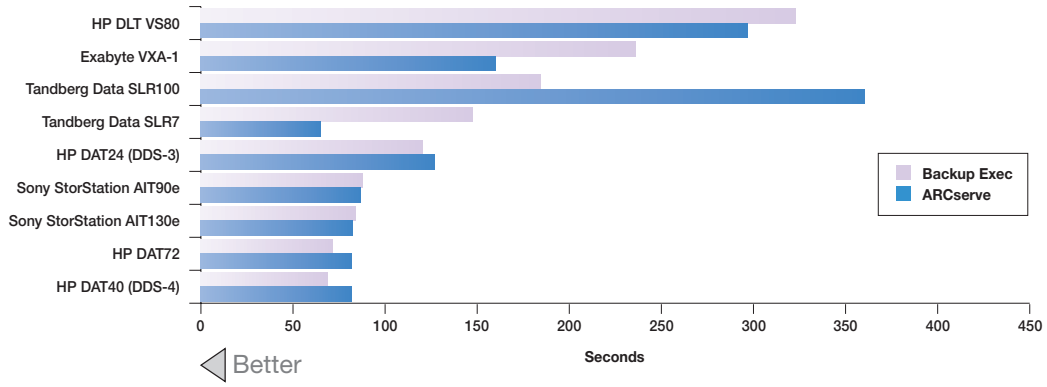
Verification



Restoration



Single File Restore



Conclusion

It's clear there is a wide range of choices for PC Server backup but a closer examination shows some formats have distinct advantages over others. Sony's AIT format looks to be one of the best solutions for PC Server backup as it satisfies all the criteria outlined at the start of this report. Storage capacity is impressive as although AIT-1 was originally announced as far back as 1998 it offers a native capacity of 35GB – only marginally less than the new DAT72. Moving up to AIT-2 delivers an impressive native capacity of 50GB, which is the same as Tandberg Data's more costly SLR100. Both AIT-1 and AIT-2 score extremely well for performance as well with AIT-2 taking first place in all the backup, restore and verification tests. As a replacement for DDS-4 the immediate benefits are a doubling in performance and a 250 per cent improvement in native storage. AIT-1 also delivered impressive speeds as only the SLR100 and AIT-2 drives were faster. Clearly, AIT-1 is an excellent choice for replacing DDS-3 as it provides a remarkable four-fold increase in performance and a tripling in capacity for a very similar unit price. AIT scores well for overall costs as both formats are priced to compete strongly with DDS and DAT72 although the higher than average media prices do involve a higher storage cost per gigabyte. One area where AIT takes a big lead is with its new low cost ATAPI drives - the StorStation AIT90ai and AIT130ai. Traditionally, the ATAPI interface has been seen as far too slow for server backup with Seagate's dying Travan format giving it a particularly bad name. However, as both these new drives perform very well and deliver speeds that are every similar to their SCSI counterparts making them a top alternative to DDS for entry-level backup. Finally, AIT satisfies the requirement for expansion as once backup demands have outgrown AIT-1 and AIT-2 there is the AIT-3 format ready and waiting. Unlike competing formats, this third generation is already mature having been first released in 2001 with it providing a massive increase in performance to 12MB/sec and an enterprise level storage capacity of 100GB. Furthermore, unlike the majority of manufacturers who do not have clear product roadmaps, AIT does have the most well defined route with a further three generations planned culminating in 2007 with AIT-6.

After taking all the criteria into consideration it is clear that AIT is the only format that satisfies all the requirements making it the best choice for PC Server based backup and the perfect replacement for the DDS-3 and DDS-4 formats.

At a glance features

Manufacturer	Exabyte	Hewlett Packard	Hewlett Packard	Hewlett Packard	Hewlett Packard	Sony	Sony	Tandberg Data	Tandberg Data
Model	VXA-1	StorageWorks DAT24e	StorageWorks DAT40e	StorageWorks DAT72	StorageWorks dlt VS80	StorStation AIT90e	StorStation AIT130e	SLR100	SLR7
Price (ex. VAT)	£562	£529	£609	£749	£1,025	£734	£929	£1,553	£657
Interface	SCSI	SCSI	SCSI	SCSI	SCSI	SCSI	SCSI	SCSI	SCSI
Format	VXAtape	DAT DDS-3	DAT DDS-4	DAT72	DLT1	AIT-1	AIT-2	SLRtape100	SLRtape7
Storage Capacity (Gb)									
Native	33	12	20	36	40	35	50	50	20
Compressed (Max)	66	24	40	72	80	91	130	100	40
Tape Length	170m	125m	150m	175m	1828ft	230m	230m	N/S	N/S
Media price (MSRP - £)	42	10	15	25	54	63	81	61	38
Storage Cost £/Gbyte (native)	1.27	0.83	0.75	0.69	1.35	1.80	1.62	1.22	1.90
Quoted performance									
Native - MB/sec	3	1	3	3	3	4	6	5	3
Compressed (Max) - MB/sec	6	2	6	6	6	10.4	15.6	10	6
Maximum Compression Ratio	2:1	2:1	2:1	2:1	2:1	2.6:1	2.6:1	2:1	2:1
Backward compatibility									
Read	N	DDS-2	DDS-3, DDS-2	DDS-4, DDS-3	DLT4000	SDX1-25C	SDX1-25C, SDX1-35C	SLR60,50,40,32,24, 7	SLR5
Write	N	DDS-2	DDS-3, DDS-2	DDS-4, DDS-3	N	SDX1-25C	SDX1-25C, SDX1-35C	SLR60,50,40	N
Software included as standard	N	TapeWare XE	TapeWare XE	TapeWare XE	TapeWare XE	NovaStor TapeCopy InstantRecovery	NovaStor TapeCopy InstantRecovery	N	N
SCSI cable	N	Y	Y	Y	Y	Y	Y	Y	Y
Host adapter supplied	N	N	N	N	N	N	N	N	N
SCSI Terminator	Y	Y	Y	Y	Y	Y	Y	Y	Y
Tape supplied	Y	Y	Y	Y	Y	Y	Y	Y	Y
Cleaning tape	Y	Y	Y	Y	Y	Y	Y	Y	Y