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**MANAGEMENT BRIEF**

# COST/BENEFIT CASE FOR IBM XIV STORAGE SYSTEM

## Comparing Costs for IBM XIV and EMC V-Max Systems


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## The User's Tale

Few storage platforms have generated as much debate as IBM's XIV Storage System. Since it was introduced as an IBM offering in August 2008, the XIV system has been the subject of a great deal of blogging and analysis. Numerous opinions have been expressed about it.

Most industry discussion, however, has focused on architectural concepts (the XIV architecture is significantly different from conventional disk system designs) and technical issues. Discussions have generally been theoretical in nature, in that the experiences of XIV users have not featured in debates.

This report remedies this situation. It is based on input from 12 organizations that have deployed XIV systems. Certain of the questions raised in industry debates may be simply answered.

First, is XIV a genuine Tier 1 system? Yes, clearly. Organizations have routinely deployed XIV systems as replacements for or alternatives to competitive Tier 1 systems. Users required high-end performance, 24x7 availability and replication of data to failover sites for disaster recovery purposes. The XIV system met these requirements.

Second, is XIV less expensive than EMC systems? Again, the answer is yes. Users reported disparities of up to five times in hardware and software costs for XIV and equivalent EMC Tier 1 systems. Other costs, including space, energy and storage administration, were also – by wide margins – lower for XIV than for EMC installations.

Another striking result emerged. Of the 12 organizations that contributed to this report, 10 had also deployed, or planned to deploy XIV systems for Tier 2 and, in two cases, Tier 3 applications displacing midrange disk systems, SATA-based retention and archiving systems, or both. XIV systems were reported to be cost-competitive with these systems.

## XIV and V-Max

The experiences of XIV users do not necessarily answer the question of whether XIV systems are less expensive to acquire, operate and support than the new EMC V-Max platform. This system became generally available only in April 2009, and many of the capabilities announced by EMC will not be delivered for some time.

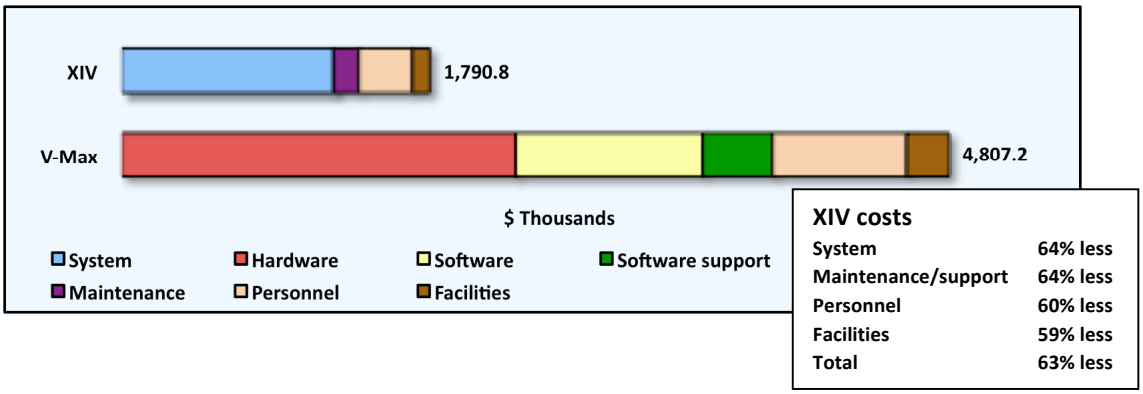
Cost comparisons are nevertheless appropriate. Many EMC users will face decisions about whether to commit to V-Max in the near future. Since EMC will not support upgrades from existing DMX systems to the new platform, it is likely that more users will review alternatives than was the case for previous new generations of DMX technology. Current pressures on IT budgets are magnifying cost concerns.

This report thus draws upon early V-Max user experiences, as well as EMC published specifications and "street" pricing data, to calculate three-year costs for V-Max systems in six representative Tier 1 installations. These are compared with three-year costs, calculated in the same manner, for equivalent XIV configurations.

Overall three-year costs for use of XIV systems averaged 63 percent less than for V-Max equivalents. Figure 1 summarizes these results.

Figure 1

**Three-year Costs for Use of IBM XIV and EMC V-Max Systems for Tier 1 Applications**




Totals for XIV systems include system (hardware and software) acquisition, and maintenance costs, which were calculated based on the original IBM one-year warranty offering. A three-year warranty option was introduced by IBM for XIV systems in July 2009.

Costs for V-Max systems include hardware and software acquisition, as well as software support. As EMC offers a three-year hardware warranty, hardware maintenance costs are not included.

Costs for both platforms include facilities (including data center occupancy, power and cooling), and storage administration personnel.

Comparisons are based on installations in manufacturing, life sciences, telecommunications and financial services companies, and in government and health care organizations with between 54 terabytes (TB) and 281 TB of initial useable capacity. Allowance was made for annual capacity growth rates of between 15 and 45 percent, depending on applications and installations.

Three-year costs for XIV systems were less for hardware and software acquisition, personnel and facilities. Hardware and software maintenance costs for XIV systems were also less than EMC software support costs.

There were some variations in comparative costs between installations. Examples are shown in figures 2 and 3.

Figure 2

**Comparative Three-year Costs: Health Care Organization Example**

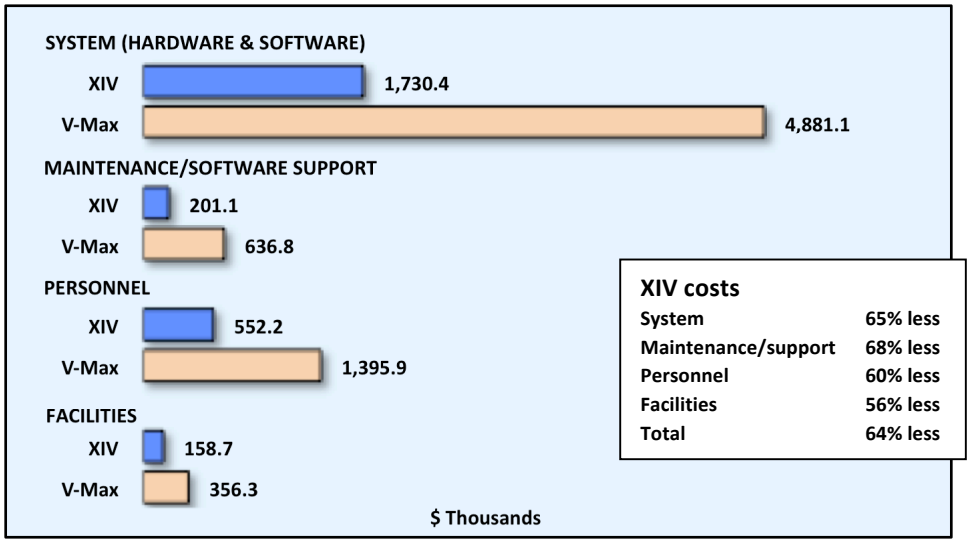
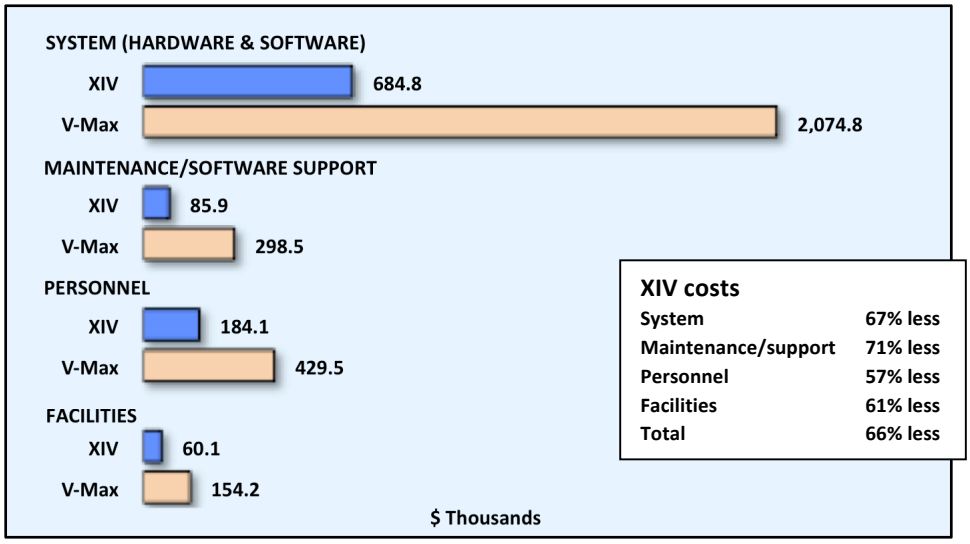


Figure 3
**Comparative Three-year Costs: Manufacturing Example**




Data on installations, configurations and staffing levels employed for cost comparisons, along with granular cost breakdowns and details of the methodology and assumptions employed, may be found in the Detailed Data section of this report.

## Implications

It has been said that the IBM XIV system is a "game changer," in that it redefines the technology standards and competitive dynamics of the disk systems business. It clearly represents a major departure from the architectures that have dominated the disk systems business since the 1980s.

The XIV is the first mainstream commercial disk system to implement a massively parallel grid architecture. Its use of "commodity" hardware components, in particular 1 TB Serial ATA (SATA) drives, results in a comparatively low cost. The core principle is that parallelism allows the totality of system resources to be exploited in a highly efficient manner, which compensates for the performance limitations of individual components.

The XIV system also incorporates a number of design features, described later in this report, which address the availability and manageability requirements of large organization storage environments. User experiences with these features have been entirely positive.

The XIV system may not be appropriate for all Tier 1 applications. In particular, it can be expected that conventional high-end disk systems will remain competitive for large, highly business-critical systems. But, in most organizations, there are large segments of Tier 1 storage infrastructures for which the XIV platform offers the potential for major cost savings without sacrifices in performance or quality of service.

It is clearly worth a closer look.

# PLATFORMS

## XIV System

### *Grid Storage*

The concept of grid storage has been researched and discussed since the early 2000s. Early deployments involved customized systems put in place by individual users for high-volume scientific, digital media, Internet services and telecommunications applications. The first grid-based arrays appeared during 2005 and 2006.

The basic principle of grid storage is that multiple self-contained storage nodes are interconnected so that any node can communicate with any other without data passing through a centralized switch. Nodes contain processors, disks, memory and other components. Synchronization of resources across nodes is handled using massively parallel software.

A key implication of this approach is that system-level performance is less dependent on such variables as controller throughput and disk drive speed than is the case for conventional disk systems. It becomes possible to deliver high levels of performance using comparatively low-cost components such as x86 server engines and SATA drives.

High performance computing (HPC) systems employ a conceptually similar approach. Most of the world's supercomputers are massively parallel clusters built around inexpensive x86 servers.

Massively parallel grid storage systems built around commodity processors and drives appeared from multiple vendors during 2008 and 2009. Examples include EMC's Atmos, Hewlett-Packard's 9100 Extreme Data Storage System and DataDirect Networks' Web Object Scaler (WOS). These systems have been aimed at high-volume applications involving unstructured data such as Web content and digital media.

### *XIV Platform*

The XIV platform evolved in a different direction. The original XIV company, which was formed in 2002 and shipped its first systems in 2005, focused on mainstream commercial applications. The XIV design incorporated features that address issues that are more significant in commercial environments. This is particularly the case in two areas:

1. ***Availability***. The XIV system employs a RAID-like data distribution algorithm (sometimes referred to as "RAID-X"), provides large-scale disk redundancy, and enables extremely rapid data rebuilds in the event of a disk failure.

   In comparison, conventional disk systems employ a combination of RAID 5 and spare drives to guard against the effects of drive failures. The RAID 5 technique spreads data across multiple drives, enabling it to be rebuilt if one drive fails. In a typical Tier 1 configuration, drives are configured in a 3:1 ratio, with one of every four drives acting as a failover device (i.e., useable capacity is 75 percent of physical capacity). Spare drives provide further protection.

   The XIV system's RAID-X technique spreads data in small (one megabyte) blocks across all of the system's drives. While this approach reduces useable capacity (an XIV system configured with 180 1 TB SATA devices has a useable capacity of 79 TB), it provides a higher level of redundancy than conventional systems, and enables data to be rebuilt more rapidly.

RAID 1, often referred to as disk mirroring, is also employed for some conventional system applications. With this approach, active and failover drives are configured in a 1:1 ratio, and useable capacity is approximately 50 percent of physical capacity.

For XIV as well as conventional systems, other components, including processors, cache memory, I/O and uninterruptible power supplies (UPS), are also configured to provide high levels of redundancy. Components are hot swappable; i.e., they may be replaced while the system remains in operation.

2. ***Manageability***. The XIV algorithm also automates data placement, provides load-balancing functions and manages capacity utilization across the entire system. In addition, it provides performance optimization functions that, in conventional disk systems, are handled using separate tools and processes.

   The XIV system also features a highly integrated and easy-to-use graphical user interface (GUI) that, according to users, further improves administrator productivity. As a result of these capabilities, staffing levels for storage administration may be significantly lower than for conventional systems.

Other XIV features also deserve mention. The system enables extremely rapid creation of snapshot copies of data (this was reported by users to be particularly useful for backups), and supports use of thin provisioning (i.e., the ability to allocate storage capacity in real time in response to application requirements, rather than in preset blocks). Both facilities materially improve capacity utilization.

Use of 1 TB SATA drives lowers energy costs. These typically operate at rotational speeds of 7,200 revolutions per minute (RPM). In comparison, the norm for high-end Fibre Channel (FC) drives is currently for devices with capacities of 146 gigabyte (GB), 300 GB or 450 GB operating at 15,000 rpm. Higher rotational speeds translate into greater energy consumption. Current industry ranges are shown in Figure 4.

Figure 4
**Power Consumption by Fibre Channel and SATA Drives**

| Type of drive | Consumption per drive | Consumption per terabyte |
|---|---|---|
| 300 GB 15,000 rpm Fibre Channel | 15-20 watts | 50-70 watts |
| 1 TB 7,200 rpm SATA II | 11-13 watts | 11-13 watts |

On a per terabyte basis, SATA drives consume approximately four to six times less energy than 15,000 rpm FC equivalents. Over the next 18 months, it is expected that the industry norm will move to 450 GB FC and 2 TB SATA drives; i.e., the disparity will widen.

The XIV operating system, along with tools for replication, snapshot copying and cloning, data migration, multipathing, host connectivity and management functions, are offered in an integrated single-price package. The package includes synchronous replication capability for disaster recovery purposes. IBM has stated its intention to deliver asynchronous capability in the second half of 2009.

This approach has a major impact on comparative XIV and V-Max costs. Providing comparable functionality for V-Max systems requires additional, separately charged tools that significantly increase overall costs for V-Max systems.

In terms of architecture, technology, pricing and packaging, there are thus reasonable grounds to expect that XIV systems offer a viable, lower-cost alternative to EMC V-Max and other Tier 1 storage systems. The central question thus becomes whether, in practice, this has proved to be the case.

### *User Experiences*

Experiences of the XIV users who contributed to this report may be summarized as follows:

- ***Applications***. All 12 organizations had deployed XIV systems to support what were characterized as Tier 1 applications. In these cases, XIV systems replaced, or were selected as alternatives to EMC DMX and other high-end disk systems.

  Among these, 10 had also deployed, or planned to deploy XIV systems for Tier 2 and, in two cases, what were characterized as Tier 3 applications.

  Tier 1 applications included support for enterprise resource planning (ERP) and other business-critical transaction processing systems, high-end business intelligence (BI) systems, e-mail networks requiring 24x7 availability, and a high-volume e-commerce system. Two IT services firms also employed XIV systems to support delivery of customer services.

  Among health care organizations, current and planned Tier 1 applications included hospital information systems (HIS), electronic medical records (EMR) and Picture Archiving and Communication Systems (PACS) employed for diagnostic imaging.

  (Health care organizations employing PACS distinguish between short-term storage, which is a Tier 1 application requiring rapid retrieval of images, and archival storage, which involves slower retrieval of images and is typically handled by Tier 2 or Tier 3 systems. Tier 1 systems might be employed to store images for, say, the first six months. XIV systems were used in this role.)

  Tier 2 applications included Web content and digital media storage, test and development systems, departmental databases, file serving, support for VMware servers and a variety of others. One health care organization also planned to employ XIV systems for long-term archiving of PACS images.

- ***Performance***. All of the XIV users who provided input for this report had selected this platform only after proof of concept (PoC) tests had demonstrated that it was capable of handling current workloads as well as projected growth. None reported subsequent performance shortfalls.

  Most users reported that XIV performance was, typically by wide margins, superior to that of their existing Tier 1 systems. Two reported that competitive tests had shown that XIV performance was superior to EMC DMX-4 systems for their workloads. The V-Max system had not been introduced when tests were conducted.

  Financial services, telecommunications and insurance companies reported that XIV systems exceeded performance requirements for high-volume transaction- or query-intensive systems. Another company reported that, in a PoC test for its core ERP system, an XIV system delivered performance of over 60,000 I/Os per second (IOPs). Others reported similar experiences.

  The ability of the XIV system to make extremely rapid copies of data was also cited as a major benefit by seven users. One organization was able to perform four differential snapshots per day over a seven-day period for a large (more than seven terabytes of raw data) Oracle database without experiencing any performance degradation.

  Backup windows were variously reduced from eight hours to around 15 minutes, eight hours to less than five minutes, and six hours to less than five minutes.

  Recovery times were also significantly reduced. Three organizations reported reductions from "hours to days" to "minutes…a few minutes…less than five minutes."

- ***Availability and disaster recovery***. XIV users reported no significant downtime problems. The ability of the system to withstand disk failures was commented upon by several users.

  For example, one organization reported that, while two drive failures had occurred, neither caused an interruption of service. In both cases, data on failing disks was redistributed to others in three or four minutes. Another user tested failover of 24 drives with no impact on service availability or performance. A third tested multiple failover scenarios, with the same results.

  Of the 12 organizations that contributed to this report, 11 employed, or planned to employ XIV replication capabilities to mirror data to second sites for disaster recovery purposes. The other employed an existing replication solution to mirror XIV data.

  Organizations that were already using these capabilities regarded them as entirely adequate, and often considered them superior to solutions offered by their original Tier 1 vendors. Four users reported that they had conducted disaster recovery tests involving failover to second sites. XIV capabilities, again, were found to be satisfactory.

- ***Manageability***. There was general agreement among XIV users that administration tasks could be performed more rapidly, with less time and effort, than was the case for the conventional systems with which they were familiar. One organization "no longer performed manual tuning."

  Seven organizations reported that storage administrator workloads had been reduced compared with previous systems. The remainder was unable to quantify potential reductions, because administrators handled multiple storage platforms, or because storage consolidation and/or other initiatives had been undertaken that made it difficult to compare "before" and "after" workloads.

  Tasks that benefited from distinctive XIV capabilities were said to include initial system setup, provisioning (users reported that provisioning processes were typically performed in a matter of minutes, or less than a minute), definition of volumes and snapshots, and data migration. Performance monitoring and optimization tasks were largely eliminated.

  It was noted that XIV manageability advantages were particularly valuable when new applications were deployed, or when workloads changed for other reasons. Gains in administrator productivity thus tended to be highest in organizations that experienced frequent changes in their storage environments.

  Two companies providing managed hosting and ISP services reported that XIV manageability strengths translated into direct bottom-line benefits. Deployment times for new customer applications, as well as ongoing storage administration overhead were significantly reduced.

  The XIV GUI was various described as "very simple…very easy to use…excellent" and as requiring "very little training…virtually no training."

- ***Costs***. All XIV users that contributed to this report agreed that XIV systems were less expensive than other Tier 1 platforms they had reviewed. Initial XIV hardware and software acquisition costs were said to be between two and five times lower than for alternatives.

  Operating costs were also reported to be between 30 and 60 percent lower than for existing Tier 1 systems.

  Most organizations regarded XIV systems as cost-competitive with Tier 2 as well as Tier 1 alternatives, and two regarded them as cost-competitive with Tier 3 platforms.

Three organizations also commented that, because XIV systems could be rapidly and easily deployed, professional services costs were minimized or avoided altogether. Two organizations reported that they had been able to set up XIV systems and provision servers in less than a day.

Users also cited IBM Capacity on Demand (COD) pricing terms, which allowed organizations to install excess capacity and pay for it only when it was activated, as an important benefit. COD pricing was particularly valued by organizations that were experiencing budgetary pressures, and wished to minimize short-term capital expenditures.

The modular structure of the XIV system facilitated this approach. In contrast, it was noted, other Tier 1 vendors required that organizations purchase system bays, storage bays and other components when installing a system, even if the disk populations these were designed to support would not be in place until well into the future.

The user organizations whose experiences are summarized above employed XIV systems in Tier 1 roles, and in some cases had added, or planned to add Tier 2, or Tier 2 and Tier 3 applications. However, a number of organizations that employed XIV systems only in Tier 2 and/or Tier 3 roles were encountered during research conducted for this report. Input from these was not included.

## V-Max System

Introduced in April 2009, the EMC V-Max platform is described by the company as its next-generation Tier 1 platform. V-Max succeeds the EMC DMX generation, which was first introduced in 2003.

EMC, however, will continue to market the most recent DMX platform, the DMX-4, which was introduced in 2007. DMX systems will not be upgradeable to V-Max. DMX scripts may run on V-Max systems, but will not support new functionality specific to this platform.

According to EMC, the V-Max system will form part of a broader Virtual Matrix architecture that will support up to 256 V-Max engines, “hundreds of petabytes” of virtualized disk storage, “tens of millions” of IOPs, and “hundreds of thousands of VMware and other virtual machines.” As described by the company, this architecture will implement a “scale-out” or “federated” model.

Few details have, however, been provided. It is unclear when this broader architecture might be delivered.

In its current form, the V-Max system supports up to eight engines and 2,400 disk drives, for maximum physical capacities of 1.08 or 2.4 petabytes using 450 GB FC or 1 TB SATA drives respectively.

The V-Max system employs the same basic controller-based structure as DMX systems, although the previously separate functions of disk, cache and I/O directors have been integrated into x86-based multifunction units. Dual redundant units form the basis of V-Max engines, which also include mirrored cache and I/O ports. RapidIO technology, an alternative to InfiniBand, is employed for interconnects.

The V-Max version of the EMC Enginuity operating system supports thin provisioning, previously introduced for DMX-4 and DMX-3 systems in 2008. EMC, along with some other vendors and industry commentators refer to this capability as “virtual provisioning.” It is the same technology described earlier for XIV systems.

Like its DMX-4 predecessor, the V-Max system is configured using System Bays, which contain engines and up 120 drives, and Storage Bays, which may be configured with 240 additional drives.

In addition, like DMX-4 systems, V-Max systems may be equipped with combinations of FC, SATA and flash (solid state) drives. The devices shown in figure 5 are supported.

Figure 5
**V-Max Supported Disk Drives**

| Tier | Technology | Capacity/ Rotational Speed |
|---|---|---|
| **0** | **EMC Enterprise Flash Drive (EFD)** | 200GB<br>400GB |
| **1** | **4Gbps Fibre Channel** | 146GB 15K rpm<br>300GB 15K rpm<br>400GB 10K rpm<br>450GB 15K rpm |
| **2** | **SATA II** | 1 TB 7.2K rpm |

Tier 0 is an EMC term for flash drives. These offer significantly higher performance rates, higher reliability (there are no moving parts) and lower power consumption than disk drives, but are a great deal more expensive. At present, in Tier 1 storage applications, flash drives are employed mainly for applications characterized by extremely high transaction volumes and requirements for exceptionally fast data retrieval.

The ability to configure Tier 1 and Tier 2 drives in a single frame supports the EMC concept of Information Lifecycle Management (ILM). The objective is to use the same system to manage frequently accessed and archival data. The system provides policy-based management of data across its entire lifecycle, moving it to lower-cost media as it becomes less active.

While tiered storage approaches have become widely adopted, few organizations have chosen to employ relatively expensive Tier 1 platforms to host multiple types of drive. The typical practice has been to employ lower-cost SATA-based systems and tape media for less active data.

EMC has announced plans, however, to deliver new V-Max Fully Automated Storage Tiering (FAST) capabilities. According to the company, FAST technology will automate the allocation and relocation of data across flash, FC and SATA drives based on application performance requirements. EMC has indicated that a subset of FAST capabilities will be delivered during 2009. It is, however, unclear when full implementation will be completed.

There are limits to V-Max useable capacity for all media. If flash drives were employed, at least one would typically be configured as a spare. For disk drives, EMC recommends eight spare drives per 100, and useable capacity is reduced further by RAID 5 redundancy. The norm for Tier 1 applications for all vendors is that systems are configured with one redundant drive for every three active drives.

In addition, 200 GB of capacity is required for each engine to provide vault space to hold cache in the event of power loss, and 64 GB is required for the Symmetrix File System. For a V-Max configuration with 120 x 300GB FC drives and physical capacity of 36 TB, useable capacity would thus be:

120 drives – (12 spares + 27 redundant drives) = 81 x 300 GB = 24.3 TB – 0.264 TB = 24.036 TB

i.e., useable capacity would be approximately 67 percent of physical capacity. Although this is a higher percentage than for XIV systems, both platforms fall well short of full utilization of physical capacity.

## Outlook

During the V-Max launch, EMC executives emphasized that the V-Max system employed commodity components such as x86-based controllers and implemented a “clustered” architecture. It was indicated that V-Max engines in multiple systems would evolve to become nodes within large Virtual Matrix clusters.

In its present form, however, V-Max is – as a number of industry observers have pointed out – essentially a hybrid system. While it incorporates new architectural components, and appears to be more scalable than DMX systems, V-Max retains core DMX components, including the Enginuity operating system, RAID 5 mechanisms and other software structures. It is an evolutionary rather than revolutionary design.

The question may be posed: what is the V-Max system intended to evolve into? Some EMC statements suggest Virtual Matrix architecture will be based on the EMC Atmos design, described earlier; i.e., it will be a form of grid storage.

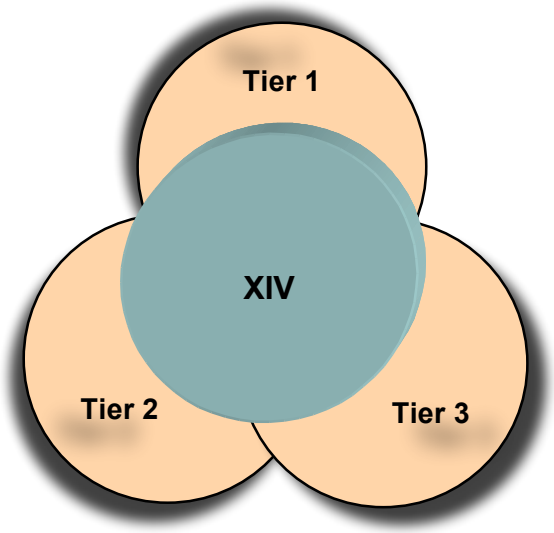
V-Max systems may continue to employ FC and flash drives for high-performance applications. But in other respects, the V-Max and XIV architectures appear to be converging rather than diverging. It is unclear whether EMC will be able to maintain its pricing differential as this occurs.

The experiences of XIV users also raise another question: if the same platform and media may be employed to handle multiple storage tiers, does this require changes to the concept of Information Lifecycle Management? Arguably it does.

Some large XIV users have adopted three-tier storage structures. However, these differ from the traditional ILM hierarchy. Conventional disk systems are employed for the most performance-sensitive and business-critical applications, tape backup is employed for long-term archival storage, and XIV is employed for everything else.

It is unlikely that XIV systems will replace all other types of disk system in many organizations. But they may have a disruptive effect on traditional storage system storage categories. They may also define a new market segment, as illustrated in figure 6.

Figure 6
**XIV Market Positioning**




One conclusion emerges clearly. The XIV system, the style of architecture it implements, and the pricing model IBM has adopted for it, will be significant factors in the future evolution of disk systems, and of the disk systems marketplace.

# DETAILED DATA

## Basis of Calculations

### *Installations*

The cost comparisons presented in this report are based on profiles of Tier 1 disk system installations in six user organizations. These installations are summarized in figure 7.

Figure 7
**Installations Summary**

| | GOVERNMENT ORGANIZATION | MANUFACTURING COMPANY | LIFE SCIENCES COMPANY |
|---|---|---|---|
| **Business profile** | Local government<br>30+ departments & agencies<br>5,000+ employees | Industrial equipment manufacturer<br>$1 billion sales<br>5,000+ employees | Biomedical products manufacturer<br>$750 million sales<br>2,000+ employees |
| **Applications** | ERP system, e-mail, departmental | ERP system | ERP system |

| | TELECOMMUNICATIONS COMPANY | FINANCIAL SERVICES COMPANY | HEALTH CARE ORGANIZATION |
|---|---|---|---|
| **Business profile** | Landline, mobile, Internet & cable services<br>$5 billion sales<br>10,000+ employees | Diversified retail bank<br>$2.5 billion sales<br>$100 billion assets<br>12,000+ employees | 12 medical centers<br>20+ other facilities<br>$2 billion revenues<br>15,000+ employees |
| **Applications** | BI, CRM, ERP, e-mail operational systems, customer services | BI, core financial, line of business, departmental, e-mail, various | HIS, EMR, HR, e-mail PACS*, departmental, various |

BI: Business intelligence
ERP: Enterprise resource planning
EMR: Electronic medical records
*Short term storage
CRM: Customer relationship management
HIS: Hospital information system
PACS: Picture Archiving and Communication Systems

Installations were constructed using data on applications, workloads, hardware and software configurations, storage administration staffing levels and growth trends supplied by 33 users of XIV and of EMC DMX-3 and DMX-4 systems. V-Max systems were still new, and few users had production experience with them when this report was prepared.

XIV installations were matched with DMX installations in organizations of approximately the same size, in the same industries, with generally similar business models and application and workload profiles.

A composite approach drawing on the experiences of multiple user organizations was employed. This approach was adopted to compensate for limitations in data obtained from some organizations; to ensure that installation details were generally representative of the industries, applications and workloads upon which comparisons were based; and to protect the confidentiality of individual organizations.

Hardware and software configurations, along with FTE storage administration staffing levels, were then determined for XIV and V-Max systems for each installation. For storage administrator staffing levels, the most efficient sites – i.e., those with the lowest number of FTEs relative to useable capacity for both platforms – formed the basis of comparisons.

Configurations and staffing levels are summarized in figure 8.

Figure 8

**Configurations and Staffing Summary**

| GOVERNMENT ORGANIZATION | MANUFACTURING COMPANY | LIFE SCIENCES COMPANY |
|---|---|---|
| **XIV Systems** | | |
| **Beginning of period** | | |
| 2 x 27 TB<br>Total: 54 TB<br>***0.2 FTE*** | 2 x 43 TB<br>Total: 86 TB<br>***0.2 FTE*** | 1 x 54 TB, 1 x 43 TB<br>Total: 97 TB<br>***0.25 FTE*** |
| **End of period** | | |
| 1 x 43 TB, 1 x 27 TB<br>Total: 70 TB<br>***0.2 FTE*** | 2 x 66 TB<br>Total: 132 TB<br>***0.2 FTE*** | 1 x 73 TB, 1 x 66 TB<br>1 x 43 TB<br>Total: 182 TB<br>***0.25 FTE*** |
| **V-Max Systems** | | |
| **Beginning of period** | | |
| 2 x 24 TB<br>Total: 48 TB<br>***0.55 FTE*** | 2 x 43 TB<br>Total: 86 TB<br>***0.45 FTE*** | 1 x 52 TB, 1 x 37 TB<br>Total: 89 TB<br>***0.6 FTE*** |
| **End of period** | | |
| 1 x 44 TB, 1 x 28 TB<br>Total: 72 TB<br>***0.6 FTE*** | 2 x 65 TB<br>Total: 130 TB<br>***0.5 FTE*** | 1 x 102 TB, 1 x 71 TB<br>Total: 173 TB<br>***0.7 FTE*** |
| **TELECOMMUNICATIONS COMPANY** | **FINANCIAL SERVICES COMPANY** | **HEALTH CARE ORGANIZATION** |
| **XIV Systems** | | |
| **Beginning of period** | | |
| 1 x 50 TB, 3 x 27 TB<br>Total: 131 TB<br>***0.35 FTE*** | 1 x 61 TB, 1 x 43 TB<br>2 x 27 TB<br>Total: 158 TB<br>***0.4 FTE*** | 3 x 43 TB, 2 x 27 TB<br>Total: 183 TB<br>***0.55 FTE*** |
| **End of period** | | |
| 1 x 79 TB, 1 x 50 TB<br>2 x 43 TB, 1 x 27 TB<br>Total: 242 TB<br>***0.4 FTE*** | 2 x 79 TB, 1 x 61 TB<br>1 x 54 TB1 x 43 TB<br>Total: 316 TB<br>***0.45 FTE*** | 1 x 66 TB, 2 x 61 TB<br>1 x 50 TB, 1 x 43 TB<br>Total: 281 TB<br>***0.65 FTE*** |
| **V-Max Systems** | | |
| **Beginning of period** | | |
| 1 x 49 TB, 1 x 24 TB<br>2 x 19 TB<br>Total: 111 TB<br>***0.85 FTE*** | 1 x 62 TB, 1 x 46 TB<br>1 x 24 TB<br>Total: 132 TB<br>***0.85 FTE*** | 1 x 40 TB, 3 x 31 TB<br>1 x 28 TB<br>Total: 161 TB<br>***1.4 FTEs*** |
| **End of period** | | |
| 1 x 105 TB, 1 x 49 TB<br>2 x 37 TB<br>Total: 228 TB<br>***1.0 FTE*** | 1 x 143 TB, 1 x 99 TB<br>1 x 56 TB<br>Total: 298 TB<br>***1.05 FTEs*** | 1 x 68 TB, 2 x 59 TB<br>1 x 49 TB, 1 x 40 TB<br>Total: 275 TB<br>***1.7 FTEs*** |

For XIV as well as V-Max systems, allowance was made for capacity growth rates of between 15 and 45 percent annually, depending on applications and installations. Configurations and staffing levels were adjusted accordingly over a three-year period. Cost calculations are for the entire period.

### *Hardware Configurations*

Configurations for XIV and V-Max systems were based on the same used capacity values. Configurations were rounded to the next largest capacity increment offered by vendors.

In the case of XIV systems, these increments were 27, 43, 50, 54, 61, 66, 73 and 79 terabytes. Configurations were based on IBM published information.

In some cases, XIV users had over-provisioned capacity, taking advantage of IBM Capacity on Demand arrangements; e.g., a system with 79 TB of useable capacity had been installed, but only 30 TB was activated and used. Where this was the case, system configurations were based on used capacity.

For V-Max systems, systems were configured in enclosure-based increments of 15 x 300 GB FC drives. When this report was prepared, EMC has published only limited data on useable capacity for V-Max systems equipped with 146 GB FC drives. The authors thus estimated useable capacity for RAID 3 +1 configurations with eight spares per 100 drives, minus allowance for cache vaulting space and the Symmetrix File System.

It was assumed that V-Max systems do not deliver higher performance or provide other functionality that would require less useable capacity than XIV equivalents. There were no obvious reasons to believe that this was the case. The full Virtual Matrix architecture might change this picture when it is delivered.

### *Software Configurations*

All XIV systems are configured with the standard XIV systems software package.

V-Max systems are configured with EMC software products providing equivalent functionality. These include the products shown in figure 9.

Figure 9
**EMC Software Products Employed for V-Max Systems**

| Function | Product |
|---|---|
| **Operating system** | Enginuity 5874 |
| **Replication** | Symmetrix Remote Data Facility |
| **Snapshot copies** | TimeFinder |
| **Storage management** | Symmetrix Manager |
| **Performance optimization** | Symmetrix Optimizer |
| **Multipathing** | PowerPath |

Not all V-Max systems were configured with all software products; e.g., Symmetrix Remote Data Facility (SRDF) was employed only on V-Max systems whose contents were replicated to a second site for disaster recovery purposes. The synchronous version of SRDF was employed to correspond to XIV capability.

### *Cost Calculations*

Costs were calculated as follows:

- ***System costs***. These include initial hardware and software acquisition, as well as costs of subsequent upgrades. Costs for V-Max systems included the software products described above.

Since EMC offers a three-year warranty for V-Max systems, no maintenance costs were included in calculations for this platform. Costs of support for the EMC software products described earlier are included. These were calculated for the full period after initial installation, and allow for subsequent capacity upgrades.

(EMC offers a 90-day software warranty for its software products. However, this applies only to defects in the media on which software is supplied. Since such defects are rare, no allowance is made for this warranty period in calculations.)

Maintenance costs for XIV systems include hardware maintenance as well as software support. Calculations allow for one-year warranties offered by IBM. Calculations for XIV as well as V-Max systems are for 24x7 coverage, again allowing for capacity upgrades.

All costs were calculated using street prices; i.e., discounted prices actually paid by users.

- ***Personnel costs***. These were calculated using an annual average FTE salary of $68,312. This was increased by 49.7 percent to allow for benefits, bonuses, training and related items.
- ***Facilities costs***. These were calculated for XIV and V-Max systems using IBM and EMC specifications respectively. Calculations include costs for data center occupancy and power, including costs of power consumed by data center infrastructure equipment such as power distribution systems, computer room air conditioning (CRAC) systems and chillers.

  Power consumption was calculated based on specific utilization levels and hours of operation for each installation. A conservative assumption for average price per kilowatt/hour was employed to determine three-year power costs.

  Occupancy costs were calculated using a conservative assumption for annual average cost per square foot for existing facilities (i.e., costs do not include new facilities construction). All calculations allow for capacity growth over the three-year measurement period.

All costs are for the United States.

## Cost Breakdowns

Detailed cost breakdowns are presented in figure 10.

Figure 10
**Three-year Cost Breakdowns**

| | GOVERNMENT ORGANIZATION | MANUFACTURING COMPANY | LIFE SCIENCES COMPANY |
|---|---|---|---|
| **XIV SYSTEMS** | | | |
| System | 498,600 | 684,800 | 1,027,200 |
| Maintenance | 65,222 | 85,882 | 128,052 |
| Personnel | 184,074 | 184,074 | 230,092 |
| Facilities | 41,201 | 60,131 | 75,594 |
| **Total ($)** | **789,097** | **1,014,887** | **1,460,938** |
| **V-MAX SYSTEMS** | | | |
| Hardware | 947,337 | 1,413,996 | 2,009,730 |
| Software | 464,052 | 660,760 | 910,014 |
| Software support | 208,033 | 298,539 | 323,456 |
| Personnel | 536,881 | 429,505 | 598,239 |
| Facilities | 108,228 | 154,207 | 205,983 |
| **Total ($)** | **2,264,531** | **2,957,007** | **4,047,422** |

| | TELECOMMUNICATIONS COMPANY | FINANCIAL SERVICES COMPANY | HEALTH CARE ORGANIZATION |
|---|---|---|---|
| **XIV SYSTEMS** | | | |
| System | 1,553,600 | 1,896,800 | 1,730,400 |
| Maintenance | 186,125 | 215,272 | 201,093 |
| Personnel | 337,468 | 383,486 | 552,221 |
| Facilities | 122,884 | 141,716 | 158,667 |
| **Total ($)** | **2,200,077** | **2,637,274** | **2,642,381** |
| **V-MAX SYSTEMS** | | | |
| Hardware | 2,751,285 | 3,331,212 | 3,289,371 |
| Software | 1,179,555 | 1,718,465 | 1,591,729 |
| Software support | 394,930 | 561,661 | 636,781 |
| Personnel | 843,670 | 874,349 | 1,395,891 |
| Facilities | 301,178 | 347,940 | 356,324 |
| **Total ($)** | **5,470,618** | **6,833,627** | **7,270,096** |

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