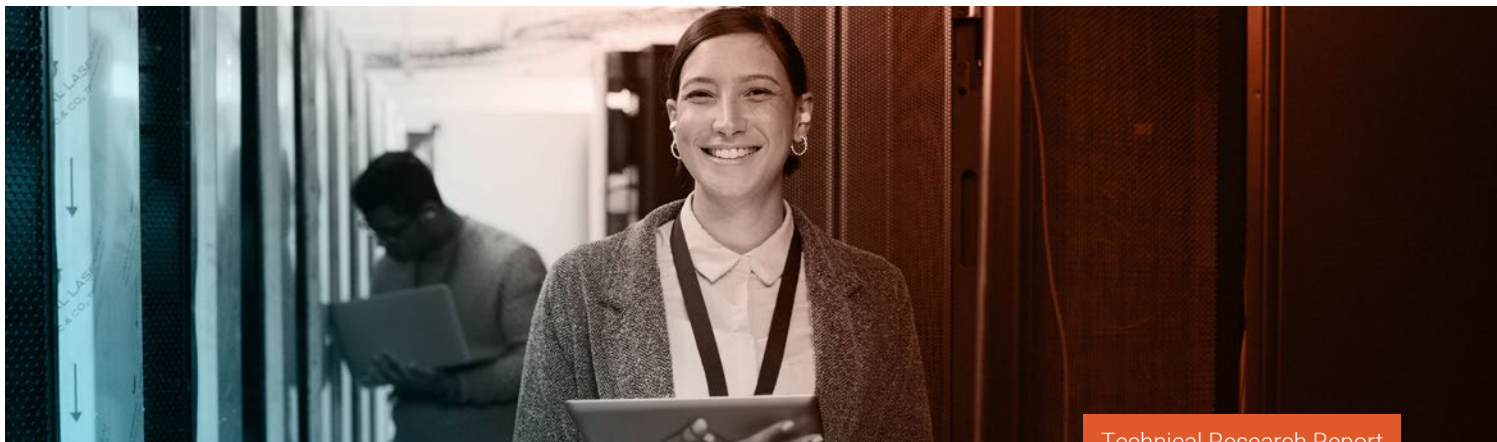




The Dell™ PowerProtect™ Data Domain™ All-Flash Appliance Achieves up to 3.8x Data Reduction Advantage

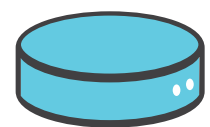
Prowess Consulting assessed the data reduction and deduplication performance of the Data Domain All-Flash appliance versus four competing backup storage solutions to determine which delivers more efficient, cost-effective cyber resilience.

Executive Summary

In this study, Prowess Consulting set out to evaluate the storage efficiency and performance of five competing storage solutions for modern data protection. We conducted rigorous testing to evaluate effective capacity, the impact of deduplication and compression on storage efficiency, and the resulting implications for data center footprint and cost.

We found that the Dell PowerProtect Data Domain All-Flash appliance delivers substantially higher average data reduction compared to the competing solutions we examined; competitors used up to 3.8x more space for the same workload.¹ It also delivered 75:1 data reduction for tested workloads and restored at speeds of up to 51 TB/hour per 500 TB system, for lightning-fast recovery.²

These results position the Data Domain All-Flash appliance as the #1 solution in data reduction among those tested, with its substantial storage savings for backup and restore offering significantly lower costs related to data center space, power, cooling, and long-term storage.



— 10 TB* —

Data Domain
All-Flash
appliance



— 10 TB* —

Vendors
C, M, X, and Y

Figure 1 | Our testing confirmed that the Dell PowerProtect Data Domain All-Flash appliance achieved better storage efficiency than competing solutions

*10 TB shown for illustration only, not the actual test dataset

Highlights

Our research confirmed that the Dell PowerProtect Data Domain All-Flash appliance outperformed the other storage solutions we tested, delivering standout advantages:¹

MORE THAN TRIPLE THE EFFICIENCY: Competitors used up to 3.8x more space for the same workload

Up to **75:1 DATA REDUCTION**²

Speeds up to **51 TB/HOUR PER 500 TB SYSTEM** for lightning-fast recovery

The Importance of Data Reduction for Cyber Resilience

Data reduction plays a critical role in improving backup efficiency for organizations of all sizes by lowering overall storage demands. Techniques such as deduplication reduce the amount of data that must be stored, helping control capacity growth and storage costs.

Restore performance is driven by how quickly protected data can be accessed and recovered when needed. Efficient restore processes reduce downtime and enable faster recovery in the event of data loss or a disaster. Paired with encryption and immutable storage, this approach strengthens cyber resilience against cyber threats, human errors, and physical disruptions.³

Research Approach Summary

We set out to discover which storage solution delivers the highest data reduction and storage capacity savings. In this study, we evaluated and compared the storage-efficiency characteristics of the Data Domain All-Flash appliance against selected all-flash and hybrid systems. Specifically, we tested the storage efficiency of the Dell Technologies all-flash appliance, in combination with the Dell PowerProtect Data Manager cyber resilience software, against four backup storage solutions. The competing solutions used either preloaded backup software or third-party backup software.

While storage optimization can be affected by data type, backup file size, and other factors, our testing showed that the Data Domain All-Flash appliance and Data Manager delivers greater effective capacity than the other backup solutions evaluated, which used up to 3.8x more space under the same workload.

Our testing also focused on deduplication efficiency, storage savings, and restore throughput for the Data Domain All-Flash appliance. These tests were designed to independently assess the Dell Technologies claim that PowerProtect Data Domain is #1 in data reduction among backup appliances.⁵ As part of this evaluation, our engineers conducted a single-vendor (Dell Technologies) deduplication efficiency analysis and a restore-performance validation test of the Data Domain All-Flash appliance.

Testing Methodology

We performed comparative testing between the Data Domain All-Flash appliance and four competitors in virtualized test environments with hardware, software, network configurations, and test data. Our comparative testing focused on deduplication efficiency and overall storage savings.

We built the test environment (shown in Table 1), which supported agentless backup of virtual machines (VMs), by integrating compatible backup software using host-level access through the VMware vSphere® API for Data Protection (VADP) with target storage appliances. This integration avoided the need to install agents inside of each VM. The target backup storage appliances consisted of all-flash arrays, such as the Data Domain All-Flash appliance, and hybrid solid-state drive (SSD)/hard-disk drive (HDD) arrays that combined both technologies, often using solid-state storage for data that required faster access.



Figure 2 | The Dell PowerProtect Data Domain All-Flash appliance

Data Domain Advantage

The Data Domain All-Flash appliance delivers next-level storage optimization, performance, and cost savings for the secure management of backup data:

- **Advanced data reduction:** Optimizes storage usage without compromising performance
- **Trusted platform:** Built on Data Domain and powered by all-flash storage for modern data protection
- **Enhanced data integrity:** Ensures reliable and secure data management
- **Robust security features:** Data immutability,³ encryption, and hardware root of trust⁴
- **Rapid restores and replication:** Minimize downtime and support business continuity
- **Seamless integration:** Integrates with Dell PowerStore™, Dell PowerMax™, and a wide range of backup software
- **Operationally efficient:** Eco-conscious design saves space and energy

Table 1 | Test environment configuration used for performance validation

Category	Configuration Details
Compute platform	VMware vSphere compute cluster
Hypervisor	VMware ESXi™ server 8.0 Update 3 running on physical servers
Network	50 gigabit Ethernet (GbE)
Management platform	VMware vCenter® 8.0 Update 3
Directory services	Microsoft Active Directory®
Network services	Domain Name System (DNS) and Network Time Protocol (NTP)

Our comparative testing of the Data Domain All-Flash appliance and solutions from leading backup storage competitors measured the actual storage consumed after each solution's data reduction methodology was applied.

Storage Consumption Comparison

Traditionally, storage consumption, especially on all-flash arrays, has been measured in raw or usable capacity. Advances in data-efficiency technologies have made logical capacity under data reduction a more relevant measure for evaluating storage value. Logical capacity reflects the amount of backup data stored after deduplication, compression, and related techniques are applied.

On platforms like the Dell PowerProtect Data Domain All-Flash appliance, high data reduction ratios (up to 75:1 in Dell Technologies internal testing) can allow logical capacity to exceed physical usable capacity by a significant margin. Achieved ratios depend on workload characteristics such as redundancy, uniqueness, and compressibility. As a result, logical capacity under data reduction provides a more accurate representation of the storage value the system delivers in real environments.

For this testing, we evaluated the storage footprint of a 30-day VM workload, including full and incremental backups after deduplication and compression. We configured the test environment to represent typical virtualized workloads, including core VM files, configuration and metadata, and temporary hypervisor snapshots to capture consistent point-in-time images. We enabled data-in-flight encryption following established security best practices.

Storage Comparison Testing Steps

1. Create a VMware cluster with sufficient storage for 18 VMs with the following configuration. Table 2 shows the number of VMs deployed, their operating systems, and the effective per-VM storage configurations we used in our testing.

Table 2 | Number of VMs, their operating systems, and per-VM storage configurations

Number of VMs Deployed (18)	Operating System	Effective Per-VM Storage Configuration
Linux® VMs (9)	Rocky Linux distribution, based on Red Hat® Enterprise Linux	All 9 VMs with operating system (OS): 25 GB 3 VMs with data: 2 x 200 GB = 425 GB 3 VMs with data: 3 x 200 GB = 625 GB 3 VMs with data: 4 x 200 GB = 825 GB
Windows® VMs (9)	Windows Server® 2019	All 9 VMs with OS: 25 GB 3 VMs with data: 2 x 200 GB = 425 GB 3 VMs with data: 3 x 200 GB = 625 GB 3 VMs with data: 4 x 200 GB = 825 GB

We standardized VM configurations across systems to ensure consistency when testing. The test configuration defines the logical data footprint used when calculating storage efficiency (data deduplication rate/data reduction ratio), effective capacity, and restore and backup performance.

Table 3 shows the total test configuration for all VMs.

Table 3 | Total test configuration for all VMs, including OS storage, data storage, and total logical data

OS Storage	Data Storage	Total Dataset Size (Logical)
18 x 25 GB = 450 GB	27 x 200 GB = 5.4 TB	450 GB + 5.4 TB = ~5.85 TB

- 2. Copy the Rocky Linux and Windows Server 2019 VMs so that there are five copies for the 18 VMs in five separate Virtual Machine and Template folders.
- 3. Configure five backup appliances:
 - a. Dell PowerProtect Data Domain 9910F All-Flash appliance
 - b. Competitor X
 - c. Competitor Y
 - d. Competitor M
 - e. Competitor C
- 4. Configure each backup appliance to back up a single Virtual Machine and Template folder.
- 5. Run a full backup of the VMs to the backup appliances.
- 6. Run 30 additional incremental backups over the course of 30 days. In the case of our validation, we accelerated the process by taking incremental backups after a 7% data change to the VMs.
- 7. Capture logs and validate storage used, storage available, data deduplication, and compression.
- 8. From the logs, review the amount of storage available, storage used, and the delta of the storage used with unique changes.
- 9. From the last log entry of storage used, divide the storage used on the competitor X, Y, M, and C backup appliances by the storage used on the Data Domain All-Flash appliance.

Our test results highlight the storage efficiency achieved across the VM workload. Following the 30-day evaluation, the Data Domain All-Flash appliance and Data Manager provided superior effective capacity (after deduplication and compression) compared with all four competitive storage solutions, which used up to 3.8x more space to store the same amount of data, as shown in Figure 3. Vendor C consumed 3.8x more storage capacity, Vendor M consumed 3.6x more, Vendor X required 3.4x more, and Vendor Y used 3.2x more for the same workload.

More Than Triple the Efficiency

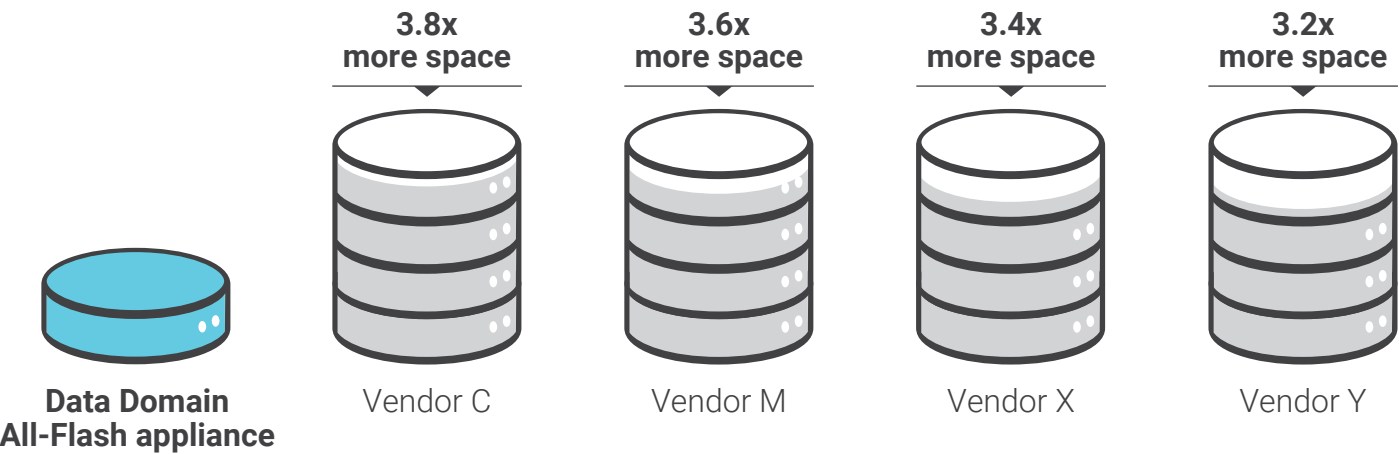


Figure 3 | Our testing confirmed that the Dell PowerProtect Data Domain All-Flash appliance achieved more than 3x the data reduction advantage compared to four competing backup appliances

All-flash arrays with higher data reduction ratios (DRRs), a storage efficiency metric calculated by dividing logical data by the physical storage consumed, can store more logical data on the same physical drives. Our findings indicate that the higher DRR of the Data Domain All-Flash appliance reduces the usable storage capacity needed and improves data center efficiency, potentially reducing overall rack space required.

Deduplication Efficiency Analysis

The Data Domain All-Flash appliance, which supports Dell Technologies and third-party software, offers up to 544 TB (482.4 TiB) of usable capacity and a maximum logical capacity of up to 40.8 PB,⁵ assuming a 75:1 data reduction ratio. In comparison, competing platforms demonstrated lower data reduction efficiency.

DRR compares the original size of the data ingested (logical, pre-reduction capacity) to the physical storage capacity consumed after data-efficiency techniques such as deduplication and compression are applied. For example, 100 TB/20 TB is a 5:1 ratio, representing five units of original data for every one unit of physical space consumed. DRR, which is typically anywhere from 4:1 to 6:1 for virtualized environments, enables organizations to quantify storage efficiency. Achieving a high DRR can free up capacity on the storage device, improve performance, and lower costs by consuming less physical storage.

In general, the higher the DRR, the better the capacity savings. Backup storage, which is focused on long-term retention, typically achieves higher DRRs than primary storage because it contains many duplicate data blocks, such as VMs, operating systems, and application files, in addition to redundant copies created as small changes are made to the same files over time. DRR is also influenced by the data reduction techniques employed. Deduplication identifies and eliminates redundant data blocks, while compression reduces the size of structured and unstructured data, such as text and logs.

Organizations should test their own data and analyze workload-specific data patterns to inform storage efficiency and capacity planning. Savings from data reduction techniques, such as deduplication and compression, and corresponding improvements in DRR are often realized over time, depending on the volume of data in primary storage and data-retention periods.

In a single-vendor performance validation test, we confirmed that the Data Domain All-Flash appliance is the clear leader in deduplication for storage data reduction. Dell Technologies claims that the appliance, in conjunction with Data Manager, can deliver up to a 75:1 data reduction ratio, significantly reducing storage requirements. The appliance implements block-level deduplication, comparing data in segments of variable length (8 KB on average) to detect and eliminate block-level redundancy.

The steps performed for this DRR test were identical to steps 1–9 above, with the addition of a tenth step:

- 10. From the Data Manager dashboard, review the Total Data Reduction metric to determine the data reduction of the Data Domain 9910F All-Flash appliance.

The results from our testing (shown in Figure 4) demonstrate that the Data Domain All-Flash appliance increased its DRR to a 78:1 deduplication rate after seven days and to 126:1 after 14 days, exceeding expectations throughout the testing period as backup data expanded.

Data Reduction Performance Over Time



Figure 4 | Our research confirmed that the Dell PowerProtect Data Domain All-Flash appliance increased its data deduplication rate over a 14-day period, leading to lower storage costs and faster backup and recovery; some backup software vendors recommend that organizations archive older or infrequently accessed data from backup arrays to cold storage after 14 days to free high-performance storage capacity, reduce costs, and optimize long-term data retention

High deduplication efficiency can improve long-term storage requirements by eliminating data blocks in files with high redundancy, lowering costs through more efficient use of physical capacity. Data Domain Boost (DD Boost) is a communication protocol that enables client-side backup processing, such as deduplication and compression. This improves performance and reduces network bandwidth consumption alongside the storage efficiency provided by Data Domain. Variable-length deduplication further improves efficiency by identifying redundancy at a finer granularity, maximizing space utilization and effective capacity.

Restore Performance Validation

As part of our evaluation, our engineers conducted a restore-performance validation test of the Data Domain All-Flash appliance. We checked recovery times and validated restore speeds of up to 51 TB/hour per 500 TB system for a single Data Domain All-Flash appliance (currently only available in the 500 TB size).

Our testing restored 90 VMs from compressed and deduplicated backup images, four 3.5 TB network-attached storage (NAS) datasets, and ten 1 TB Microsoft® SQL Server® databases (10 TB total) from a single Data Domain All-Flash appliance using the Data Manager software, targeting multiple primary storage destinations:

1. VM image data to all-flash Fibre Channel (FC) datastore logical unit numbers (LUNs)
2. NAS data to a Dell PowerStore 5200T storage appliance
3. Multiple SQL Server databases to a Dell™ PowerEdge™ R760 server running SQL Server (using the SQL Server plugin from Data Manager)

The following are the high-level steps we used to validate the achieved throughput of up to 51 TB/hour per 500 TB system:

1. Configure a full backup of the following content to the Data Domain 9910F All-Flash appliance:
 - a. 90 VMs with varying sizes of virtual hard disks
 - b. Four NAS shares at 3.5 TB each
 - c. 10 SQL Server databases of 1 TB each, all located on a single physical Windows Server environment
2. Once the full backup is completed, use the following steps to restore the content:
 - a. From a pre-prepared script that issues API calls to the Data Manager, restore the previously backed up VMs, NAS shares, and SQL Server databases.
 - b. From the Data Manager user interface (UI), browse to Jobs > Projection Jobs to watch the restore process.
 - c. From the Data Manager command-line interface (CLI), run the following command to collect statistics:

```
ddboost show stats interval 1
```

It is important to note that the observed performance does not represent maximum achievable performance, and it is constrained by the tested configuration. Our results reflect performance observed in this specific test configuration and workload and should not be interpreted as a guarantee of performance or efficiency in other environments.

Our tests validated the capabilities of the Data Domain All-Flash appliance as a backup target, capable of meeting recovery point objectives (RPOs) and recovery time objectives (RTOs), key disaster-recovery metrics that also support cyber resiliency by limiting data loss and downtime in the event of a cyber incident.



Restore at blazing speed: up to
51 TB/hour per 500 TB system

Key Takeaways

Data-reduction technologies implemented in all-flash arrays significantly improve storage efficiency by increasing effective capacity and reducing the physical resources required to restore data. By lowering required rack space and power and cooling requirements, these efficiencies can translate into reduced capital and operating expenditures, ultimately improving total cost of ownership (TCO) while maintaining consistent performance.

Our evaluation showed that the Data Domain All-Flash appliance achieved greater effective capacity than four leading competitive backup storage solutions, which used up to 3.8x more space when tested with the same workload. Based on our testing and research, the Data Domain All-Flash appliance continues to offer higher efficiency for many organizations, driven by its deduplication effectiveness, storage savings, and faster restore throughput. With the growing demands of AI infrastructure, enterprises can use the additional capacity provided by Dell Technologies solutions to support the compute, storage, and networking resources needed for advanced technologies today.

Visit the Dell Technologies site for more information on the [Data Domain](#) All-Flash appliance.

Endnotes

¹ Based on Prowess Consulting's testing and analysis as of December 2025.

² Based on Prowess Consulting's testing of the Dell Technologies claim of up to a 75:1 data reduction ratio. December 2025. Actual results may vary.

³ "Immutability" is subject to the terms and limitations set forth in the Legal Notices and Disclaimers section.

⁴ Dell Technologies. "[Dell PowerProtect Data Domain Cybersecurity Framework and Zero Trust Architecture](#)." November 2024.

⁵ Dell Technologies. "[Dell PowerProtect Data Domain](#)." 2025.



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