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Modernizing mission-critical storage

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Executive summary

As organizations face challenges such as exploding data volumes, performance bottlenecks, rising operational costs, and evolving security and compliance needs, there is a push to implement innovative storage architectures and strategies to not only meet today's requirements but to anticipate evolving needs. This document analyzes current pain points — including cost concerns, data protection issues and operational complexities — and pairs them with emerging modern storage platforms that have high-availability, hybrid cloud storage support and AI-driven management capabilities.

Key findings

- Data growth and high costs are top challenges for enterprise storage, requiring organizations to maximize the value of their storage investments and prioritize scalable and multipurpose storage. In a recent 451 Research survey, organizations estimated, on average, that the volume of data under management is growing by 28% annually.
- Most organizations have experienced a costly outage that has had a major impact on their business, highlighting the importance of resiliency and consistency for mission-critical storage.
- Storage performance remains essential. One-third of respondents experienced an outage due to incidents of poor performance on storage systems including cloud storage.
- Environmental, social and governance pressures drive the need for reduced power and rack space consumption and highlight the need for longer life cycles for storage equipment.

Scalability, cost of ownership and performance challenges intensify

Organizations are increasingly pressured by rapid data expansion and rising operational costs. New workloads and multiple data silos strain storage infrastructures, while difficulties in recruiting and retaining skilled staff further elevate operational expenses. Concurrently, insufficient storage performance disrupts productivity, revenue and customer satisfaction and could delay adoption of new workloads such as generative AI. In 451 Research's Voice of the Enterprise (VotE): AI & Machine Learning, Infrastructure 2025 study, a large segment of respondents said they plan to develop AI/ML workloads at least partially on-premises in the next 12 months — 18% said they'll do so exclusively on-premises, 32% said mainly on-premises with some public cloud usage, and 31% said mainly in public cloud with some on-premises. Only 19% said their new workloads would be developed solely in the public cloud, highlighting the necessity of addressing storage concerns across on-premises, cloud and hybrid environments.

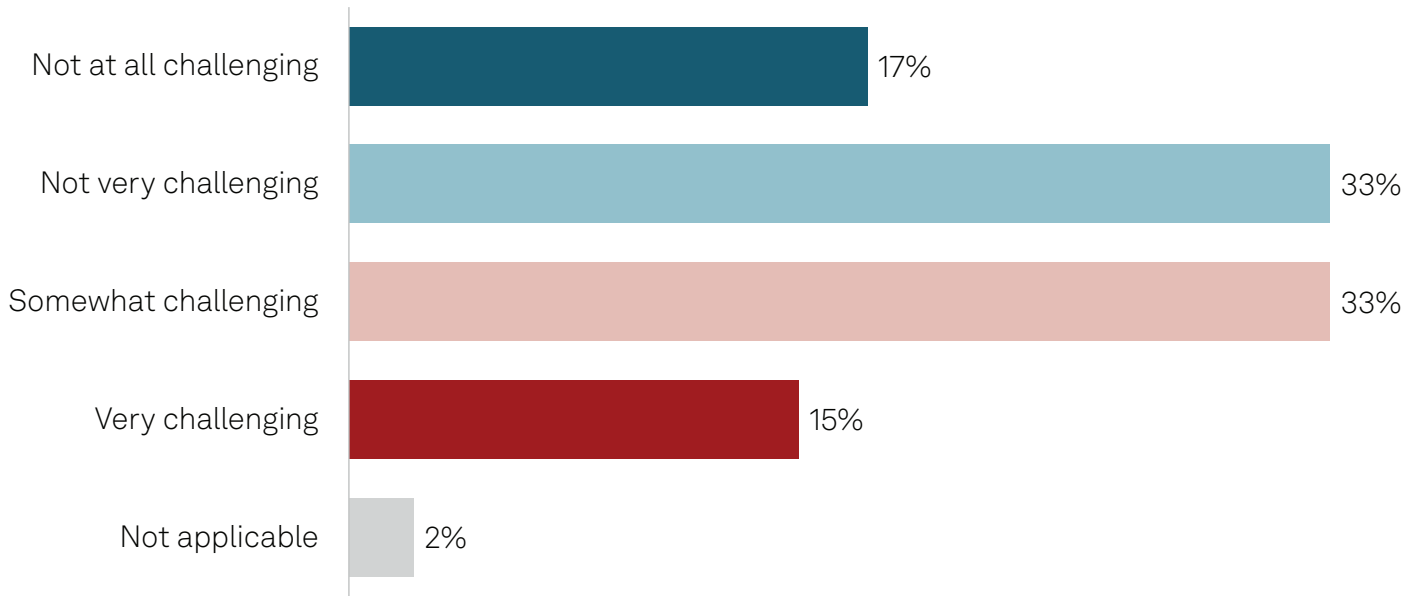
Data growth and operational costs are top challenges

In today's data-driven landscape, organizations are grappling with the dual challenge of rapid data growth and rising operational costs. According to our VotE: Storage, Budgets 2025 survey, the volume of enterprise data under management is growing at an estimated average annual rate of 28%. This rapid growth significantly impacts almost all organizations, forcing IT decision-makers to rethink their storage strategies.

The primary driver behind this data explosion is the emergence of new workloads. As organizations adopt advanced technologies and methods such as AI, internet of things and big-data analytics, the volume of data generated is increasing at an unprecedented pace. This surge in data is associated with numerous challenges, including the complexity of managing multiple data silos. Handling disparate data sources becomes tiresome for IT teams, leading to inefficiencies and increased operational burdens. In the VotE: AI & Machine Learning, Infrastructure 2025 study referenced above, 54% of respondents strongly agreed that "Our ML infrastructure gives our organization a competitive edge," while just 1% disagreed, reflecting broad expectations that investments in storage and other infrastructure assets that support AI projects will be justified by delivering business value.

Difficulty hiring and retaining skilled staff exacerbates operational costs. As demand for expertise in managing complex storage infrastructures increases, organizations face a competitive labor market. Talent shortage not only strains existing resources but also contributes to higher operational expenditures because organizations are compelled to offer competitive salaries and benefits. In the same VotE: AI & Machine Learning, Infrastructure study, 48% of respondents rated on-premises storage and data protection as technically challenging (see Figure 1). This difficulty is reflected in many enterprises' efforts to improve their storage and data protection environments.

Figure 1. Many organizations struggle with storage and data protection in their AI infrastructure



Q. How would you rate your organization's experience with the following technical aspects of its ML infrastructure when on-premises? - Storage (including data protection).
Base: All respondents (n=699).
Source: 451 Research's Voice of the Enterprise: AI & Machine Learning, Infrastructure 2025.

High costs associated with power and rack space further compound operational challenges. As organizations scale their storage capabilities to accommodate growing data volumes, the need for efficiency becomes paramount. Rising costs of energy and physical infrastructure amplify the urgency for organizations to optimize their storage strategies, ensuring they can manage their resources effectively while minimizing expenses.

Performance still matters

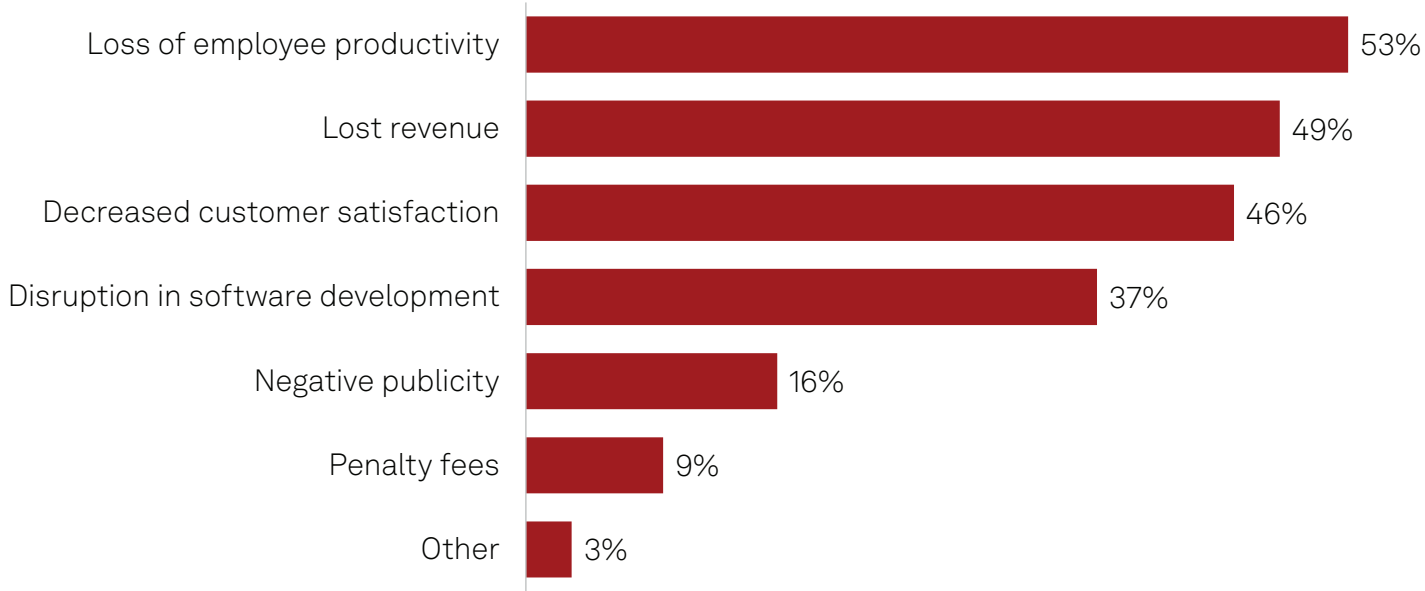
While managing data growth and operational costs is critical, performance remains a key consideration for organizations. Alarmingly, poor storage performance has negatively impacted approximately one-third (32%) of organizations surveyed. In an era where speed and efficiency are crucial, performance consistency is increasingly in demand.

High throughput is essential, particularly for use cases involving AI, data protection and large volumes of unstructured data. These applications require robust storage solutions capable of handling significant data loads without compromising performance. For mission-critical workloads and structured data workloads, which often involve heavy transaction loads, metrics such as input/output operations per second and low latency become especially important. Given that appliances and workloads are evolving rapidly, storage platforms with the flexibility to simultaneously handle high transaction volumes and high-throughput use cases will greatly boost storage utilization and alleviate the data silo problem.

Negative impacts of poor performance

The repercussions of inadequate storage performance extend beyond mere inconvenience (see Figure 2). In our study, organizations reported a range of negative impacts including lost productivity, which can hinder operational efficiency. When storage systems fail to perform optimally, employees may face delays in accessing critical data, leading to wasted time and resources. Furthermore, lost revenue is a significant concern. For many organizations, the ability to process transactions swiftly and efficiently is directly tied to their bottom line. For example, delays in data access can result in missed sales opportunities, ultimately affecting profitability.

Figure 2: Consequences of poor storage performance



Q. What was the result of the slow storage performance incident? (Please select all that apply.)
Base: Respondents whose organizations have been impacted by slow performance from storage services (n=68).
Source: 451 Research's Voice of the Enterprise: Storage, ESG Attitudes 2024.

Poor storage performance also affects customer experience. In today's competitive landscape, organizations must prioritize delivering seamless and responsive services to retain customer loyalty. When customers encounter delays or issues due to storage inefficiencies, their satisfaction diminishes, leading to potential churn.

Additionally, organizations may face financial repercussions in the form of service-level agreement (SLA) penalty fees. Many organizations commit to specific performance standards in their SLAs, and failure to meet these benchmarks can result in costly penalties.

For newer workloads such as GenAI, poor performance and the inability to quickly locate relevant data will negatively impact the entire AI workflow including training, inference and retrieval-augmented generation. This could lead to inaccurate responses and poor customer satisfaction with GenAI outputs.

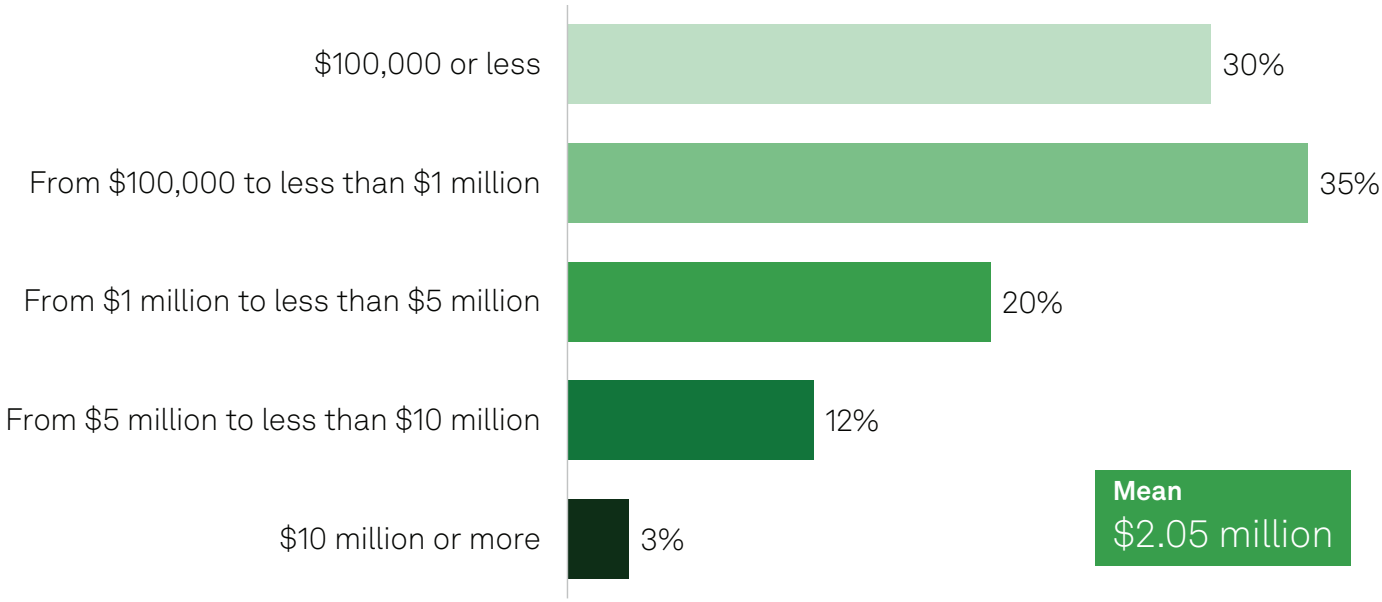
Cybersecurity threats and other outages have a deep impact

Organizations increasingly rely on technology to operate efficiently and effectively. However, the prevalence of outages — whether due to cybersecurity threats or other causes — poses significant risks to business continuity and financial stability.

Outages are common and costly

According to recent findings, outages are not just an occasional inconvenience; they are a frequent occurrence that can have devastating financial implications. On average, respondents report that each outage costs their organization over $2 million (see Figure 3). This figure highlights the need for robust contingency planning and risk management strategies.

Figure 3: Outages are costly



Q. Please estimate the total cost to your organization of its most recent outage or downtime (from outage to full recovery, including direct costs, opportunity costs, etc.).
Base: Excluding respondents who were unable to provide outage or incident costs (n=240).
Source: Voice of the Enterprise: Storage, Disaster Recovery 2025.

The financial burden of outages extends beyond immediate costs. Organizations often face reputational damage, loss of customer trust and potential legal ramifications, all of which can have long-term impacts on profitability. IT decision-makers must understand the ramifications of outages and develop comprehensive strategies for mitigation.

Outage recovery remains difficult

Despite advancements in technology and recovery solutions, recovering from outages remains a formidable challenge. Many organizations struggle with lengthy recovery times, which can exacerbate the financial impact of an outage. The complexities involved in restoring services and systems can lead to extended downtime, further compounding the costs associated with an incident.

Moreover, the recovery process often requires significant personnel and technology resources. IT teams must be prepared to respond swiftly and effectively to minimize disruption, yet many organizations lack the training or tools to do so. This gap underscores the importance of investing in both technology and human capital to enhance outage recovery capabilities.

Security incidents are a leading cause of outages

Security incidents have emerged as a leading cause of outages. In our VotE: Storage, Disaster Recovery 2025 survey, 23% of respondents cited a security issue as the cause of their most recent outage. Cyberattacks — ranging from ransomware to data breaches — can halt an organization's operations, making it imperative for decision-makers to prioritize cybersecurity measures.

The increasing sophistication of cyberthreats means that organizations cannot afford to be complacent. Regular security assessments, employee training and the implementation of advanced security technologies are essential components of a proactive approach to cybersecurity. By addressing vulnerabilities before they can be exploited, organizations can significantly reduce the likelihood of outages caused by security incidents.

Cloud outages are becoming more significant

As organizations continue to migrate to cloud-based solutions, the significance of cloud outages is becoming increasingly apparent. In the Disaster Recovery study cited above, 19% said a cloud or SaaS failure led to their most recent outage. While cloud services offer numerous advantages, including scalability and flexibility, they also introduce vulnerabilities. Outages in cloud services can disrupt not only the affected organization but also its customers and partners, leading to a ripple effect of consequences.

Reliance on third-party providers for critical services necessitates a renewed focus on vendor management and contingency planning. Organizations must ensure that their cloud service providers have robust outage response plans and are prepared to communicate effectively during an incident. Additionally, organizations should consider multicloud strategies to mitigate the risks associated with reliance on a single provider.

The impact of cybersecurity threats and other outages is profound and warrants the attention of IT decision-makers. By understanding the costs associated with outages, recognizing the challenges of recovery, addressing security incidents and managing cloud risks, organizations can better equip themselves to navigate the complexities of today's technology landscape.

Requirements for modern mission-critical storage

Modern enterprise storage solutions are evolving rapidly to meet increasing demands for speed, reliability and scalability. As organizations grapple with the challenge of managing vast data volumes, advancements in technology are reshaping how data is stored, accessed and secured. When evaluating options for modernizing mission-critical storage, organizations should consider the following attributes:

Guaranteed eight-nines availability

For mission-critical environments, availability is typically the top requirement because the cost of outages for these workloads would likely far exceed the cost of systems, maintenance and operations to keep them running. In extreme cases, such outages could lead a company to dissolve or trigger severe penalties or leadership terminations. Given variations in the market — e.g., some vendors only provide up to six-nines availability — organizations must choose solutions that meet their recovery point and recovery time objectives.

With the rise of ransomware and other cyberthreats, organizations should consider not only data availability guarantees, but also whether a vendor offers zero-data-loss capabilities such as synchronous replication, immutable snapshots and backups, which can facilitate rapid recovery should an incident occur.

Data reduction guarantee

Storage efficiency guarantees, initially used to justify the purchase of costly all-flash arrays, have become more common over the past decade. Today, organizations may expect to see guarantees for reduction at a 4:1 or 5:1 ratio, which facilitate storage of data exceeding the raw capacity of the system. Notably, not all guarantees are equal, and some policies may have conditions that could invalidate a reduction claim based on the type of workload and data stored, such as for large media files that may be poor candidates for deduplication. Guarantee programs without constraints can help keep pace with a customer's data growth or agility requirements, regardless of potential changes in data or workload type.

Common OS and unified management interface

Using a consistent control plane can cut down training time and reduce operational errors. With a common operating system and management interface, organizations can also facilitate policy-consistent workload mobility, allowing for movement of idle applications to free up high-performance capacity for active, high-demand workloads. Unified systems and processes can also support efforts to verify system configuration settings against established management policies. This topic is covered in greater depth in a prior report, "The Rising Data Challenges Driving Storage Modernization."

Given that many organizations favor hybrid cloud infrastructure for data protection, the ability to extend the common OS and management to the cloud will facilitate data migration and recovery between on-premises and cloud environments because both venues will have the same management tools and can leverage the same replication engine from the storage OS.

AI-enhanced management

AI-enhanced management can offer transformative benefits for organizations dealing with modern data management complexities. These management tools provide warnings, enabling organizations to be proactive in identifying potential issues before they escalate into critical problems. This approach enhances system reliability and minimizes downtime, safeguarding business continuity. Additionally, AI-driven systems analyze usage patterns and performance metrics to offer optimization suggestions, leading to cost reductions by streamlining operations and eliminating unnecessary expenditures.

AI-enhanced management systems are also designed to handle large estates with minimal staff, which is crucial in a competitive labor market where skilled IT personnel are in high demand. By automating routine tasks and providing intelligent insights, these systems empower leaner teams to manage extensive and complex storage environments effectively. Compatibility with hybrid cloud infrastructures ensures that AI management tools can operate seamlessly across both on-premises and cloud-based systems, which is essential for organizations adopting hybrid cloud strategies to balance performance, cost and scalability. Furthermore, the integration of a comprehensive tools ecosystem that supports third-party integrations ensures a cohesive and efficient IT environment, bolstering the value of AI-enhanced management systems in contemporary enterprise storage solutions.

Aggressive storage media adoption

Flash and hard drive storage media continue to evolve, which gives an advantage to vendors that quickly embrace new innovations, such as high-capacity NVMe TLC SSDs (non-volatile memory express, triple-level cell solid-state drives). Systems using the latest storage media can reduce their power and cooling needs and physical footprint while providing high storage capacity, enabling cost-effective expansion and improved performance in dense environments. Organizations that prioritize these factors will want to look for vendors that offer high-density storage, as measured in terabytes of capacity per rack unit.

Support for both open and mainframe workloads

Broad platform support allows companies to consolidate heterogenous workloads on one platform, which can simplify operations while providing the necessary storage protocol support and isolation between open and mainframe environments.

Scalability across multiple dimensions

Multidimensional scalability allows for significant performance and capacity expansion to accommodate growing business demands, ensuring that storage solutions remain future-proof. Platforms with high scalability for block, file and object storage will have consolidation benefits to help organizations eliminate storage silos in their data center environment. The ability to scale up with improved controllers or scale out using additional nodes (common for network-attached and object storage) should be evaluated to ensure a storage solution will be able to handle future challenges.

Cybersecurity resiliency

Ransomware and malware detection have become common features in modern storage systems. These functions can proactively find and halt attacks before they lead to significant downtime. Customers should also evaluate a system's immutable storage capabilities since snapshots and backup repositories are key recovery assets that are now being targeted by cybersecurity threats.

Federal Information Processing Standard (FIPS) compliance at the system or device level can provide independent validation and streamline audits; it is often mandatory in regulated sectors. System-level certification providers offer broader assurances compared with device-only claims.

Figure 4: Storage value propositions and why they matter

Value proposition	Why it matters
Guaranteed eight-nines availability	Minimizes downtime risk, ensuring almost uninterrupted operations for mission-critical workloads and enhancing overall business continuity.
Data reduction guarantee	Offers predictable capex, reduces physical storage requirements and lowers operational costs by enabling more efficient data storage and management.
Common storage OS and unified management interface	Simplifies training and operations by providing a consistent interface to manage data services and storage capabilities across on-premises and cloud environments, minimizing complexity and reducing errors.
AI-enhanced management	Provides proactive warnings and recommendations that can improve reliability and optimize utilization. Organizations with staffing shortages can benefit from these advanced tools to bridge skill gaps.
Aggressive storage media adoption	Hard drives, flash and other storage media are constantly evolving, which gives vendors that are quicker to adopt innovations an advantage in the form of reduced floor space, power consumption and cooling requirements.
Scalability across multiple dimensions	Scalability for block, file and object storage will have consolidation benefits, helping organizations eliminate storage silos. Organizations should also evaluate system performance, scalability and upgradability.
Support for both open and mainframe workloads	Enables workload consolidation on a single system, simplifying management and reducing the need for multiple specialized systems.
Cybersecurity resiliency	Beyond traditional snapshots and replication, organizations need various tools to improve the resiliency and recoverability of their environments, such as immutable storage, ransomware detection and FIPS-compliant security.

Source: S&P Global Market Intelligence 451 Research.

Conclusions

Organizations face mounting pressure from expanding data volumes, performance bottlenecks, escalating operational costs, and evolving security and resiliency requirements. These challenges demand a fundamental shift toward modern storage architectures that address current operational needs while providing flexibility to support emerging workloads such as AI and machine learning applications.

To address these challenges, organizations should prioritize storage platforms that deliver guaranteed high availability, proven data reduction capabilities and unified management interfaces. Implementations can benefit from aggressive adoption of advanced storage media, comprehensive workload support spanning both open systems and mainframe environments, and multidimensional scalability across block, file and object storage protocols. Additionally, regulatory compliance through system-level FIPS certification ensures audit readiness and supports compliance in regulated sectors.

Investment in these modern storage capabilities can transform infrastructure from a cost center into a competitive differentiator. Organizations that implement platforms with guaranteed availability, automated management and flexible scaling capabilities position themselves to capitalize on emerging technology opportunities while minimizing operational risks. The key to success lies in selecting solutions that consolidate disparate storage silos, reduce operational complexity and provide the performance consistency required for mission-critical applications. By focusing on these fundamental requirements, enterprises can build storage infrastructures that support both current operational demands and future business growth initiatives.

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Henry Baltazar is research director of the 451 Research Storage channel within S&P Global Market Intelligence, with a focus on data storage. In his current role, Henry analyzes the market trends around environmental, social and governance (ESG) storage challenges, infrastructure modernization and resiliency. He publishes reports on trends in data storage, disaster recovery and hybrid cloud. He is often cited as a subject expert by publications such as MIT Technology Review, Forbes and TechTarget.

Henry arrived at S&P Global Market Intelligence through its 2019 acquisition of 451 Research, where he began working as an analyst in August 2006. After spending three years running the storage research practice at Forrester, he returned to 451 Research in 2015 to fill the research director role and lead the storage practice.

Henry graduated from the University of California, Berkeley with a bachelor's degree in environmental sciences.

About this paper

A Pathfinder paper navigates decision-makers through the issues surrounding a specific technology or business case, explores the business value of adoption, and recommends the range of considerations and concrete next steps in the decision-making process.

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