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Analysis of SSD usage for performance improvement on the Asus TUF FX505DU

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Abstract

Storage subsystems often become the bottleneck in modern laptops, especially when applications generate high I/O demand. This study evaluated the performance impact of replacing a 5400 rpm HDD with an NVMe SSD in an Asus TUF FX505DU laptop. A qualitative descriptive approach was used by combining literature review, an interview with a computer technician, and controlled benchmarking on the same hardware platform. Four tools were employed: ATTO Disk Benchmark, AS SSD Benchmark, HD Tune Pro, and Cinebench 2024. The SSD demonstrated substantially higher sequential throughput and significantly lower access latency than the HDD; HD Tune Pro reported an average read rate of 660.5 MB/s for the SSD compared with 4.5 MB/s for the HDD, with access time reduced from 95.1 ms to 0.251 ms. Application-related results also improved, including a higher GPU score in Cinebench. However, some CPU-related metrics did not improve and the SSD scenario showed higher CPU utilization during storage testing, indicating that faster I/O could shift the bottleneck to computation. Overall, the results confirmed that SSD adoption markedly improved laptop responsiveness and data access performance, and it was recommended as the primary storage option for modern workloads.

Keywords: Solid-state drive; Hard disk drive; Benchmarking; Laptop performance.

1. Introduction

Information technology and personal computing have become central to daily activities, including document processing, online learning, multimedia creation, software development, and gaming. As software workloads become more data-intensive, laptop performance is no longer determined only by the processor, memory, or graphics card. The storage subsystem also plays an important role because it affects boot time, application launch, file access, data transfer, and system responsiveness. Recent storage studies have shown that modern workloads increasingly depend on low-latency and high-throughput storage systems, especially when applications generate frequent input/output (I/O) requests [1], [2], [3]

Hard disk drives (HDDs) store data using rotating magnetic platters and mechanical read/write heads. Although HDDs remain useful because of their large capacity and relatively low cost, their performance is limited by seek time, rotational delay, and lower random I/O capability. These limitations make HDDs less suitable for modern workloads that require frequent access to many small files. Solid-state drives (SSDs), on the other hand, use flash memory and electronic controllers, allowing data to be accessed without mechanical movement. As a result, SSDs generally provide higher throughput, lower latency, and better responsiveness than conventional HDDs [1], [4], [5].

The development of NVMe-based SSDs has further improved storage performance by supporting parallel I/O queues, optimized data transfer, and more efficient communication between storage devices and the host system [6], [7]. Several recent studies also show that SSD performance is strongly influenced by internal mechanisms such as cache management, address mapping, flash translation layers, and controller-level optimization [8], [9], [10], [11]. Therefore, evaluating SSD performance should not only focus on sequential read/write speed, but also include random access performance, access latency, and system-level benchmark behavior.

Previous studies have compared HDD and SSD technologies from different perspectives, including read/write performance, storage architecture, flash-memory management, and future storage trends [1], [2], [4], [5]. However, practical performance evaluation on a specific laptop platform is still relevant because the actual benefit of an SSD upgrade depends on hardware configuration, operating system behavior, benchmark workload, and possible system bottlenecks. A storage upgrade may significantly improve I/O performance, but it does not necessarily improve all computing metrics, especially CPU-oriented performance.

This study compares the performance of an HDD and an SSD installed on the same Asus TUF FX505DU laptop. The comparison was conducted using ATTO Disk Benchmark, AS SSD Benchmark, HD Tune Pro 5.75, and Cinebench 2024. The novelty of this study lies in its practical evaluation of SSD usage on a real laptop platform by combining storage-oriented benchmarks and application-related benchmark indicators. The results are expected to provide practical insight into whether replacing an HDD with an SSD can improve laptop responsiveness and overall user experience.

2. Material and methods

This research used a descriptive comparative approach by evaluating storage performance before and after replacing the HDD with an SSD on the same laptop platform. The descriptive approach was selected because the study aimed to interpret benchmark results, compare measurable performance indicators, and explain the observed differences based on the technical characteristics of HDD and SSD storage. Similar performance-evaluation studies emphasize that storage benchmarking should compare devices under controlled conditions and interpret the results in relation to workload behavior, latency, throughput, and I/O characteristics [4], [6], [11], [12].

Benchmark testing was conducted on an Asus TUF FX505DU laptop. Two storage devices were evaluated: a Toshiba MQ01ABF050 500 GB HDD and an Intel SSDPEKNW512G8 512 GB SSD. The benchmark was performed on the same hardware platform to reduce variation from other components such as processor, memory, graphics card, and operating system. This comparison design allows the observed performance differences to be interpreted mainly as the effect of storage-device replacement. The test-bed specification is presented in Table 1.

Table 1: Hardware specifications of the test-bed

No	Device	Specifications
1	Asus TUF FX505DU	Processor: AMD Ryzen 5 3550H Cores/Threads: 4 cores, 8 threads @ 2.1 GHz GPU: NVIDIA GeForce GTX 1660 Ti OS: Windows 11 (64-bit)
2	HDD Toshiba MQ01ABF050 (500 GB)	Rotation speed: 5400 rpm Internal transfer speed: 638.9–1288.6 Mbit/s
3	SSD Intel SSDPEKNW512G8 (512 GB)	Sustained read: 1500 MB/s Sustained write: 1000 MB/s

The use of multiple benchmark tools was intended to provide a broader understanding of storage performance. Sequential benchmarks are useful for observing large file transfer capability, while random 4K tests are more representative of daily operating-system and application workloads, where many small files are accessed repeatedly. Recent SSD studies show that random I/O, cache behavior, parallel request handling, and latency are important indicators for evaluating modern SSD performance [8], [9], [10], [11], [13]. Therefore, combining ATTO, AS SSD, HD Tune Pro, and Cinebench allows the analysis to cover both storage-specific behavior and application-related performance.

A literature review was also conducted to support the theoretical explanation of HDD and SSD characteristics, flash-memory storage systems, NVMe architecture, cache management, storage abstraction, and system-level performance behavior [1], [2], [3], [4], [5], [6], [7]. In addition, a non-structured interview with a computer technician was used to obtain practical insight regarding laptop storage upgrades and common performance changes observed by users after replacing HDDs with SSDs.

For data analysis, the benchmark results from the HDD and SSD were compared side-by-side. The analysis focused on identifying differences in sequential throughput, random-access performance, access time, CPU usage, and application-related benchmark scores. The results were then interpreted using relevant storage-system literature to explain why SSDs provide higher performance in I/O-heavy workloads and why some system metrics may not improve directly after a storage upgrade [3], [12], [14], [15].

3. Results and discussion

Benchmarking was conducted on the Asus TUF FX505DU using the two storage devices described in Table 1. Table 2 summarizes the key results from each benchmark tool. Subsequent sub-sections discuss the results in more detail.

Table 2: Summary of benchmark results for HDD and SSD

No	Benchmark tool	HDD	SSD
1	ATTO Disk Benchmark	Write: 64.932 MB/s Read: 63.287 MB/s	Write: 559.180 MB/s Read: 1023.031 MB/s
2	AS SSD Benchmark	Read score: 8 Write score: 8 Overall score: 20	Read score: 484 Write score: 327 Overall score: 1015
3	HD Tune Pro 5.75	Average read: 4.5 MB/s Access time: 95.1 ms CPU usage: 4.5%	Average read: 660.5 MB/s Access time: 0.251 ms CPU usage: 16.6%
4	Cinebench 2024	GPU: 2129 pts CPU (multi-core): 105 pts CPU (single-core): 22 pts MP ratio: 4.69×	GPU: 2663 pts CPU (multi-core): 63 pts CPU (single-core): 21 pts MP ratio: 2.95×

Overall, the SSD produced substantially higher performance than the HDD in storage-related benchmarks. This result is consistent with the technical characteristics of SSDs, which use flash memory and electronic controllers instead of mechanical platters and read/write heads. Recent studies have also reported that SSDs provide better performance than HDDs because they reduce mechanical delay, improve data-transfer efficiency, and support more advanced I/O handling mechanisms [1], [4], [5], [10].

ATTO Disk Benchmark

ATTO Disk Benchmark was used to evaluate sequential read and write performance across different transfer sizes. Figures 1 and 2 show the benchmark results for the HDD and SSD, while Table 3 presents the average sequential throughput. The HDD achieved an average write speed of 64.932 MB/s and an average read speed of 63.287 MB/s. In comparison, the SSD achieved an average write speed of 559.180 MB/s and an average read speed of 1023.031 MB/s.

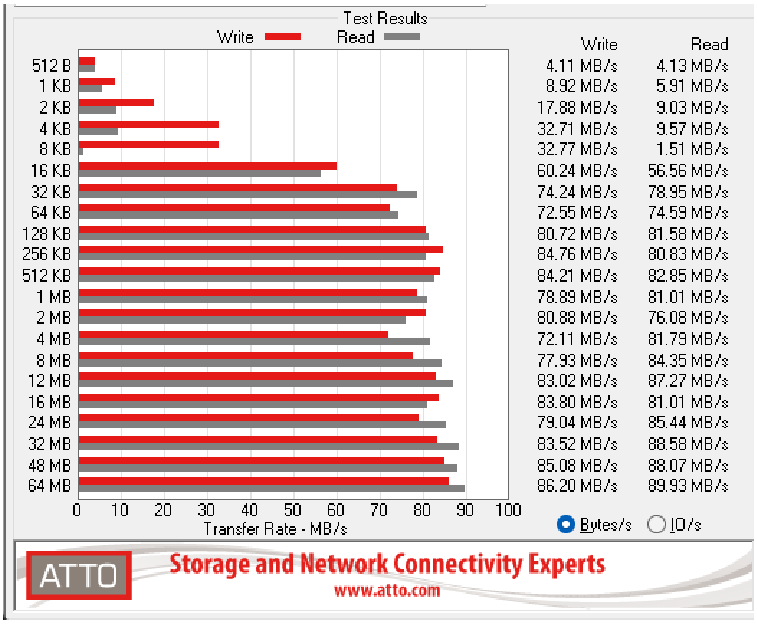

Figure 1: ATTO Disk Benchmark result (HDD)

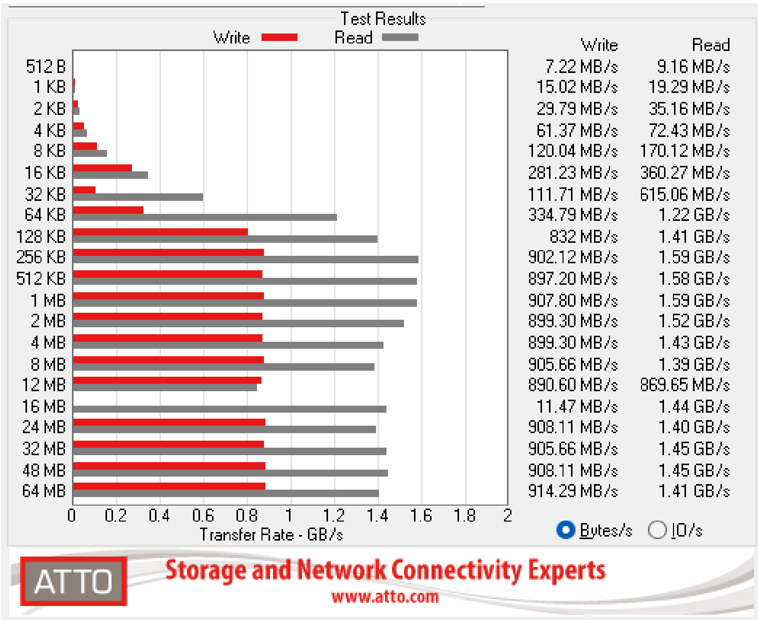

Figure 2: ATTO Disk Benchmark result (SSD)

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Table 3: ATTO Disk Benchmark average sequential throughput

Metric	HDD (MB/s)	SSD (MB/s)
Write (average)	64.932	559.180
Read (average)	63.287	1023.031

Based on Table 3, the HDD achieved an average write speed of 64.932 MB/s and an average read speed of 63.287 MB/s. In comparison, the SSD achieved an average write speed of 559.180 MB/s and an average read speed of 1023.031 MB/s. This means that the SSD produced approximately 8.61 times higher write performance and 16.16 times higher read performance than the HDD.

The large performance difference is mainly caused by the different architecture of HDD and SSD storage. HDDs require mechanical movement to position the read/write head before accessing data. This mechanism creates delay, especially when the device must read or write data from different physical locations on the disk. SSDs do not have this limitation because data is accessed through flash-memory cells and managed electronically by the controller [1], [5]. Therefore, SSDs can provide higher sequential transfer rates and faster response during large data transfers.

The ATTO result is consistent with Wang [4], who reported that SSDs provide higher read/write performance than HDDs under different data-block and workload scenarios. Recent studies on flash-memory storage systems also explain that SSDs are designed to deliver higher bandwidth and lower latency than mechanical storage devices [1], [2]. In this study, the SSD advantage was particularly clear in read performance, which is important for booting the operating system, opening applications, loading games, installing software, and accessing large multimedia files.

From a practical perspective, the ATTO results show that replacing the HDD with an SSD can significantly improve the user experience on the Asus TUF FX505DU. Users are likely to experience faster file transfers, shorter application loading times, and better overall responsiveness. Therefore, the SSD upgrade can be considered an effective method for improving laptop performance without replacing other major components such as the processor, memory, or graphics card.

AS SSD Benchmark

AS SSD Benchmark was used to evaluate sequential performance, random 4K performance, multi-threaded 4K performance, access time, and overall storage score. Figures 3 and 4 show the AS SSD Benchmark results for the HDD and SSD, while Table 4 presents the read and write performance values.

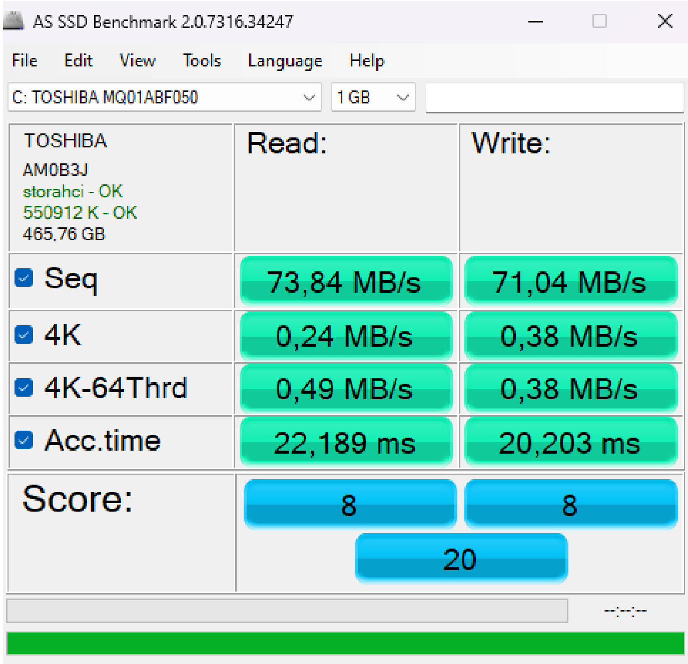

Figure 3: AS SSD Benchmark result (HDD)

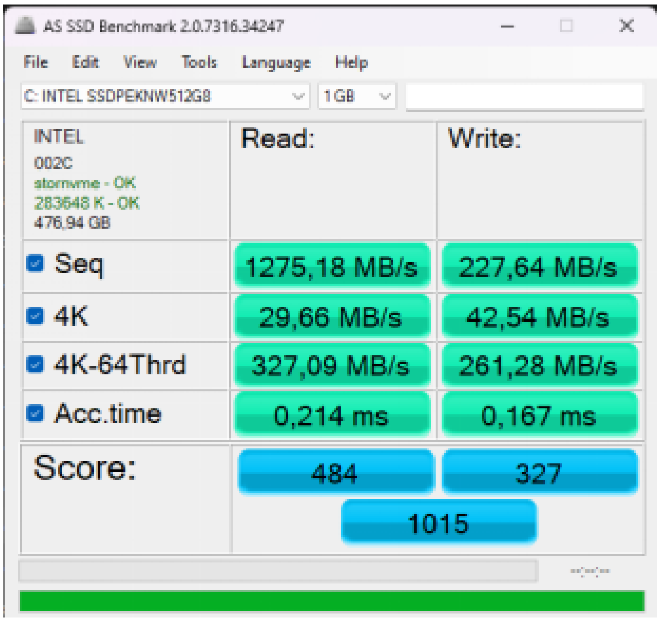

Figure 4: AS SSD Benchmark result (SSD)

Table 4: AS SSD Benchmark results (read and write)

Metric	HDD Read	HDD Write	SSD Read	SSD Write
Sequential (MB/s)	73.84	71.04	1275.18	227.64
4K (MB/s)	0.24	0.38	29.66	42.54

4K-64Thrd (MB/s)	0.49	0.38	327.09	261.28
Access time (ms)	22.189	20.203	0.214	0.167
Score	8	8	484	327
Overall score	-	20	-	1015

The SSD outperformed the HDD in all AS SSD Benchmark categories. In sequential read performance, the SSD reached 1275.18 MB/s, while the HDD only reached 73.84 MB/s. In sequential write performance, the SSD achieved 227.64 MB/s compared with 71.04 MB/s on the HDD. These results confirm that the SSD provides much higher sequential throughput than the HDD.

The most significant difference appeared in the random 4K and 4K-64Thrd tests. The HDD achieved only 0.24 MB/s in 4K read and 0.38 MB/s in 4K write, while the SSD achieved 29.66 MB/s and 42.54 MB/s, respectively. In the 4K-64Thrd test, the SSD achieved 327.09 MB/s read and 261.28 MB/s write, whereas the HDD remained below 1 MB/s. This result shows that the SSD was much more capable of handling random and parallel I/O workloads.

Random 4K performance is highly relevant to daily computing because operating systems and applications frequently access many small files, such as system libraries, browser cache, application components, and temporary files. HDDs perform poorly in this condition because each random access may require physical head movement. SSDs can access small data blocks more quickly because they use flash memory and controller-based data mapping [1], [10], [13].

The high 4K-64Thrd result also reflects the ability of SSDs to handle multiple I/O requests more efficiently. Recent studies on NVMe SSDs show that SSD performance can be improved through parallel I/O processing, cache management, request scheduling, and optimized controller mechanisms [10], [14]. Other studies also explain that internal cache policies and address mapping can influence SSD throughput and [8], [10], [13]. Therefore, the AS SSD results in this study are consistent with the technical characteristics of modern SSDs.

The overall score further confirms this performance gap. The HDD obtained an overall score of 20, while the SSD obtained 1015. This difference indicates that the SSD did not only improve one metric, but delivered broad improvement across sequential access, random access, access time, and multi-threaded storage performance. For users, this improvement is expected to appear as faster booting, quicker application launching, smoother multitasking, and reduced system delay during storage-heavy activities.

HD Tune Pro benchmark

HD Tune Pro was used to measure transfer-rate characteristics, access time, and CPU usage during read operations. Figures 5 and 6 show the HD Tune Pro benchmark results for the HDD and SSD, while Table 5 summarizes the measured values.

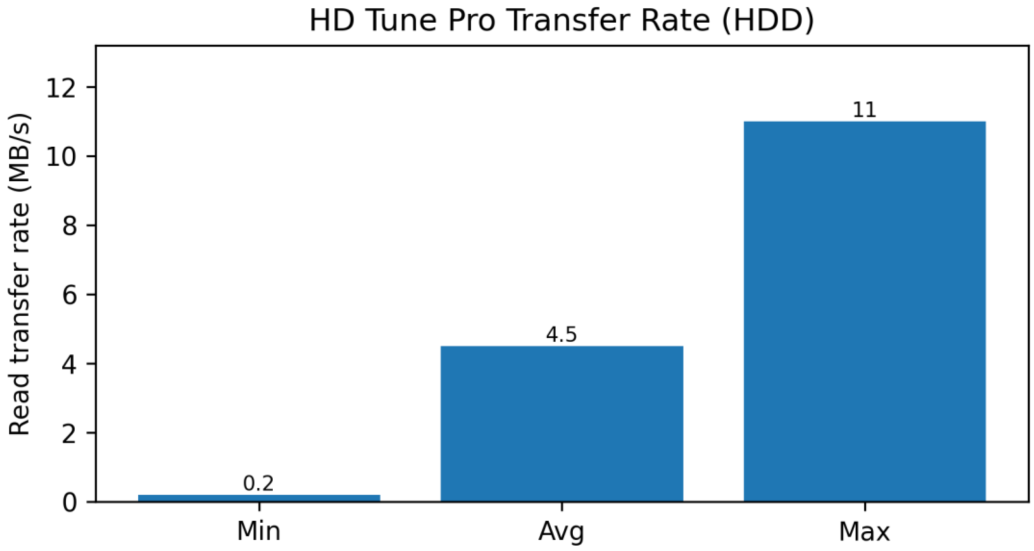

Figure 5: HD Tune Pro read benchmark result (HDD).

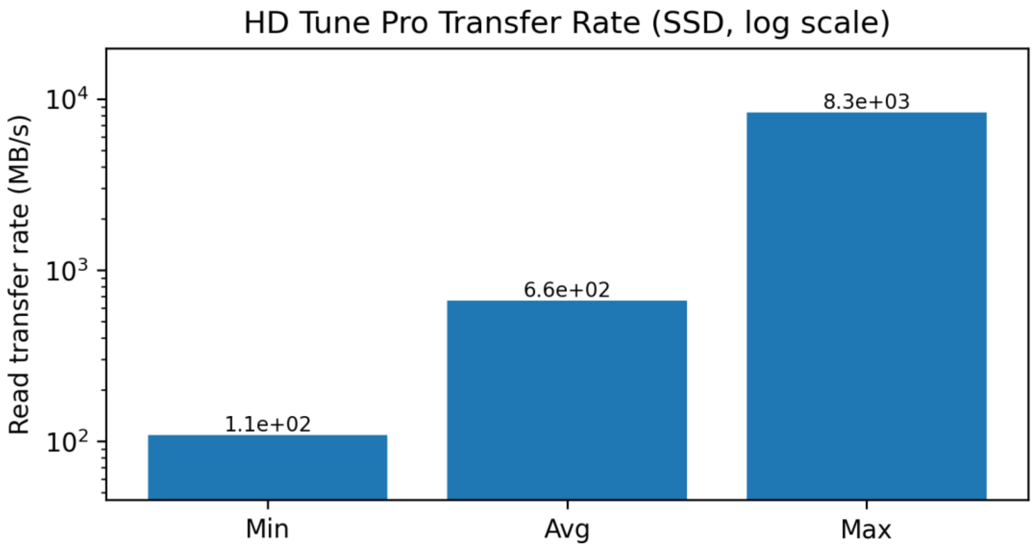

Figure 6: HD Tune Pro read benchmark result (SSD, log scale).

Table 5: HD Tune Pro results

Metric	HDD	SSD
Transfer rate min (MB/s)	0.2	108.3
Transfer rate max (MB/s)	11.0	8321.2
Transfer rate average (MB/s)	4.5	660.5
Access time (ms)	95.1	0.251
CPU usage (%)	4.5	16.6

Based on Table 5, the HDD achieved an average transfer rate of 4.5 MB/s, while the SSD achieved 660.5 MB/s. The minimum transfer rate also increased from 0.2 MB/s on the HDD to 108.3 MB/s on the SSD. In addition, access time decreased significantly from 95.1 ms on the HDD to only 0.251 ms on the SSD.

The access-time result is one of the clearest indicators of SSD superiority. Access time represents how quickly a storage device can locate and retrieve data. The HDD produced much higher access time because mechanical movement is required before data can be read. In contrast, the SSD can retrieve data almost instantly through flash-memory access. This explains why SSD-based systems usually feel more responsive, even when the processor and memory remain unchanged [1], [6].

The SSD's higher average transfer rate also confirms that it can sustain faster data movement during read operations. This result supports the ATTO and AS SSD findings, where the SSD consistently achieved higher throughput than the HDD. Recent studies on SSD performance explain that modern SSD architectures benefit from internal cache mechanisms, parallel I/O, optimized data-transfer mechanisms, and controller-level management, which help increase throughput and reduce latency [7], [9], [11].

However, the HD Tune Pro result also showed that CPU usage increased from 4.5% in the HDD test to 16.6% in the SSD test. This result should not be interpreted as a weakness of the SSD. A more reasonable explanation is that when storage becomes faster, the system spends less time waiting for I/O operations and more time actively processing data. As a result, workload activity may shift from the storage device to the CPU. This condition is consistent with recent studies showing that faster storage devices can expose performance mismatches or bottlenecks in other system components [3], [12].

Therefore, the HD Tune Pro results confirm two important findings. First, SSD installation significantly improves transfer rate and access latency. Second, storage upgrades may shift system bottlenecks rather than eliminate them completely. This means that while SSDs improve I/O responsiveness, overall system performance is still influenced by processor capability, operating-system behavior, memory, background processes, and workload characteristics.

Cinebench 2024 benchmark

Cinebench 2024 was used as an application-oriented benchmark to evaluate GPU and CPU-related performance under the HDD and SSD configurations. Figure 7 visualizes the relative results, while Table 6 presents the raw benchmark scores.

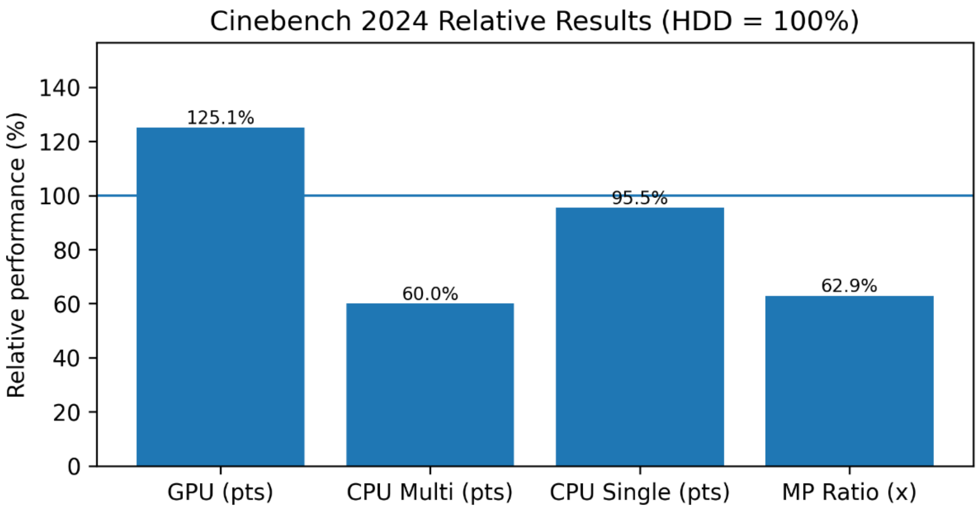

Figure 7: Cinebench 2024 relative results (HDD = 100%).

Table 6: Cinebench 2024 results

Metric	HDD	SSD
GPU (pts)	2129	2663
CPU multi-core (pts)	105	63
CPU single-core (pts)	22	21
MP ratio (×)	4.69	2.95

The GPU score increased from 2129 points in the HDD configuration to 2663 points in the SSD configuration. This indicates an improvement of approximately 25.08%. The higher GPU score may be associated with faster data access, reduced loading delay, and better data availability during application execution. Although Cinebench is not a pure storage benchmark, faster storage can still support application-level performance when workloads require file loading, asset access, or temporary data operations.

However, the CPU multi-core score decreased from 105 points in the HDD configuration to 63 points in the SSD configuration. The CPU single-core score also slightly decreased from 22 points to 21 points. This result shows that replacing an HDD with an SSD does not automatically increase raw CPU computational capability. CPU-oriented benchmark results are mainly influenced by processor performance, thermal condition, background processes, operating-system scheduling, and power-management behavior.

This finding is important because it prevents overgeneralization of SSD benefits. The SSD strongly improved storage-focused benchmarks, but CPU-oriented workloads still depend mainly on the processor and overall system condition. This interpretation is consistent with storage-system studies showing that faster storage improves I/O responsiveness but can also reveal limitations in other system components or software configurations [3], [9], [12].

Therefore, the Cinebench result should be understood as a complementary finding. SSD installation can support smoother application execution by reducing storage-related delay, but it should not be expected to directly improve every CPU benchmark score. For users, SSD upgrades are most beneficial for I/O-heavy activities such as booting, opening applications, loading games, transferring files, and multitasking, rather than purely CPU-bound computation.

Overall Discussion

The benchmark results consistently demonstrate that the SSD provided significant advantages over the HDD in storage-related performance. The strongest improvements were observed in sequential read/write throughput, random 4K performance, multi-threaded I/O, and access latency. These improvements are technically consistent with SSD architecture, which uses flash memory, electronic controllers, internal cache mechanisms, and optimized data-management strategies [1], [8], [9], [10], [11].

The findings are also consistent with previous studies comparing SSD and HDD performance. Wang [4] reported that SSDs generally provide faster read/write performance than HDDs under different workload scenarios. Recent studies on flash-memory storage systems further explain that SSDs are widely adopted because they provide higher performance, lower latency, and stronger support for modern workloads than traditional mechanical storage [1], [2], [11].

Nevertheless, the results also show that SSD installation does not improve every benchmark metric. The higher CPU usage in HD Tune Pro and the lower CPU multi-core score in Cinebench indicate that faster storage can shift the bottleneck to other system components. This supports the argument that storage performance should be evaluated as part of the entire computing system, not only as an isolated device-level measurement [3], [12].

Overall, replacing the HDD with an SSD on the Asus TUF FX505DU significantly improved data access performance and system responsiveness. The upgrade is highly beneficial for workloads involving frequent file access, application loading, operating-system booting, multitasking, and large data transfer. However, for CPU-intensive workloads, users should also consider processor capability, thermal condition, memory capacity, and background processes. Thus, SSD adoption is recommended as an effective and practical upgrade for improving laptop usability, especially in I/O-heavy workloads.

4. Conclusion

This study compared HDD and SSD storage on an Asus TUF FX505DU laptop using four benchmark tools and supporting qualitative inputs. The results showed that the SSD delivered much higher sequential throughput and dramatically lower access latency than the HDD, which directly supports faster boot, application launch, and file access behavior. While the SSD improved several application-related indicators (e.g., GPU score), some CPU benchmark scores were not higher and CPU utilization during disk testing increased, implying that faster I/O can shift the bottleneck to computation or other system factors. Overall, SSDs are recommended as the primary storage option for modern laptop workloads where responsiveness and data access speed are important. Future work should test storage devices under the same interface constraints (e.g., SATA-based HDD vs SATA-based SSD, or equal NVMe classes) and control background processes and thermal conditions to isolate performance effects more precisely.

Author contribution

Ahmad Fauzan contributed to conceptualization, benchmarking execution, data analysis, and manuscript drafting. Adly Fitra Kusuma contributed to data collection, literature review, and manuscript editing. Yuliarman Saragih contributed to supervision, methodology refinement, and manuscript review.

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