ADVANTECH

Enabling an Intelligent Planet

Performance Whitepaper by HDD

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All data in this report has been through actual verification and test. We record the data and save them in the database. Engineers will then use them to run the data analysis report. This report covers the data from every tested hard drive over a 4 year period from 2009 to 2013. The report includes analysis based on different SATA specifications, different spindle speeds, different capacities, different cache types, and different applications.

Please click the following links to view details:

1. SATA Specifications on Hard Drive Performance
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4. Cache Size to Hard Drive Efficiency
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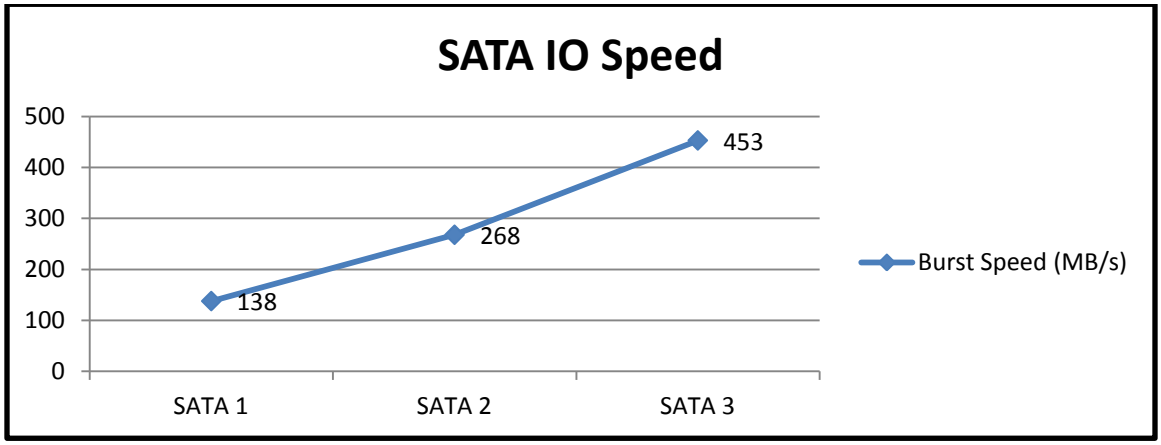
1. SATA Specifications on Hard Drive Performance

Serial Advanced Technology Attachment (SATA) is a serial interface. It replaces the previous parallel PATA interfaces. SATA increases the theoretical transfer rate to 150MB/s, which is 50% more compared with PATA standard ATA/100 and 13% more compared with standard PATA ATA/133. Current SATA interface speed has expanded to 2 times and 4 times faster which defined as SATA2 = 300MB/s and SATA3=600MB/s.) See graphics shown below:

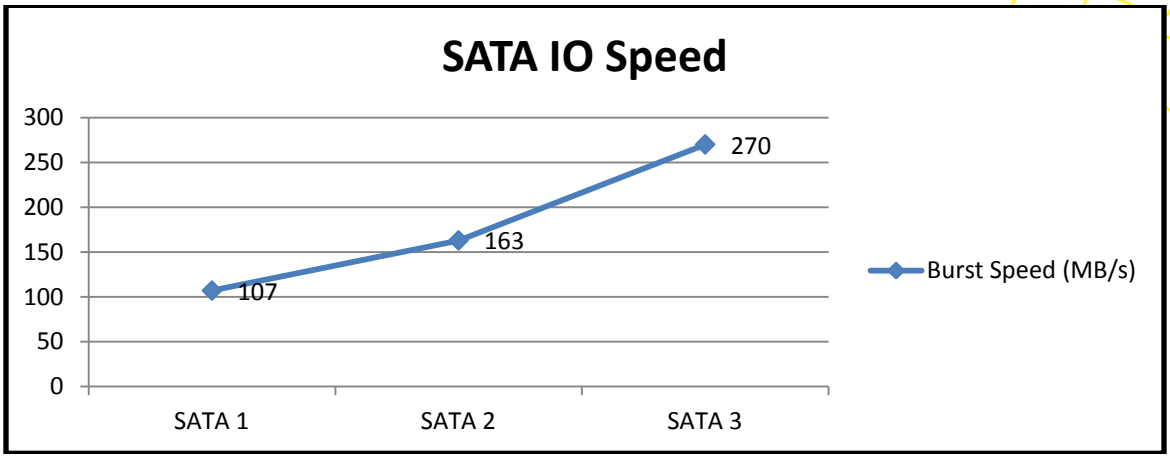
Interface Burst Speed:
Below are the results for the best performance

SATA	HD Tach Version 3.04.0 : Burst Speed (MB/s)
SATA 1	138
SATA 2	268
SATA 3	453
Note: Higher Value; Better Performance	



Interface Burst Speed:
Below are the results for the worst performance

SATA	Burst Speed (MB/s)
SATA 1	107
SATA 2	163
SATA 3	270
Note: Higher Value; Better Performance	

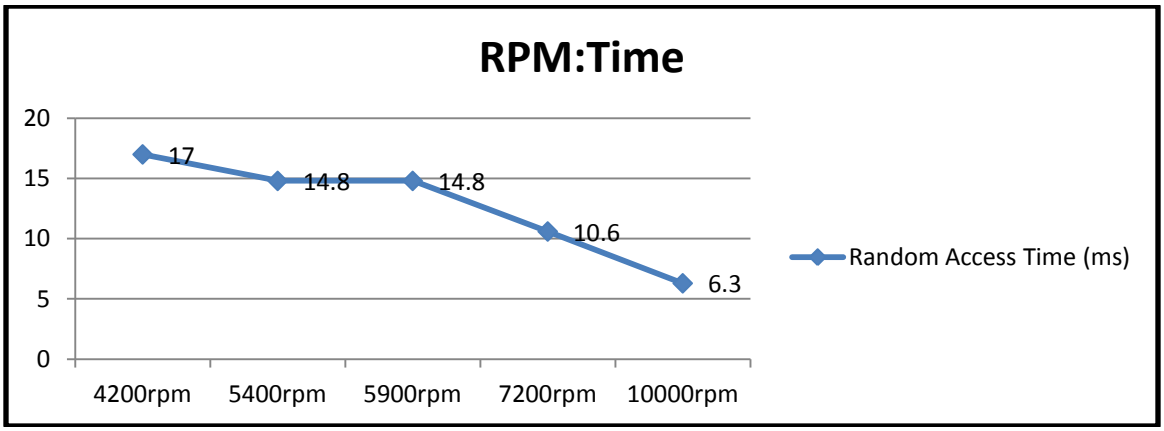

SATA IO Speed
300
250
200
150
100
50
0
107
163
270
SATA 1
SATA 2
SATA 3
Burst Speed (MB/s)

2. Spindle Speed on Hard Drive Speed

Spindle speed is the rotation speed of the spindle motor in a hard drive and also refers to the maximum rotation speed in one minute. It is a key factor to determine the speed of the internal hard disk transfer rate as well. Internal hard disk transfer rate is a major factor that directly and significantly impacts the speed of the hard disk. Generally speaking, the faster the speed, the faster a hard drive looks for files. Below is a hard drive speed comparison between 4200RPM, 5400RPM, 5900RPM, 7200RPM, and 10,000RPM drives:

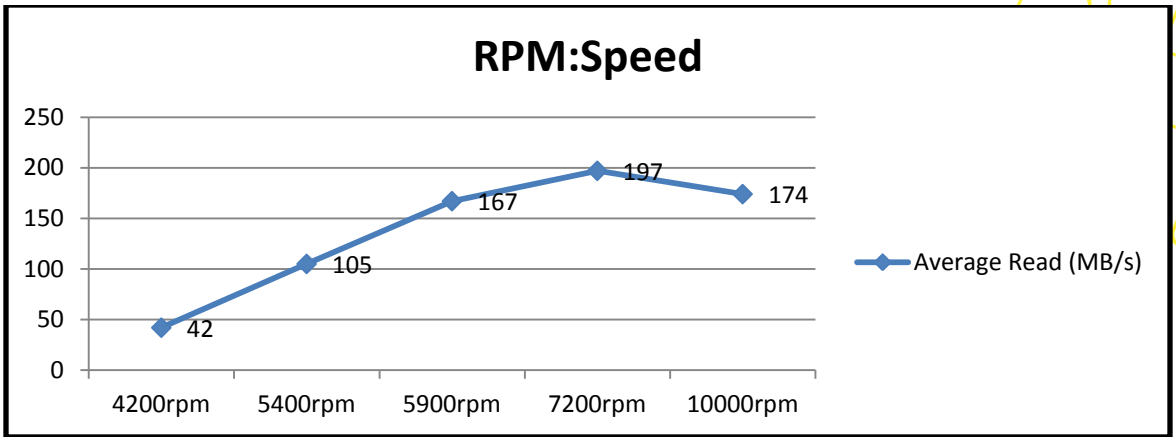
Random Seeking Time:

RPM	HD Tach version 3.0.4.0：Random Access Time (ms)
4200RPM	17
5400RPM	14.8
5900RPM	14.8
7200RPM	10.6
10000RPM	6.3
Note: Lower Value; Better Performance	



Internal Hard Disk Transfer Rate:

RPM	HD Tach version 3.0.4.0：Random Read (MB/s)
4200RPM	42
5400RPM	105
5900RPM	167
7200RPM	197
10000RPM	174
Note: Higher Value; Better Performance	


RPM:Speed
250
200
150
100
50
0
42
105
167
197
174
4200rpm
5400rpm
5900rpm
7200rpm
10000rpm
Average Read (MB/s)

3. Storage Per Disk on Hard Drive Storage

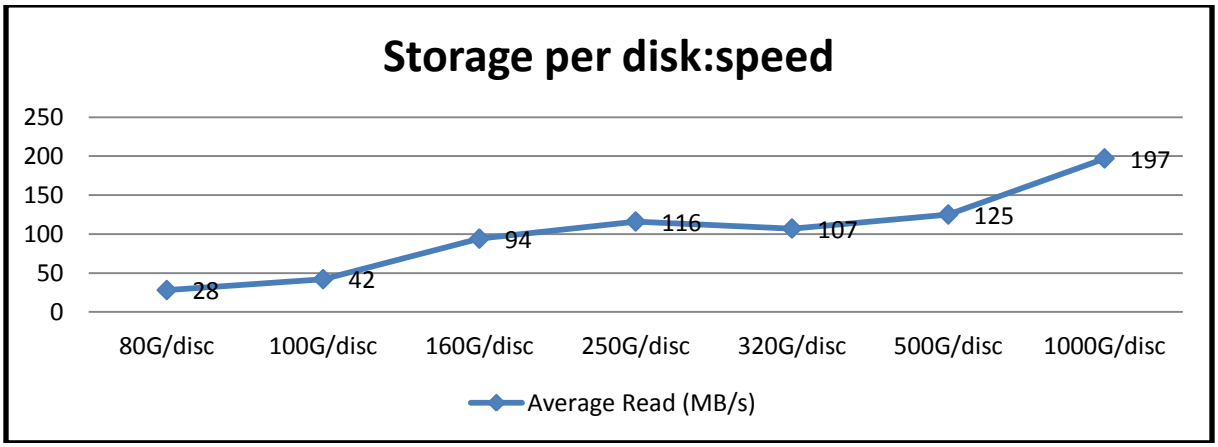
Storage per disk refers to the maximum amount of data that can be stored in one storage disk. Data is stored on the disk tracks. When the track density increases, the data density is higher too. Hard drive magnetic heads can read more data in every disk revolution. With more data read, the internal transfer rate is faster. Secondly, when the numbers of tracks increase in every single unit area, the hard drive seek times will decrease as well.

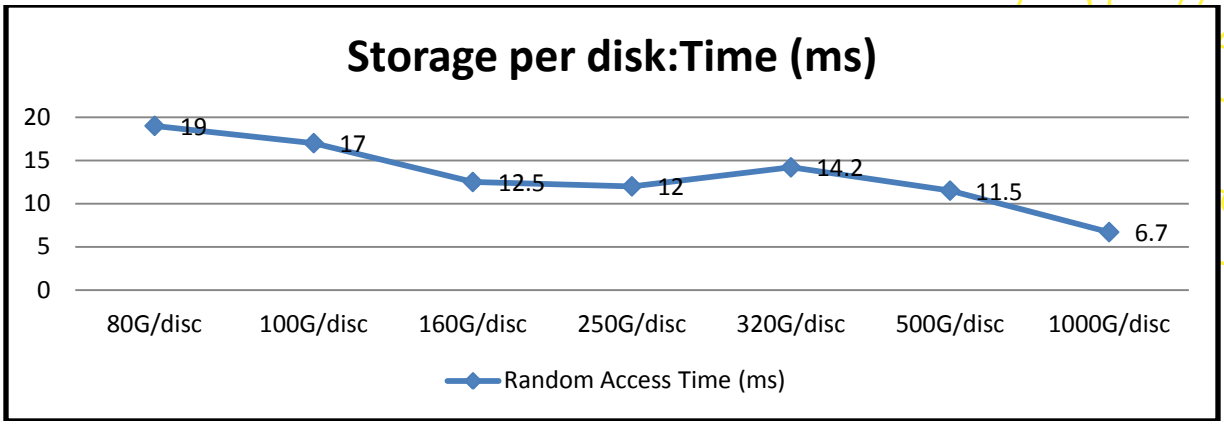
Capacity enhancement in single disk storage depends on the innovation of the magnetic recording technology. Traditional standard recording technology allows data bits to set horizontally on a magnetic medium. Perpendicular recording methodology allows data bits to stand perpendicularly on a magnetic medium, which greatly improves the magnetic recording density, and capacity per platter. Both improve hard drive performance and increase cost saving.

Note: In high density, high speed and multiple magnetic head environments, extracting accurate data becomes more difficult, especially in a high storage density data. Therefore, enterprise-grade hard disk storage density is usually lower than general hard disks, and the number is limited to 5 disks or less for hard drive capacity increases.

Now let's take a look the speed rate comparison between 7200rpm hard drives with different capacities.

Storage Per Disk	HD Tach version 3.0.4.0	
	Average Read (MB/s) Internal Transfer Rate *Higher Value; Better Performance*	Random Access Time (ms) Random Seek Time *Lower Value; Better Performance*
80G/disc	28	19
100G/disc	42	17
160G/disc	94	12.5
250G/disc	116	12
320G/disc	107	14.2
500G/disc	125	11.5
1000G/disc	197	6.7



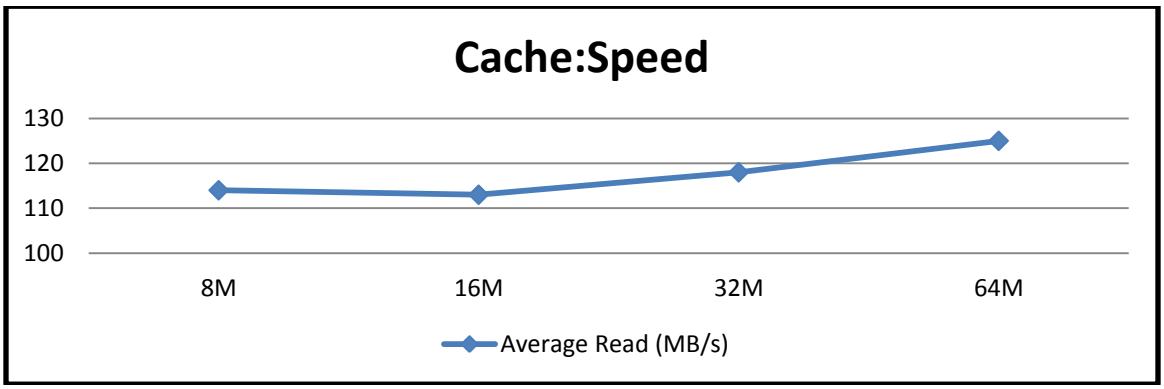

Storage per disk:Time (ms)
20
15
10
5
0
19
17
12.5
12
14.2
11.5
6.7
80G/disc
100G/disc
160G/disc
250G/disc
320G/disc
500G/disc
1000G/disc
Random Access Time (ms)

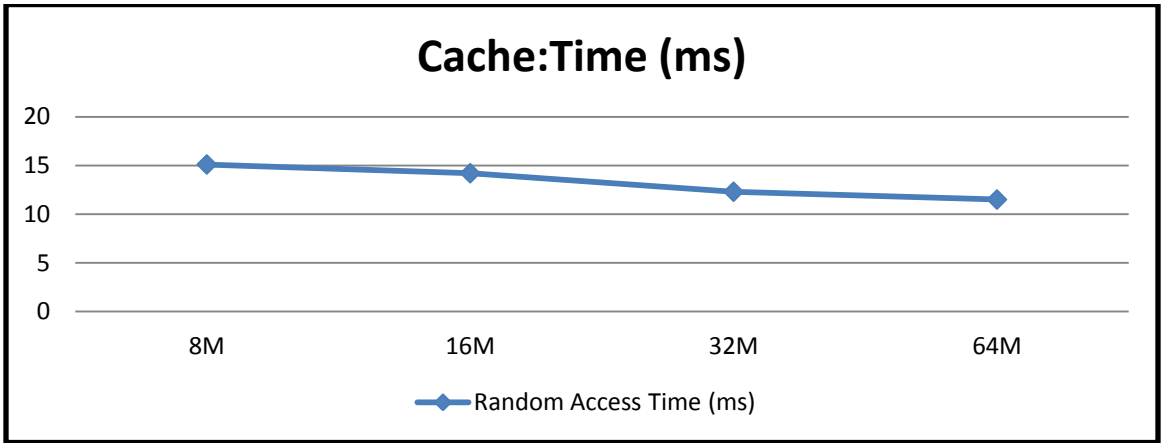
4. Cache Size to Hard Drive Efficiency

Buffer size, also known as cache capacity, refers to a memory chip on the hard drive controller. It has fast access read and write speed as well as a buffer between internal and external storage. A buffer can speed up hard drive read and write speed, reduce repeatable reads and writes, and effectively protect and prolong the life of the drive.

The following data is from 7200rpm drives with different buffer sizes. It seems that speed doesn't increase significantly. The main advantage from the buffer is to extend the life of hard drive.

Cache	HD Tach version 3.0.4.0	
	Average Read (MB/s) Internal Transfer Rate *Higher Value; Better Performance*	Random Access Time (ms) Random Seek Time *Lower Value; Better Performance*
8M	114	15.1
16M	113	14.2
32M	118	12.3
64M	125	11.5

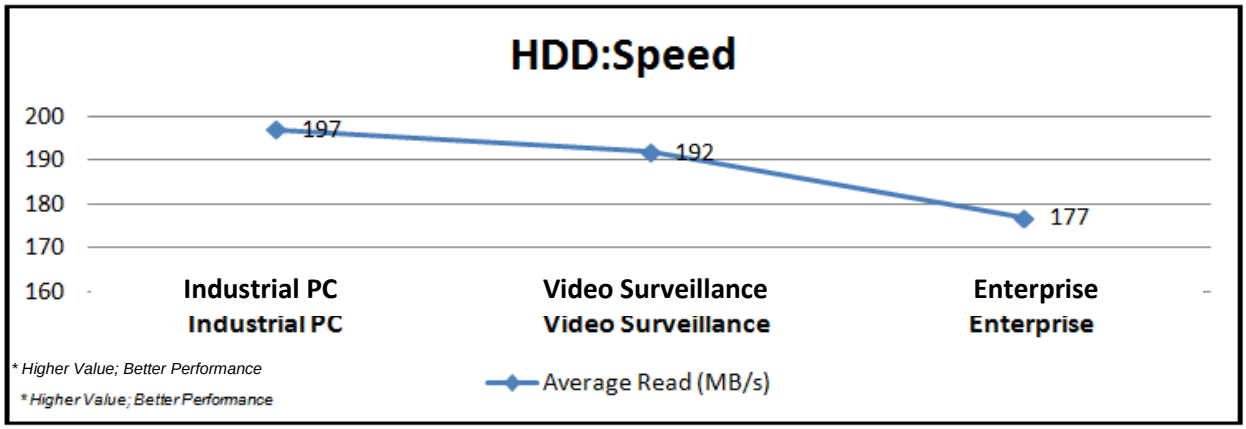


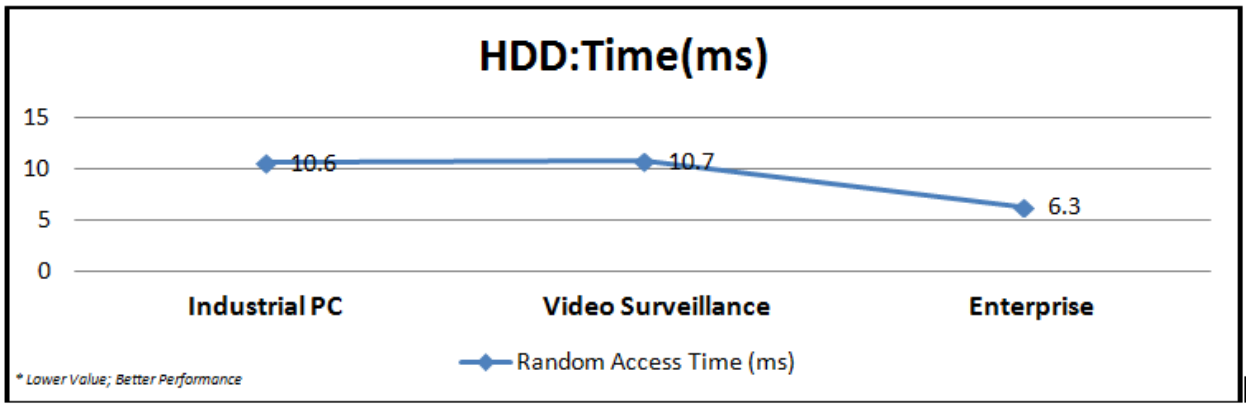


5. Hard Drive Performance Comparison with the Different Applications

No matter whether using Seagate, Western Digital, or Toshiba, the main applications for hard drives fall into three areas: Personal Computers, Video Surveillance, and Enterprise. The following table shows the hard drive specifications for the three applications:

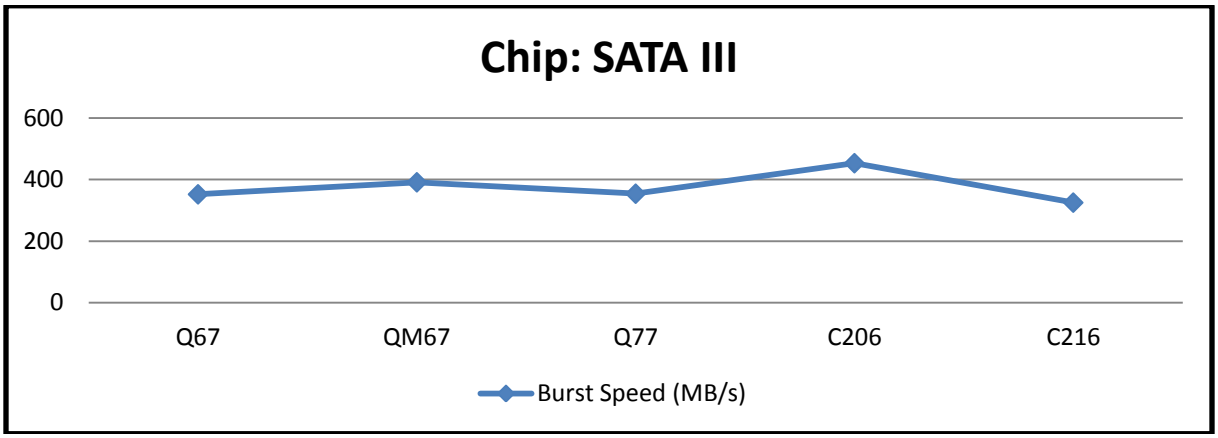
Item	General Industrial PC	Video Surveillance	Enterprise
MTBF	> 600,000	> 1,000,000	> 1,200,000
Power on Hours (hrs/day x days/wk)	8 x 5	24 x 7	24 x 7
Interface	SATA	SATA	SATA/SAS/FC
PRM	5400 ~ 7200	5400 ~ 7200	5900 ~ 15000
Unrecoverable Read Error/ Readable Data (bits)	$1/10E^{14}$	$1/10E^{14}$	$1/10E^{14}$
Startup Current (Ampere)	2.8A ~ 3.2A	Under 2A	Under 2A
Price	Low	Medium	High
Applications	Industrial PC with no special requests to temperature and vibration	Multimedia, video surveillance, security and defense industries	Server, RAID solution, graphics workstation

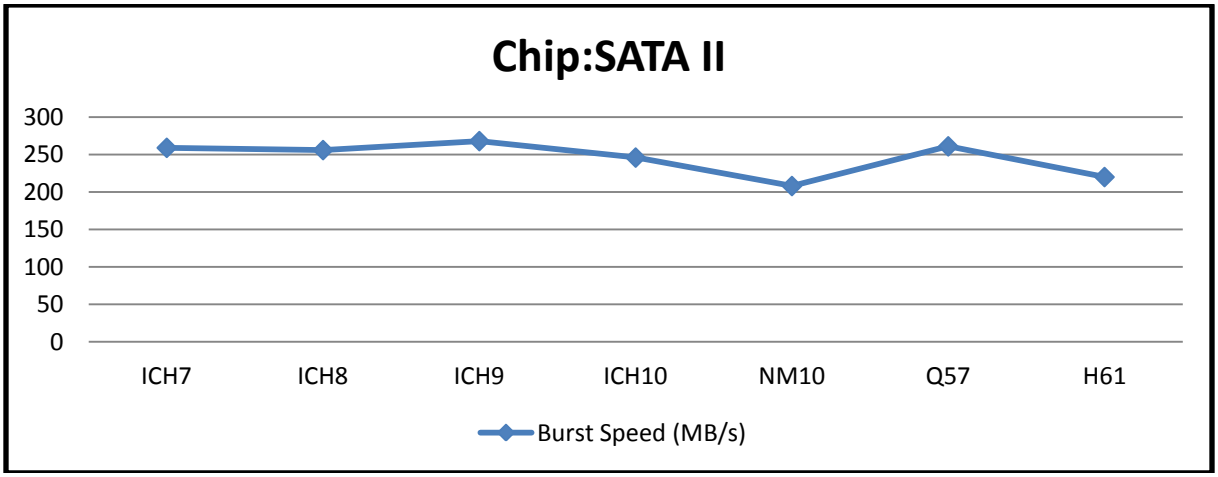




6. **Chipset with Different SATA Input and Output Performance Measurements:**

Chip	SATA IO (Number)	MB/s	Note
ICH5	2	150	SATA I
ICH6	4	150	SATA I
ICH7	4	300	SATA II
ICH8	6	300	SATA II
ICH9	6	300	SATA II
ICH10	6	300	SATA II
NM10	2	300	SATA II
Q57	6	300	SATA II
H61	4	300	SATA II
Q67	4	300	SATA II
	2	600	SATA III
Q77	2	300	SATA II
	4	600	SATA III
Q87	6	600	SATA III





7. Conclusion

- There are two main reasons that affect the speed of a hard drive:

  One is the spindle speed. Currently, 7200RPM seems to hit the peak. According to the Hitachi technology development center, they are developing one type of hard drive, so called Helium-filled Hard Drive. Helium is lighter than air and with smaller molecular weight. Since its chemical nature is less active and has less density, scientists believe helium can increase the speed of the hard drive. Accelerating the rotation speed of the hard drive can improve performance and eliminate noise, vibration, and chaos (turbulence), as well as other mechanical problems.

  The second reason is to enhance the palter density. If follows the current growth rate of storage density, in the next 5 to 10 years, the data bits will become very small and a superparamagentic phenomenon might occur. Eventually this will make the data become very unstable. So improving the current magnetic recording technology becomes very important. As an analogy, using fixed size paper, the smaller the surface of the write head, the more words can be written on the paper.

- The number of disks or the density on each platter determines the hard drive capacity:

  With current technology of 1TB on a platter, the limit is reached at a maximum total capacity of 4TB. It is hard to improve the current magnetic recording technology that records longitudinally and vertically. According to Seagate, they are leading the development of Heat-Assisted Magnetic Recording technology (HAMR) which will become the next generation of recording technology—taking advantage of a laser element to change the recording unit. This thermal-assisted recording head size is only 1mm x 1mm. This means that without changing the hard drive size, based on current perpendicular magnetic recording technology, magnetic recording density can increase 300 times, from 421GB per square inch to 50TB per square inch. In addition, with the significant increase in data density on the track, the head can read more data within the same time and the number of tracks will be reduced. In addition, the hard disk internal transmission performance will be enhanced and reduce mechanical damage which is caused by the rate of aging

- The Advantages of Hard Drives to the Storage Market: Large Capacity and Low Cost

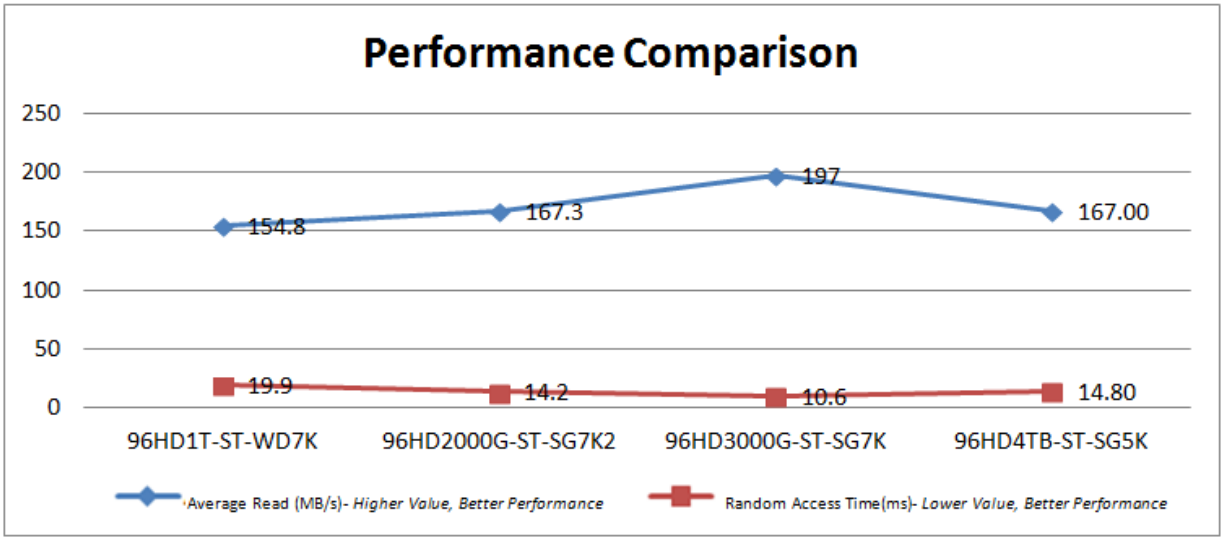
  With the rise of smart phones, tablet PCs and solid state drives (SSD), the major consumer market for traditional hard drive will focus on enterprise-grade applications, cloud storage, and big data analysis. These applications are more concerned about data security, stability and the most cost-efficient per storage capacity unit.

8. Appendix : High Performance Hard Drive Recommendations

- General Industrial PC Applications

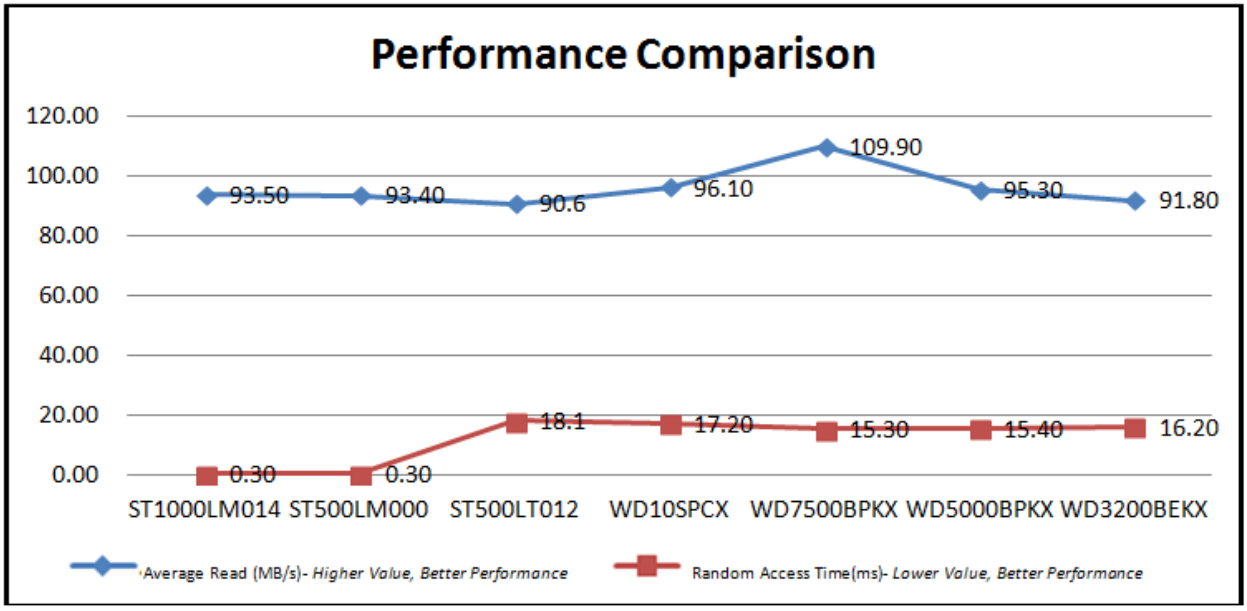
>> 3.5”: Large Capacity, Low Cost, High Speed

PN	96HD1T-ST-WD7K	96HD1000G-ST-SG7K6	96HD2000G-ST-SG7K2	96HD3000G-ST-SG7K (coming soon)	96HD4TB-ST-SG5K (coming soon)
Rating	★	★★★	★★	★★★	★★
Type	WD10EZEX	ST1000DM003	ST2000DM001	ST3000DM001	ST4000DM000
Brand	WD	Seagate	Seagate	Seagate	Seagate
Capacity	1TB	1T	2TB	3TB	4TB
Interface	SATA III	SATA III	SATA III	SATA III	SATA III
Speed	7200	7200	7200	7200	5900
Disk	1	1	3	3	4
Buffer Size	64	64	64	64	64
Application	* WD Blue, PC, Industrial Systems, and External Host Shell * Not recommended for RAID environments	PC-based industrial systems, RAID solutions (with hard drive numbers under 4) , Direct-attached Storage (DAS), Network Attached Storage (NAS)			



>> 2.5”: Small Size, Portable

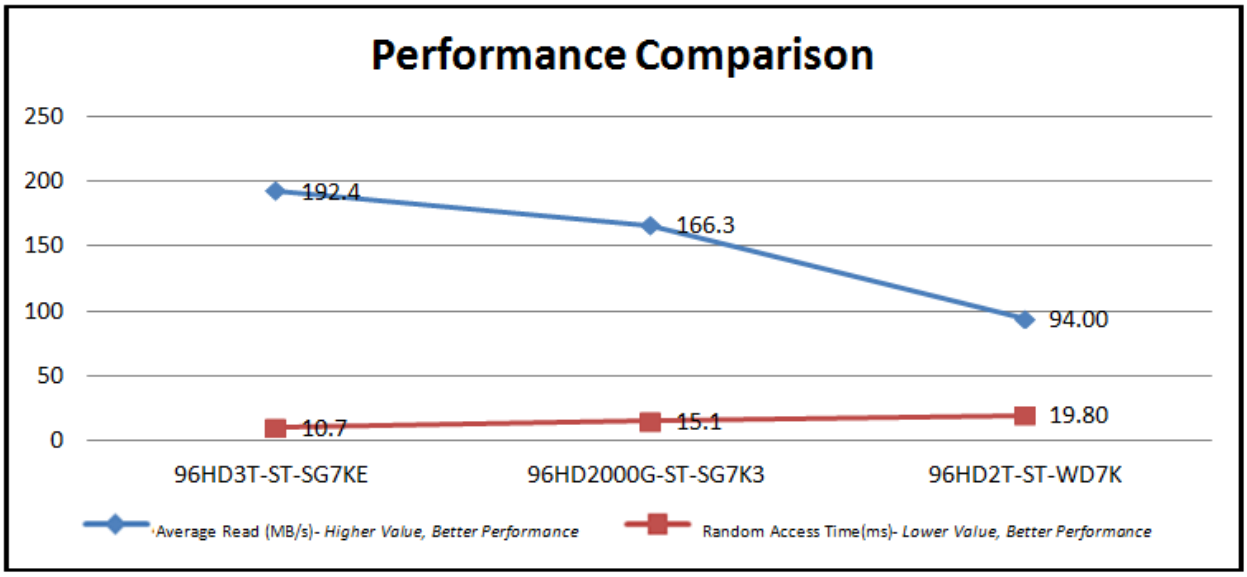
PN	96ND1TB-ST-SG5K	96ND500G-ST-SG5K3	96ND500G-ST-SG5K2	96ND1T-ST-WD5K1	96ND750G-ST-WD7K1	96ND500G-ST-WD7K3	96ND320G-ST-WD7K1
Rating	★★	★★	★	★★	★★★	★★	★
MPN	ST1000LM014	ST500LM000	ST500LT012	WD10SPCX	WD7500BPKX	WD5000BPKX	WD3200BEKX
Brand	Seagate	Seagate	Seagate	WD	WD	WD	WD
Capacity (GB)	1000	500	500	1000	750	500	320
Interface	SATAIII	SATAIII	SATA II	SATAIII	SATAIII	SATAIII	SATAIII
Speed	5400	5400	5400	5400	7200	7200	7200
Disk	2	1	2	2	2	2	2
Buffer Size	8	64	16	16	16	16	16
Appli-cation	7mm Solid State Hard Drive has the same fast random access capability as SSD and almost same capacity of the traditional hard drive		7mm self-encrypting hard drives to protect sensitive data. They can be used with ultra-thin consumer electronic devices and portable devices from entry-level to high performance .	WD Blue, Low power consumption , suitable for low heat, and energy saving applications	WD Black, suitable to applications requiring high-performance, such as photo and video editing and other applications requiring high speed		



- AV (Video Surveillance)

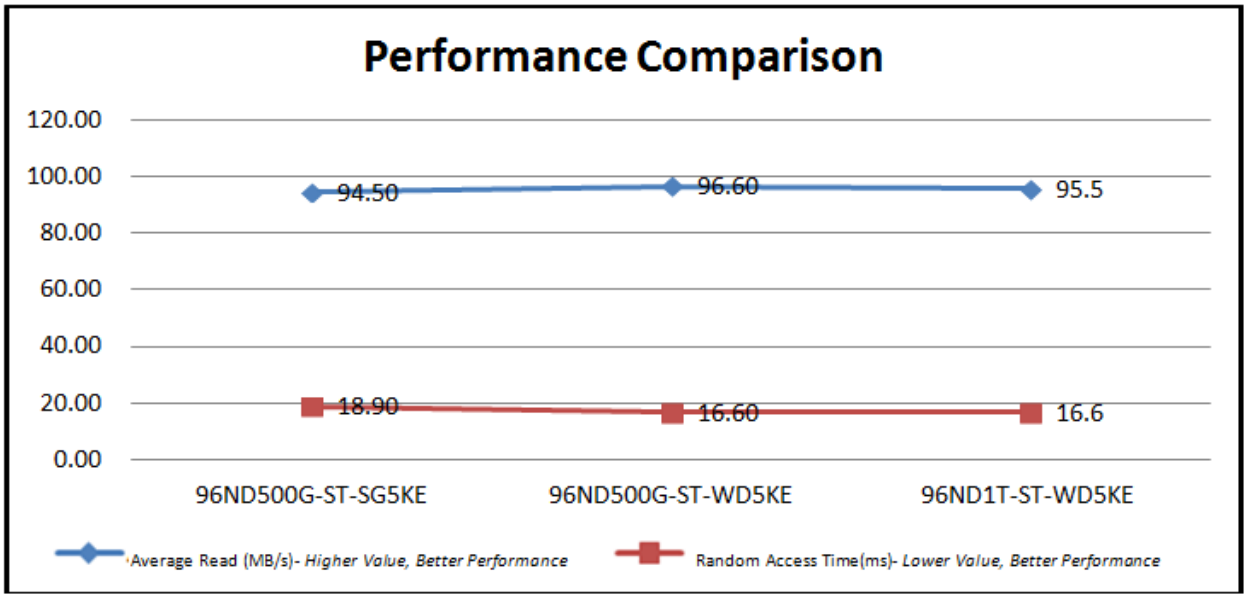
>> 3.5” Mass Storage, Efficient, and Sustainable Work Environment

PN	96HD3T-ST-SG7KE	96HD2000G-ST-SG7K3	96HD1000G-ST-SG7K7	96HD2T-ST-WD7K
Rating	★★★	★★	★★★	★
MPN	ST3000VX000	ST2000VX000	ST1000VX000	WD20EURS
Brand	Seagate	Seagate	Seagate	WD
Capacity (GB)	3000	2000	1000	2000
Interface	SATA III	SATA III	SATA III	SATA II
Speed	7200	7200	7200	IntelliPower
Disk(s)	3	3	1	2
Buffer Size	64	64	64	64
Application	Cost-effective, long-lasting durability, large capacity for network monitoring video cameras, surveillance digital video recorders, direct-attached or network-attached JBOD video storage with RAID solutions (hard drive number under 4)			Low-power consumption, mute, suitable for streaming digital audio/video environments such as PVR, DVR, set-top boxes (STB) and surveillance video recording.



>> 2.5” small system, energy-saving, and quiet

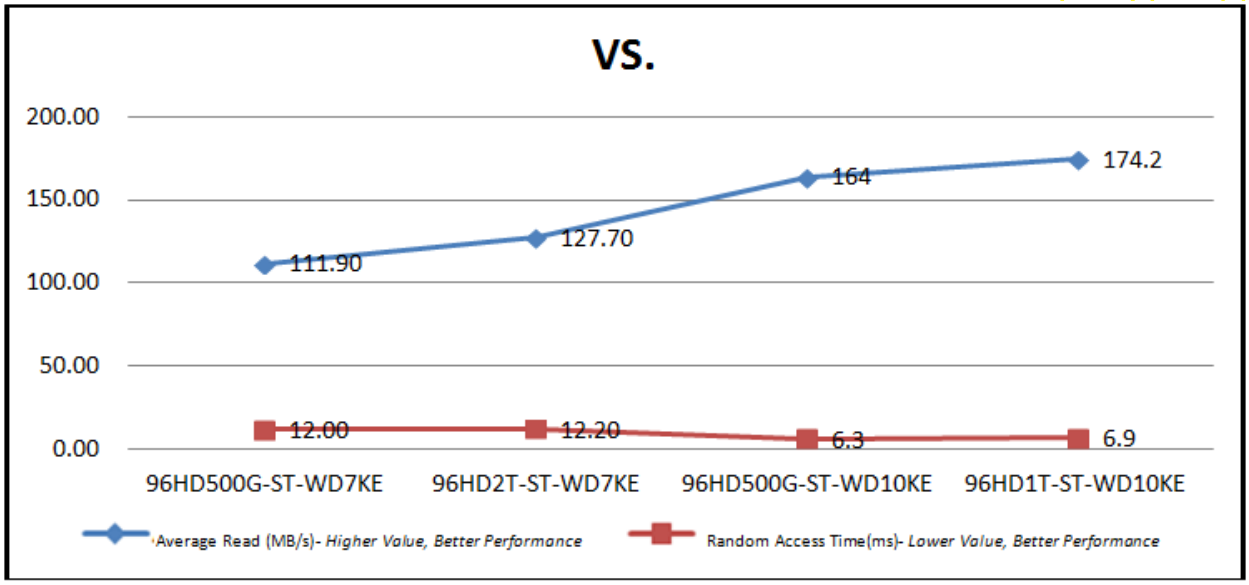
PN	96ND500G-ST-SG5KE	96ND500G-ST-WD5KE	96ND1T-ST-WD5KE
Rating	★	★★★	★★
MPN	ST500VT000	WD500LUCT	WD10JUCT
Brand	Seagate	WD	WD
Capacity(GB)	500	500	1000
Interface	SATA II	SATA II	SATA II
Speed	5400	5400	5400
Disk	1	1	2
Buffer	16	16	16
Application	HD storage for DVR media center; Cable, satellite, and IP TV set-up box; built-in camera; home monitoring system	Low power consumption, low operating temperature, and quiet for video surveillance, DVR/PVR, set-top boxes. High-end audio systems and digital signage.	



- Enterprise Application (Server & Workstation)

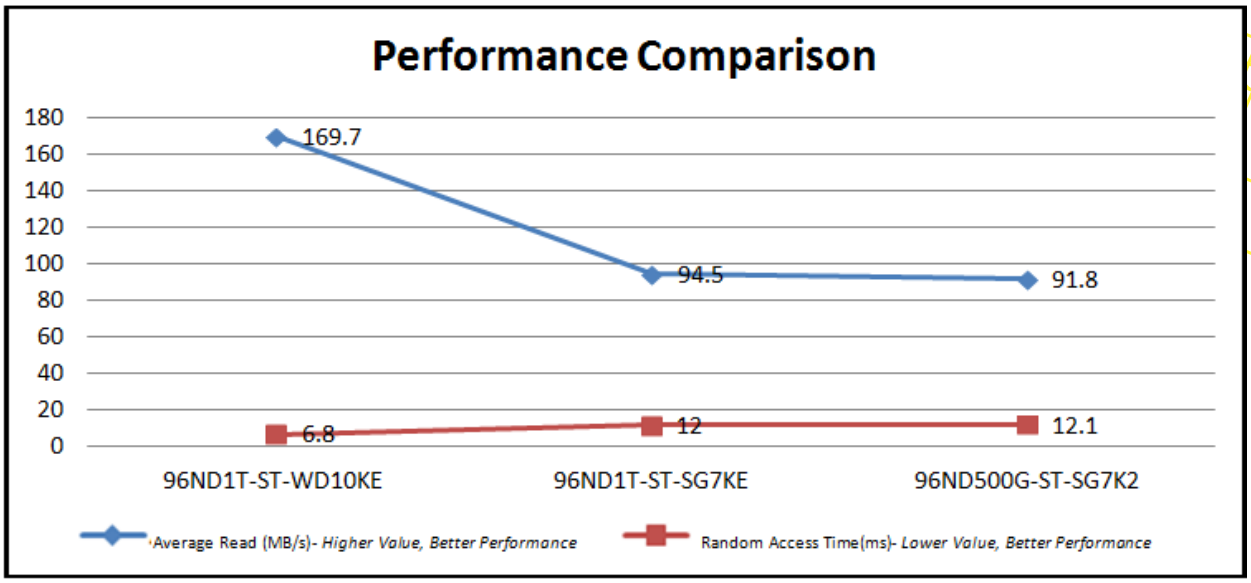
>> 3.5” large capacity and high quality

PN	96HD500G-ST-WD7KE	96HD2T-ST-WD7KE	96HD500G-ST-WD10KE	96HD1T-ST-WD10KE
Rating	★★	★★★	★★	★★★
MPN	WD5003ABYZ	WD2000FYYZ	WD5000HHTZ	WD1000DHTZ
Brand	WD	WD	WD	WD
Capacity	500	2000	500	1000
Interface	SATAIII	SATAIII	SATA III	SATA III
Speed	7200	7200	10000	10000
Disk	1	3	2	3
Buffer	64	64	64	64
Application	High quality and reliability suitable for large-capacity data storage, data computing, business-critical environments, SAN/NAS/DAS, network monitoring systems and cloud storage, RAID solution		High performance and high reliability suitable for high-performance computing, 3D rendering effect, digital content creation and editing, scientific computing and image management, and RAID solutions.	



>> 2.5” small size with large storage capacity

PN	96ND1T-ST-WD10KE	96ND1T-ST-SG7KE	96ND500G-ST-SG7K2
Rating	★★★	★★	★★
MPN	WD1000CHTZ	ST91000640NS	ST9500620NS
Brand	WD	Seagate	Seagate
Capacity (GB)	1000	1000	500
Interface	SATA III	SATA III	SATA III
Speed	10000	7200	7200
Disk	3	4	2
Buffer Size	64	64	64
Application	High performance and high reliability suitable for high-performance computing, 3D rendering effect, digital content creation and editing, scientific computing and image management, and RAID solutions.	Seagate Constellation 2. Low power consumption, high reliability, self-encrypting hard drive suitable for blade server, DAS, SAN, NAS, rich media content and centralized monitoring data and cloud storage	


Performance Comparison
180
160
140
120
100
80
60
40
20
0
169.7
94.5
91.8
6.8
12
12.1
96ND1T-ST-WD10KE
96ND1T-ST-SG7KE
96ND500G-ST-SG7K2
Average Read (MB/s)- Higher Value, Better Performance
Random Access Time(ms)- Lower Value, Better Performance