



Get more out of your Windows 10 laptop experience with SSD storage instead of HDD storage

Storage is more than a convenient place to stash your favorite photos and music library—it also launches your apps and transfers your data. While each of us have our own specific requirements when it comes to Microsoft Windows® 10 laptop style, form factor, price point, or features, we can all agree that we want our laptops to launch apps and transfer data as quickly as possible. So, which storage option is faster—solid-state drives (SSDs) or hard disk drives (HDDs)?

Our experts tested 24 Windows 10 laptops powered by Intel® Core™ i3, i5, and i7 processors with varying amounts of RAM. First, we measured Iometer performance to determine how many megabits of data each storage option could read and write per second. Then, we ran the laptops through ten common activities to evaluate how drive selection could affect your laptop experience. Our experts found that the Windows 10 laptops with SSD storage performed on average better than the laptops with HDD storage.

Read on to see exactly how choosing SSD storage over HDD storage could give your Windows 10 laptop the extra boost it needs to get you up and running as quickly as possible.

 **Your laptop could handle an average of 4X as many megabits of data per second if you choose SSD storage over HDD storage**

 Load email video attachments an average of **4.7X as fast** (9 sec faster)

 Start watching an HD video an average of **10 seconds sooner**

 Perform Windows updates an average of **3X as fast**

 Manage finances, edit documents, and transfer files **in less time**

 Start chatting on Skype an average of **25 seconds faster**

 Launch online video games in a **fraction of the time**



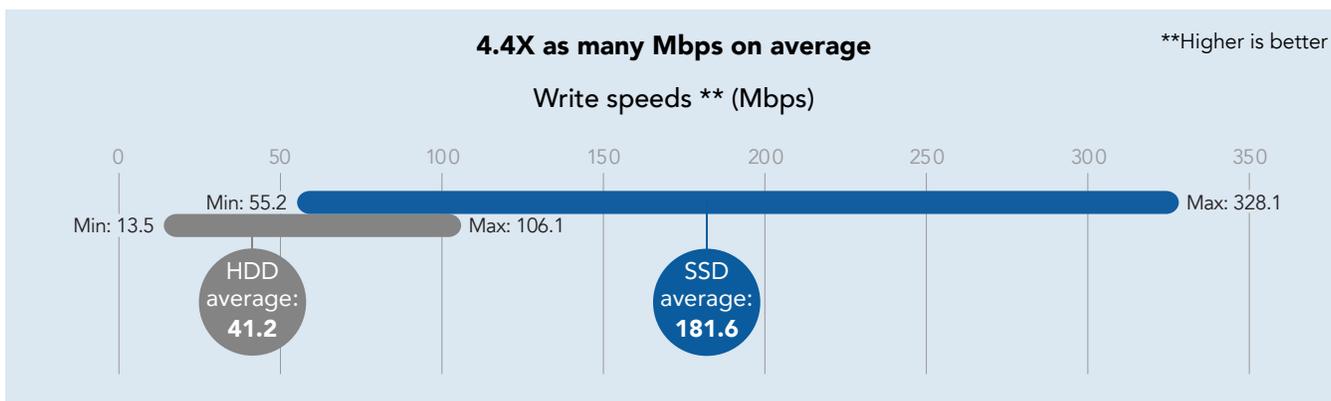
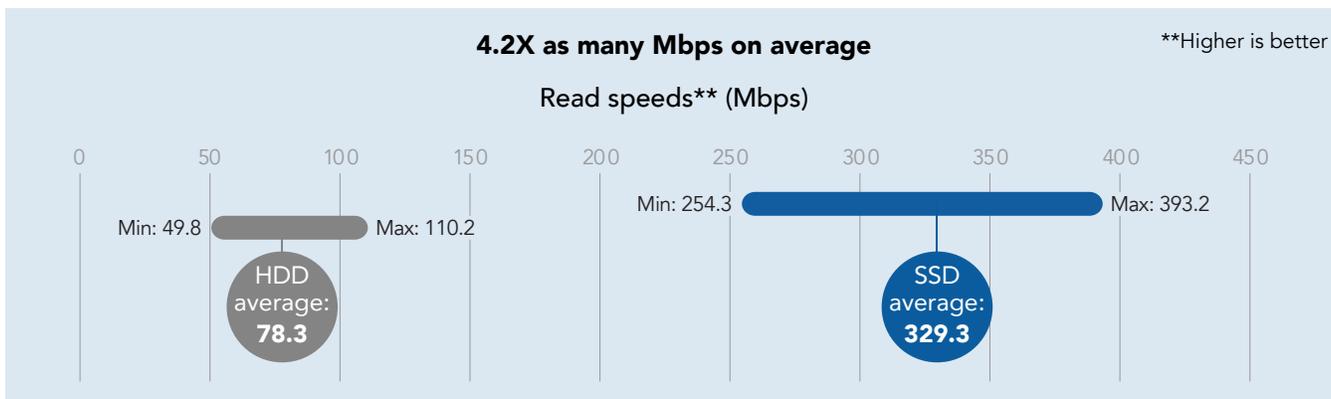
Our process

Our experts tested 12 Windows 10 laptops with SSD storage and 12 with HDD storage. All 24 laptops were powered by Intel Core i3, i5, or i7 processors with 4 or 8 GB of RAM to represent a wide array of users. In our hands-on tests, we found that Windows 10 laptops equipped with SSD storage started day-to-day activities faster than laptops with HDD storage. In this document, we provide a high-level takeaway of SSD vs. HDD storage performance averages. For an in-depth dive into individual laptop results, a breakdown by processor and RAM specifications, and our step-by-step testing process, please read the accompanying [science behind the report](#).



Iometer results

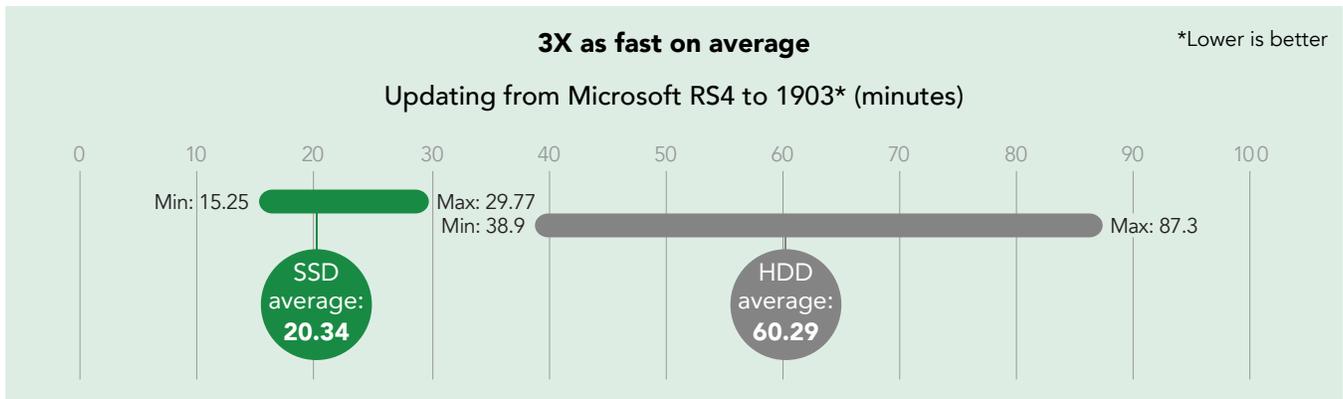
We measured Iometer performance to determine how each storage option affected each laptop's ability to process incoming and outgoing data. This is important, because the rate at which your laptop can read and write per second (Mbps), the faster you can upload and download large files. In our tests, the Windows 10 laptops with SSD storage handled four times as many Mbps on average compared to those with HDD storage.





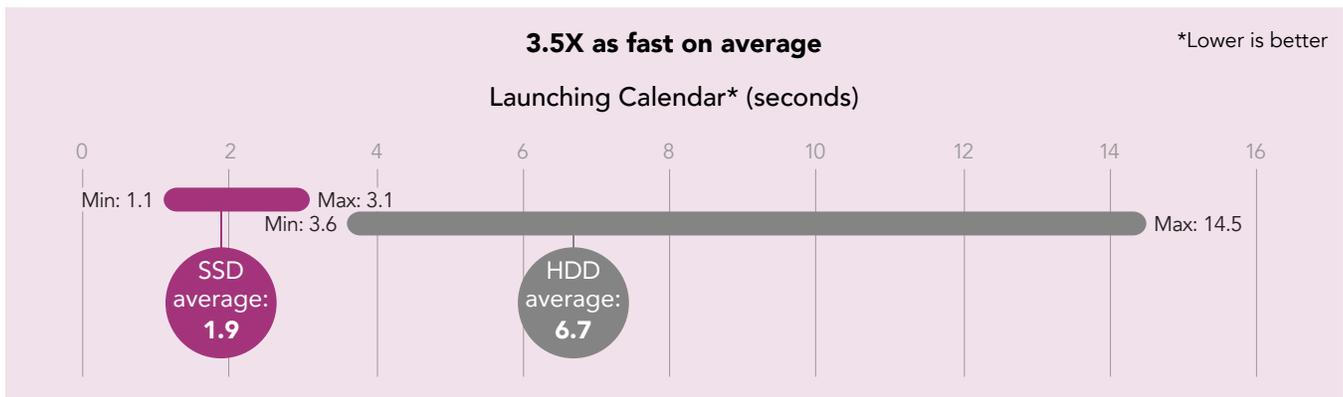
Applying a Windows update

Software updates are great, but losing access to your laptop for almost an hour and a half can be daunting. In our test, the laptops equipped with SSD storage were back up and running in less than half a hour—and sometimes half that time—making them three times as fast on average compared to Windows 10 laptops with HDD storage.



Checking your schedule

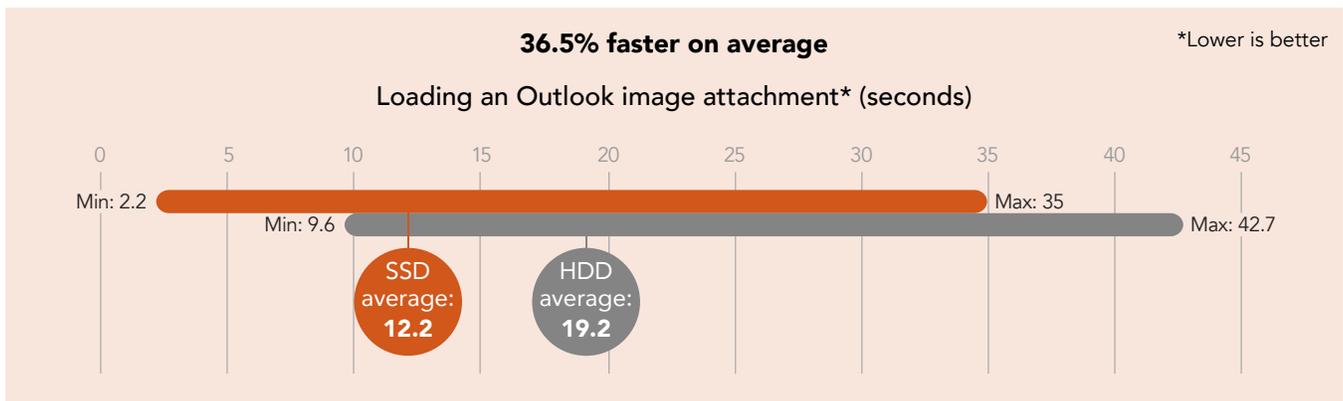
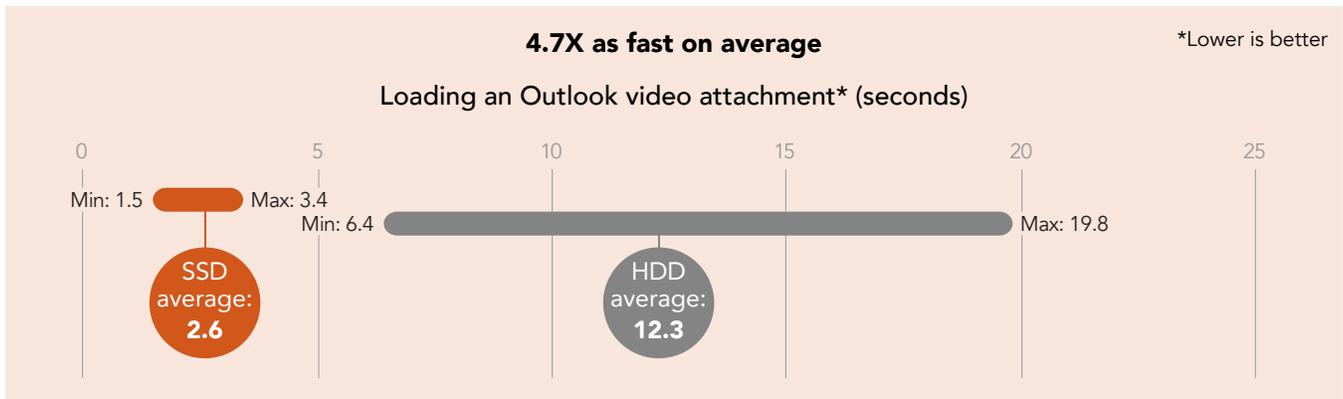
Between work meetings, school events, personal appointments, friend meet-ups, and family gatherings, juggling your commitments can be a time-consuming endeavor. In our tests, Windows 10 laptops equipped with SSD storage launched the Calendar app three and a half times as fast on average compared to the similarly specced laptops with HDD storage we tested—freeing up your time if not your itinerary.





Collaborating through email

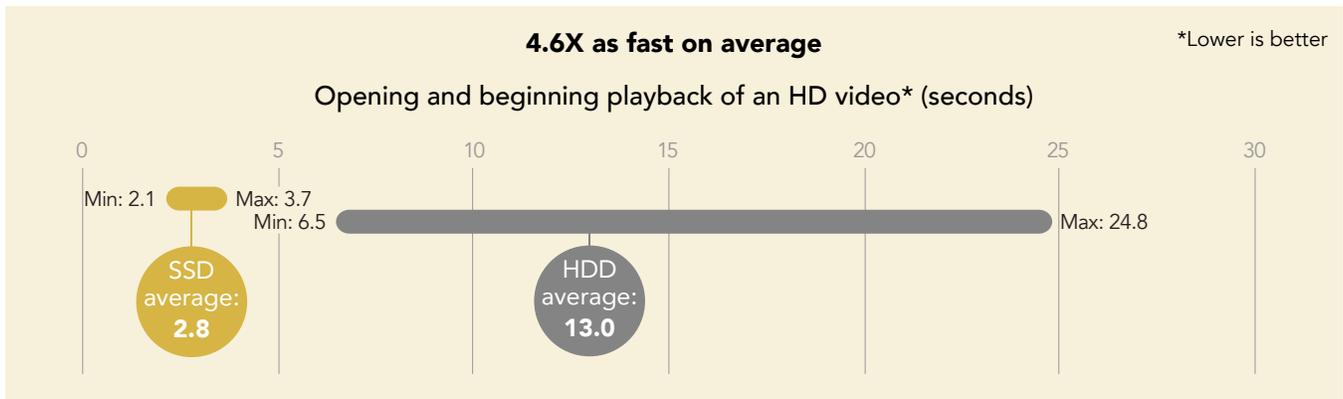
Reading your email is quick and easy when you're only dealing with text-only messages. But you can wait much longer for something to load when the incoming missive includes attachments. In our tests, the Windows 10 laptops equipped with SSD storage loaded Microsoft Outlook® attachments 4.7 times as fast on average compared to their HDD equivalents.





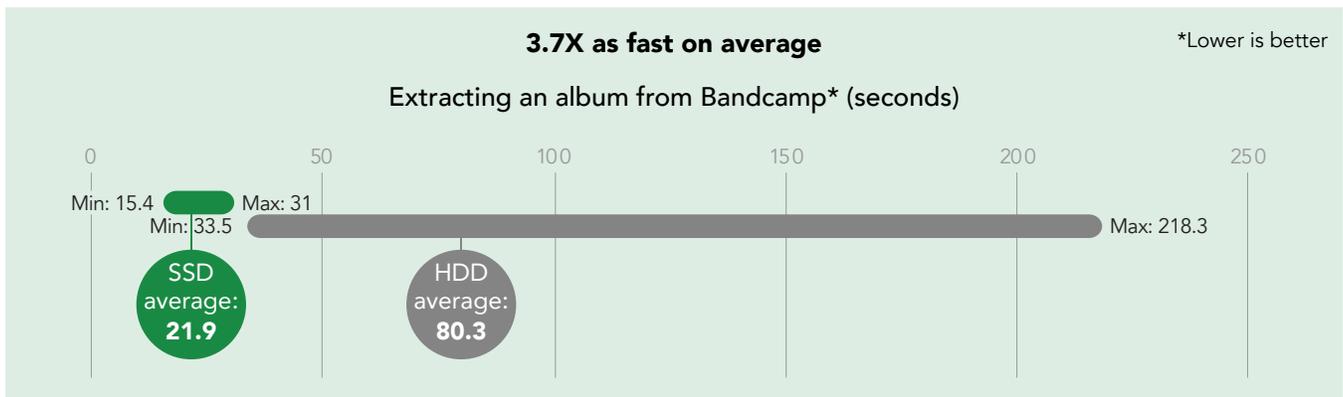
Watching videos

Waiting for a video to start can be annoying—especially if it takes 24.8 seconds—the longest wait time we experienced on the laptops with HDD storage. By contrast, the laptops with SSD storage we tested started playing their videos in 3.7 seconds or less. For context—none of the laptops with HDD storage started playing their videos in under 6.5 seconds.



Listening to music

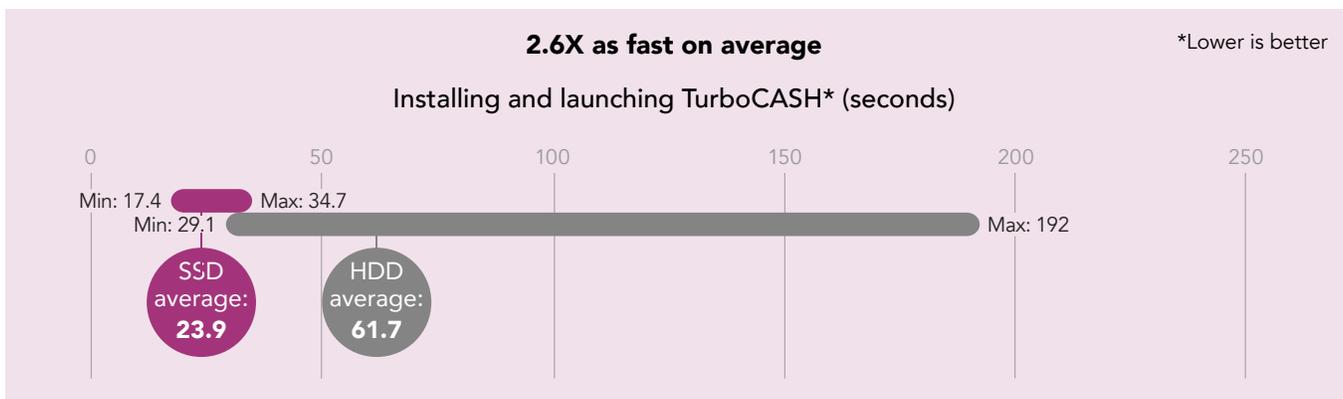
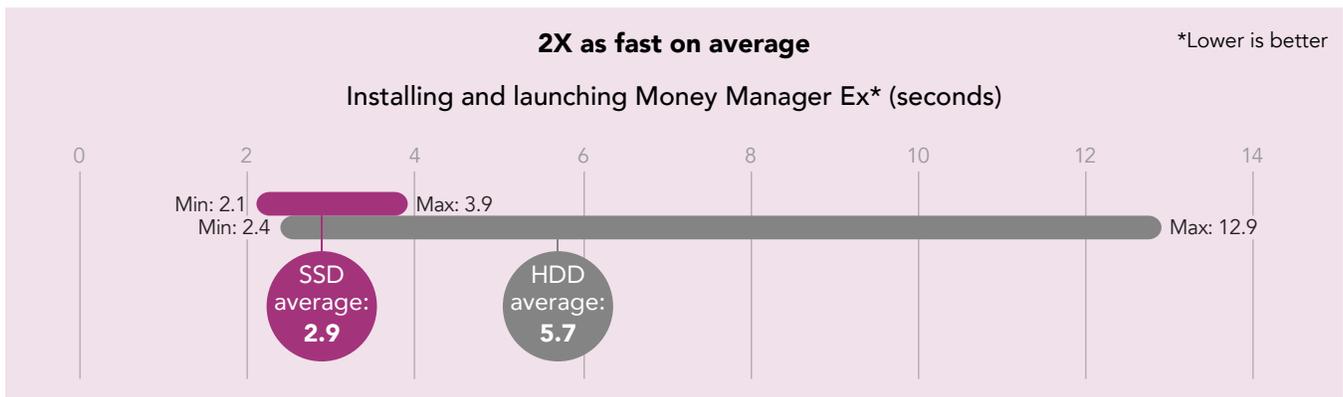
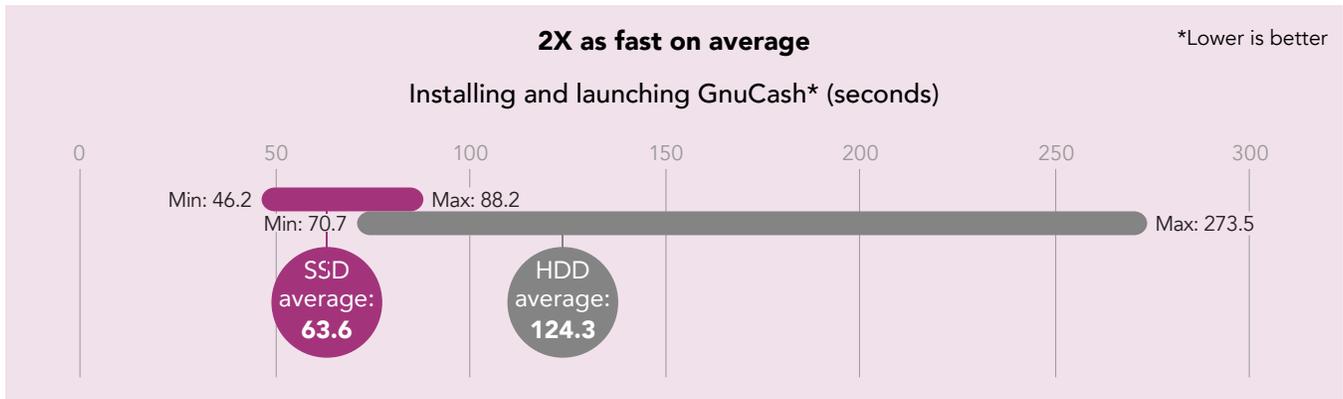
Purchasing new music is fun, but slow storage can detract from your listening pleasure. In our tests, the slowest Windows 10 laptop equipped with SSD storage extracted an album from Bandcamp in 31 seconds—a feat no Windows 10 laptop in our test group could match when they utilized HDD storage instead of SSD storage.





Managing finances

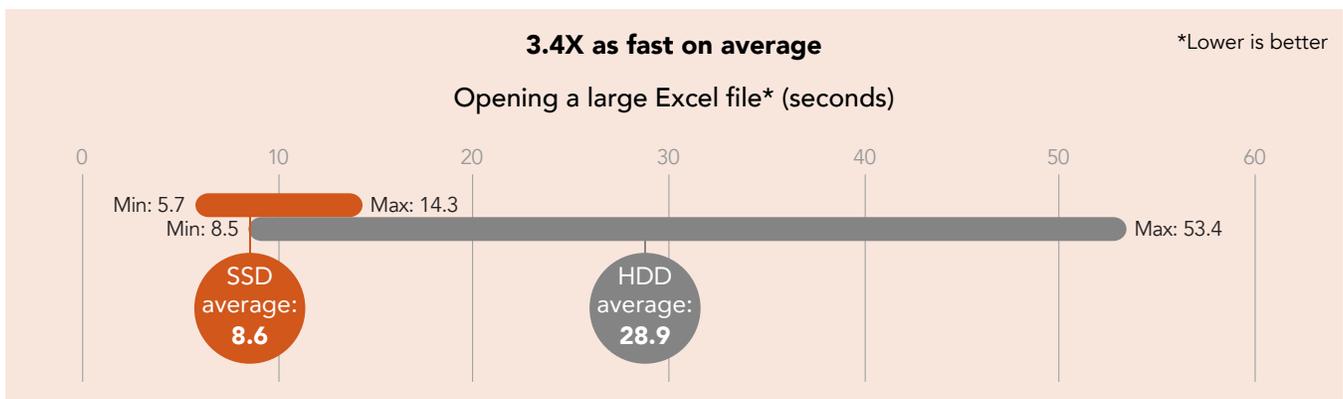
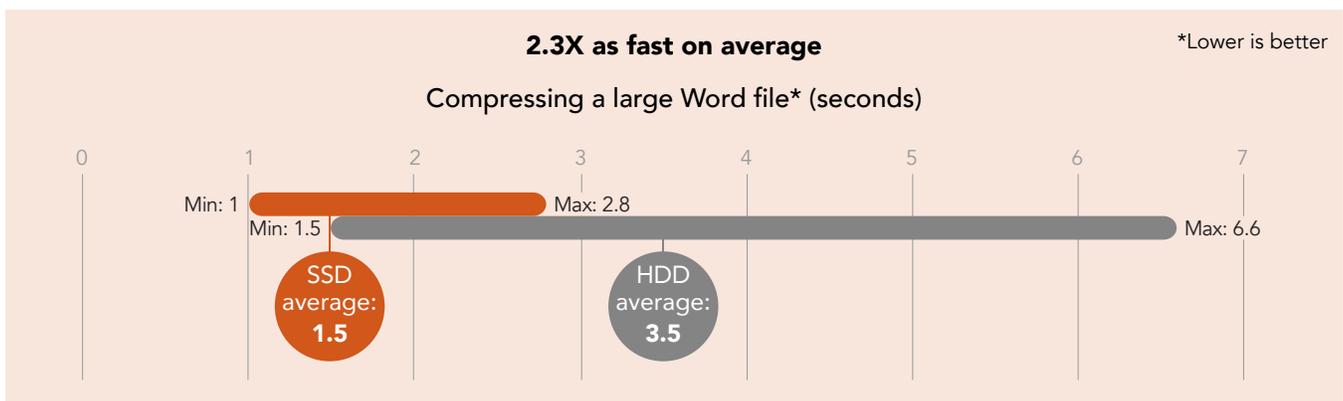
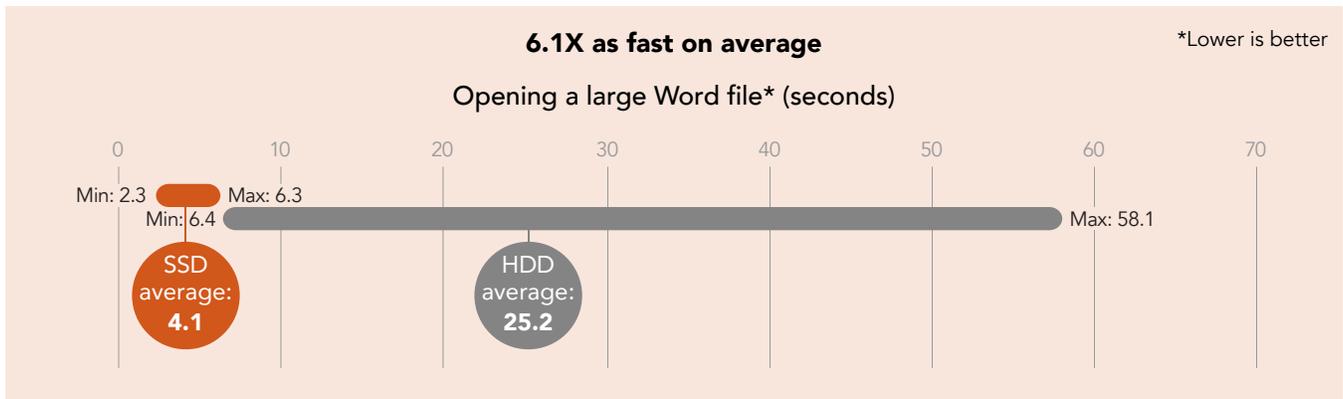
When you're crunching numbers, you want to get started as quickly as possible. Our experts found that installing and launching three different accounting software packages (GnuCash, Money Manager Ex, and TurboCash) on Windows 10 laptops with SSD storage resulted in shorter wait time averages than the same tasks on Windows 10 laptops with HDD storage.





Editing documents

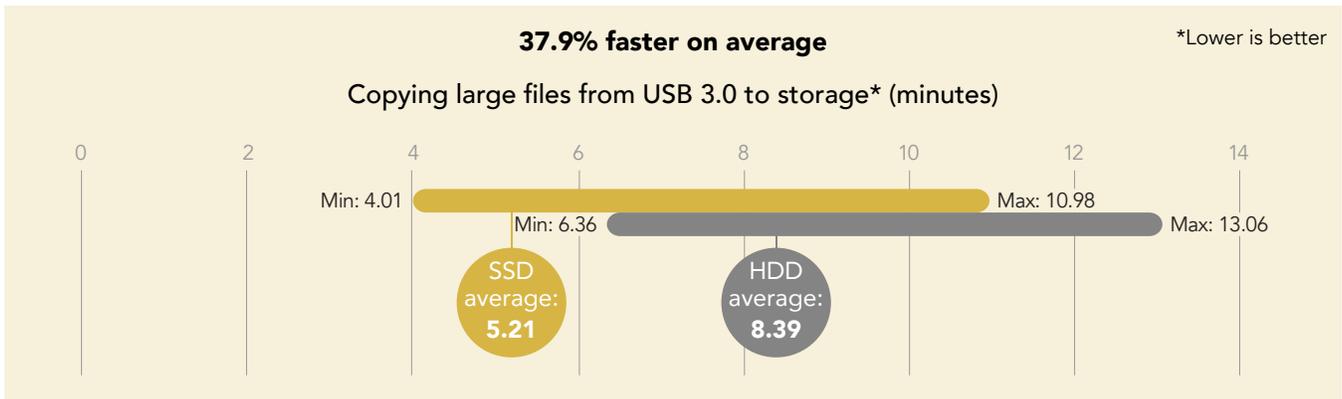
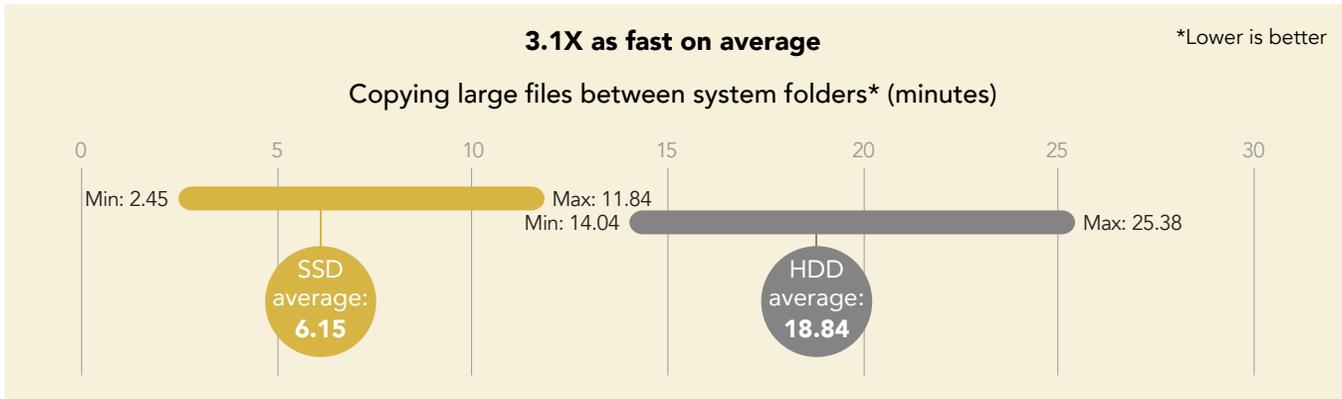
When it's time to sit down and tackle a project, the last thing you want is to wait almost half a minute for info stored on your laptop to pop up. In our tests, that was the average wait time when opening a large Excel® file on Windows 10 laptops equipped with HDD storage. By contrast, the SSD storage-powered Windows 10 laptops we tested opened the same file in under 9 seconds on average.





Backing up and transferring files

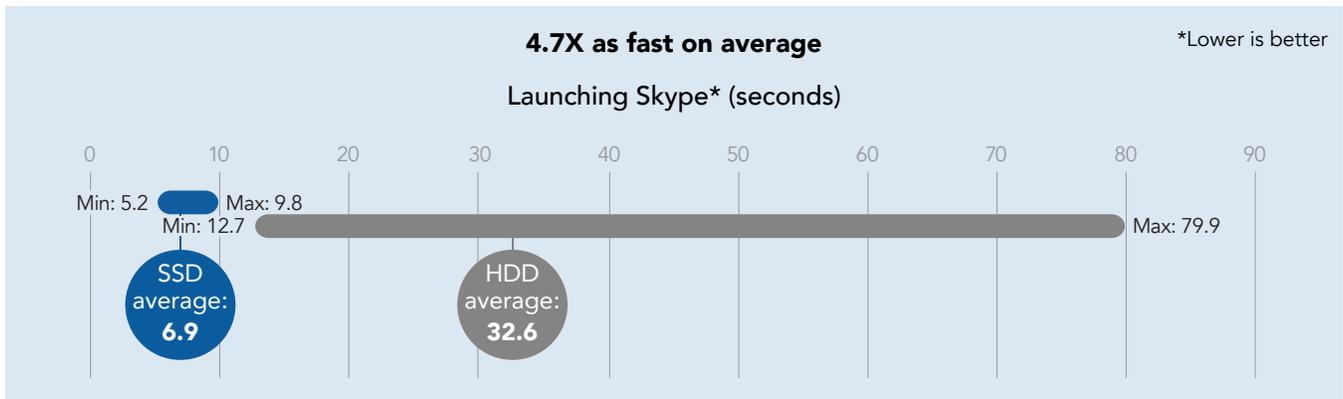
Backing your work up regularly can be a lifesaver when catastrophes happen, but there's no reason it should take any longer than absolutely necessary. Our experts found that Windows 10 laptops outfitted with SSD storage instead of HDD storage typically completed backups and file transfers in less time.





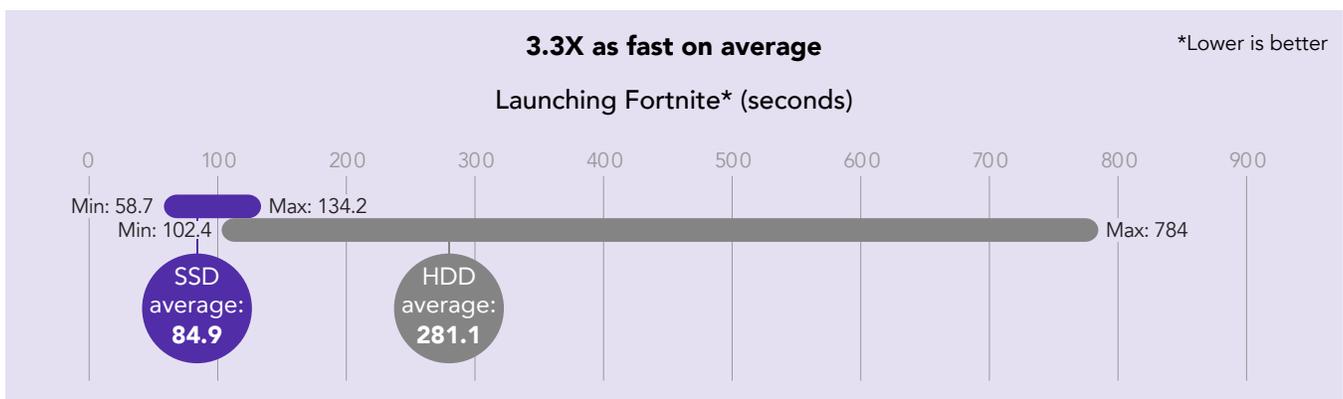
Keeping in touch

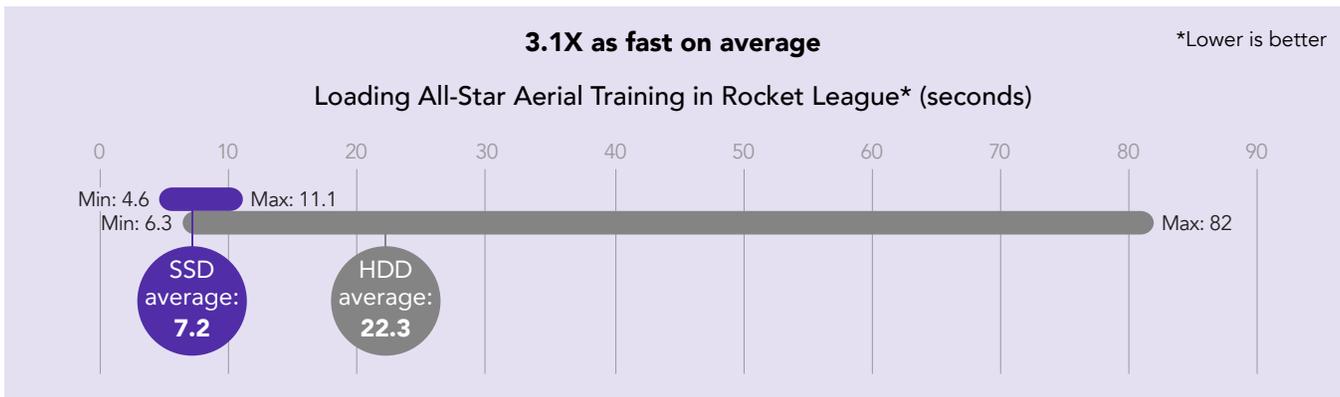
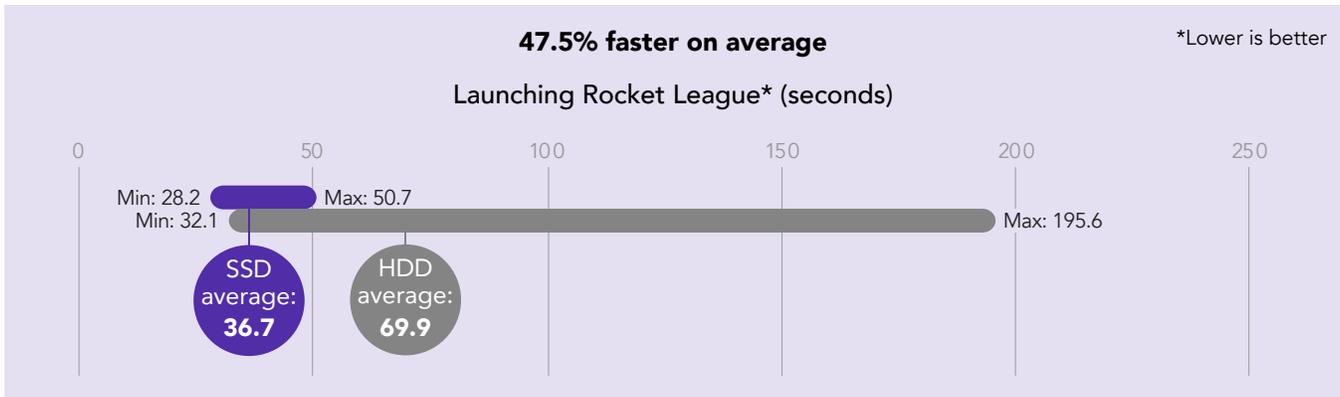
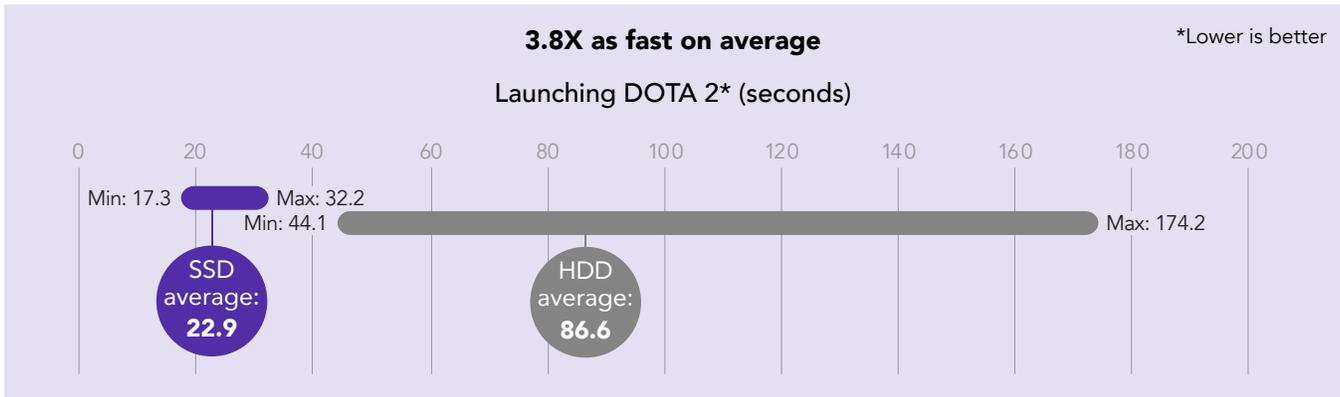
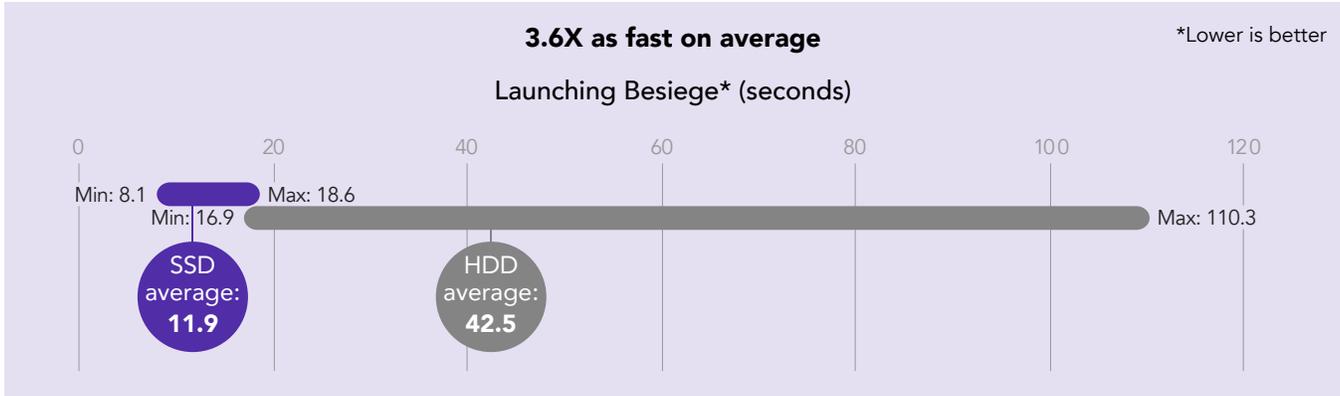
Using your laptop is a convenient way to spend a few minutes with friends and loved ones or conduct a business meeting when everyone can't be in the same location at the same time. But it's unprofessional, not to mention rude, to make someone wait for over a minute while your laptop struggles to join a Skype™ call. In our tests, the Windows 10 laptops running on SSD storage were up and running in under 10 seconds.



Playing online video games

According to Limelight Networks, "video gamers spend an average of 5.96 hours each week playing games" and "play for an average of one hour and 20 minutes at a time."¹ Losing an average of three minutes every time you launch Fortnite can really cut into play time. While launch and load times varied greatly across the games we used for this test, Windows 10 laptops equipped with SSD storage were generally up and running faster than those with HDD storage.







Conclusion

Your time is precious. Choosing a laptop that loads apps and transfers data as quickly as possible is one way to make sure you get the most from your time investment. Our hands-on testing found that most users could start their day-to-day activities faster with a Windows 10 laptop powered by SSD storage instead of HDD storage.

1 Limelight Networks, "State of Online Gaming -- 2019 Report", accessed November 20, 2019, <https://www.limelight.com/resources/white-paper/state-of-online-gaming-2018/#spend>

We concluded our hands-on testing on December 4, 2019. During testing, we determined the appropriate hardware and software configurations and applied updates as they became available. The results in this report reflect configurations that we finalized on October 24, 2019 or earlier. Unavoidably, these configurations may not represent the latest versions available when this report appears.

What we tested

This is a broad overview of the laptops we tested. For more detailed information, go to the [system configuration section](#).

Model number	Intel® processor family	Memory (RAM)	Storage type
Lenovo® IdeaPad™ S340	Core™ i3	4GB	HDD
Lenovo IdeaPad S340	Core i3	8GB	SSD
Lenovo IdeaPad S340	Core i3	8GB	HDD
Lenovo IdeaPad 330S	Core i3	4GB	SSD
Lenovo IdeaPad 330S	Core i5	8GB	SSD
Lenovo IdeaPad 330S	Core i5	8GB	HDD
HP Notebook – 14-cf0014dx	Core i3	8GB	SSD
HP Notebook – 14-cf0006dx	Core i3	4GB	SSD
HP Laptop – 15-dw0043dx	Core i5	8GB	SSD
Asus® ZenBook S UX391U	Core i7	8GB	SSD
Asus VivoBook Flip	Core i3	4GB	SSD
Microsoft Surface® Laptop 2	Core i5	8GB	SSD
Lenovo IdeaPad L340-15IWL	Core i7	8GB	HDD
Lenovo Yoga C930-13IKB	Core i7	8GB	SSD
HP Spectre x360 Convertible 13-ap0013dx	Core i7	8GB	SSD
HP Pavilion 15t-cs200	Core i7	8GB	HDD
HP Pavilion 15-cs0051wm	Core i5	8GB	HDD
Dell™ Inspiron™ 13-5378	Core i3	4GB	HDD
Dell Inspiron 15-5570	Core i3	8GB	SSD
Dell Inspiron 15-3567	Core i3	8GB	HDD
Dell Inspiron 15-3580	Core i7	8GB	HDD
Acer® Spin SP515-51N	Core i5	8GB	HDD
HP Laptop 15- DW0037WM	Core i3	8GB	HDD
HP Laptop 15-DA0032WM	Core i3	4GB	HDD

Our results

We ran each laptop through each test three times and use the median score to represent each laptop. The tables below present our findings in three ways. The first section is the high-level takeaway of SSD vs. HDD storage performance averages across all 24 laptops. The second section breaks down the SSD vs. HDD performance by processor and RAM specifications. The third section reports our findings for each laptop in detail.

High-level SSD vs. HDD storage performance results

The table below presents the SSD vs. HDD storage result averages across all laptops.

Hand-timed tasks on all laptops (Reported in Mbps)	Average HDD megabits of data	Average SSD megabits of data	Average time difference	Average SSD percentage win	Average SSD times (X) win
Iometer results					
Read speed	78.3	329.3	N/A	76.2%	4.2
Write speed	41.2	181.6	N/A	77.3%	4.4

Hand-timed tasks on all laptops (Reported in seconds)	Average HDD laptop wait time	Average SSD laptop wait time	Average time difference	Average SSD percentage win	Average SSD times (X) win
Applying a Windows update					
Updating from Microsoft RS4 to 1903	3617.9	1220.5	2397.4	66.3%	3.0
Checking your schedule					
Launching Calendar Microsoft app	6.7	1.9	4.8	71.6%	3.5
Collaborating through email					
Loading an Outlook video attachment	12.3	2.6	9.7	78.9%	4.7
Loading an Outlook image attachment	19.2	12.2	7.0	36.5%	1.6
Watching videos					
Opening and beginning playback of a 4.2GB HD video	13.0	2.8	10.2	78.5%	4.6
Listening to music					
Extracting a 1.6GB .zip WAV album from Bandcamp	80.3	21.9	58.4	72.7%	3.7
Managing finances					
Installing GnuCash	86.0	55.1	30.9	35.9%	1.6
Launching GnuCash	38.4	8.5	29.9	77.9%	4.5
Installing Money Manager Ex	2.9	1.6	1.3	44.8%	1.8
Launching Money Manager Ex	2.9	1.2	1.7	58.6%	2.4
Installing TurboCASH	45.6	17.9	27.7	60.7%	2.5
Launching TurboCASH	16.1	6.1	10.0	62.1%	2.6

Hand-timed tasks on all laptops (Reported in seconds)	Average HDD laptop wait time	Average SSD laptop wait time	Average time difference	Average SSD percentage win	Average SSD times (X) win
Editing documents					
Opening a 13.5MB Word file	25.2	4.1	21.1	83.7%	6.1
Compressing a 13.5MB Word file	3.5	1.5	2.0	57.1%	2.3
Opening a 23.2MB Excel file	28.9	8.6	20.3	70.2%	3.4
Backing-up and transferring files					
Copying 40 GB of files between system folders	1130.4	369.1	761.3	67.3%	3.1
Copying 40 GB of files from USB 3.0 to SSD/HDD	503.9	313.0	190.9	37.9%	1.6
Keeping in touch					
Launching Skype	32.6	6.9	25.7	78.8%	4.7
Playing online video games					
Launching Fortnite	281.1	84.9	196.2	69.8%	3.3
Launching Besiege	42.5	11.9	30.6	72.0%	3.6
Launching DOTA 2	86.6	22.9	63.7	73.6%	3.8
Launching Rocket League	69.9	36.7	33.2	47.5%	1.9
Loading All-Star Aerial Training in Rocket League	22.3	7.2	15.1	67.7%	3.1

SSD vs. HDD storage performance results broken down by processor and RAM

The tables below presents the SSD vs. HDD result averages determined by Intel processor, RAM, and storage type across all laptops.

Hand-timed tasks on laptops with Core i3 processors and 4GB RAM (Reported in Mbps)	Average HDD megabits of data	Average SSD megabits of data	Average time difference	Average SSD percentage win
Iometer results				
Read speed	60.8	295.2	N/A	79.4%
Write speed	20.6	123.1	N/A	83.3%

Hand-timed tasks on laptops with Core i3 processors and 4GB RAM (Reported in seconds)	Average HDD laptop wait time	Average SSD laptop wait time	Average time difference	Average SSD percentage win
Applying a Windows update				
Updating from Microsoft RS4 to 1903	4533.8	1567.7	2966.1	65.4%
Checking your schedule				
Launching Calendar Microsoft app	6.8	2.8	4.0	58.8%
Collaborating through email				
Loading an Outlook video attachment	18.8	2.9	15.9	84.6%
Loading an Outlook image attachment	24.8	17.0	7.8	31.5%
Watching videos				
Opening and beginning playback of a 4.2GB HD video	19.5	3.3	16.2	83.1%
Listening to music				
Extracting a 1.6GB .zip WAV album from Bandcamp	119.8	28.5	91.3	76.2%
Managing finances				
Installing GnuCash	107.7	70.4	37.3	34.6%
Launching GnuCash	48.6	10.6	38.0	78.2%
Installing Money Manager Ex	4.4	2.0	2.4	54.5%
Launching Money Manager Ex	4.4	1.5	2.9	65.9%
Installing TurboCASH	87.3	22.0	65.3	74.8%
Launching TurboCASH	20.2	7.5	12.7	62.9%
Editing documents				
Opening a 13.5MB Word file	41.5	5.3	36.2	87.2%
Compressing a 13.5MB Word file	3.8	1.8	2.0	52.6%
Opening a 23.2MB Excel file	31.6	11.9	19.7	62.3%

Hand-timed tasks on laptops with Core i3 processors and 4GB RAM (Reported in seconds)	Average HDD laptop wait time	Average SSD laptop wait time	Average time difference	Average SSD percentage win
Backing-up and transferring files				
Copying 40 GB of files between system folders	1376.9	460.8	916.1	66.5%
Copying 40 GB of files from USB 3.0 to SSD/HDD	608.4	369.4	239.0	39.3%
Keeping in touch				
Launching Skype	60.7	8.5	52.2	86.0%
Playing online video games				
Launching Fortnite	693.7	119.9	573.8	82.7%
Launching Besiege	85.5	15.7	69.8	81.6%
Launching DOTA 2	139.2	28.8	110.4	79.3%
Launching Rocket League	147.1	45.4	101.7	69.1%
Loading All-Star Aerial Training in Rocket League	62.6	9.3	53.3	85.1%

Hand-timed tasks on laptops with Core i3 processors and 8GB RAM (Reported in Mbps)	Average HDD megabits of data	Average SSD megabits of data	Average time difference	Average SSD percentage win
Iometer results				
Read speed	74.1	280.5	N/A	73.6%
Write speed	21.9	159.5	N/A	86.3%

Hand-timed tasks on laptops with Core i3 processors and 8GB RAM (Reported in seconds)	Average HDD laptop wait time	Average SSD laptop wait time	Average time difference	Average SSD percentage win
Applying a Windows update				
Updating from Microsoft RS4 to 1903	3329.2	1250.8	2078.4	62.4%
Checking your schedule				
Launching Calendar Microsoft app	8.7	2.3	6.4	73.6%
Collaborating through email				
Loading an Outlook video attachment	12.1	2.3	9.8	81.0%
Loading an Outlook image attachment	23.8	16.0	7.8	32.8%
Watching videos				
Opening and beginning playback of a 4.2GB HD video	15.1	3.0	12.1	80.1%
Listening to music				
Extracting a 1.6GB .zip WAV album from Bandcamp	81.0	21.6	59.4	73.3%

Hand-timed tasks on laptops with Core i3 processors and 8GB RAM (Reported in seconds)	Average HDD laptop wait time	Average SSD laptop wait time	Average time difference	Average SSD percentage win
Managing finances				
Installing GnuCash	61.6	59.6	2.0	3.2%
Launching GnuCash	45.2	8.3	36.9	81.6%
Installing Money Manager Ex	2.2	1.7	0.5	22.7%
Launching Money Manager Ex	2.2	1.2	1.0	45.5%
Installing TurboCASH	40.5	18.2	22.3	55.1%
Launching TurboCASH	18.4	6.0	12.4	67.4%
Editing documents				
Opening a 13.5MB Word file	31.7	5.0	26.7	84.2%
Compressing a 13.5MB Word file	4.4	1.4	3.0	68.2%
Opening a 23.2MB Excel file	32.3	9.1	23.2	71.8%
Backing-up and transferring files				
Copying 40 GB of files between system folders	1123.4	458.1	665.3	59.2%
Copying 40 GB of files from USB 3.0 to SSD/HDD	486.0	381.3	104.7	21.5%
Keeping in touch				
Launching Skype	34.0	6.7	27.3	80.3%
Playing online video games				
Launching Fortnite	122.9	87.2	35.7	29.0%
Launching Besiege	28.1	11.3	16.8	59.8%
Launching DOTA 2	75.7	22.9	52.8	69.7%
Launching Rocket League	40.9	36.8	4.1	10.0%
Loading All-Star Aerial Training in Rocket League	6.9	6.4	0.5	7.2%

Hand-timed tasks on laptops with Core i5 processors and 8GB RAM (Reported in Mbps)	Average HDD megabits of data	Average SSD megabits of data	Average time difference	Average SSD percentage win
Iometer results				
Read speed	82.4	373.0	N/A	77.9%
Write speed	48.3	171.7	N/A	71.9%

Hand-timed tasks on laptops with Core i5 processors and 8GB RAM (Reported in seconds)	Average HDD laptop wait time	Average SSD laptop wait time	Average time difference	Average SSD percentage win
Applying a Windows update				
Updating from Microsoft RS4 to 1903	3824.6	1103.6	2721.0	71.1%

Hand-timed tasks on laptops with Core i5 processors and 8GB RAM (Reported in seconds)	Average HDD laptop wait time	Average SSD laptop wait time	Average time difference	Average SSD percentage win
Checking your schedule				
Launching Calendar Microsoft app	4.8	1.2	3.6	75.0%
Collaborating through email				
Loading an Outlook video attachment	8.7	2.5	6.2	71.3%
Loading an Outlook image attachment	11.5	9.7	1.8	15.7%
Watching videos				
Opening and beginning playback of a 4.2GB HD video	9.7	2.3	7.4	76.3%
Listening to music				
Extracting a 1.6GB .zip WAV album from Bandcamp	71.4	19.6	51.8	72.5%
Managing finances				
Installing GnuCash	123.7	48.5	75.2	60.8%
Launching GnuCash	31.5	8.0	23.5	74.6%
Installing Money Manager Ex	2.9	1.4	1.5	51.7%
Launching Money Manager Ex	2.7	1.0	1.7	63.0%
Installing TurboCASH	34.6	17.9	16.7	48.3%
Launching TurboCASH	14.0	5.7	8.3	59.3%
Editing documents				
Opening a 13.5MB Word file	17.0	2.9	14.1	82.9%
Compressing a 13.5MB Word file	3.5	1.4	2.1	60.0%
Opening a 23.2MB Excel file	33.9	6.4	27.5	81.1%
Backing-up and transferring files				
Copying 40 GB of files between system folders	1060.2	341.3	718.9	67.8%
Copying 40 GB of files from USB 3.0 to SSD/HDD	450.6	254.6	196.0	43.5%
Keeping in touch				
Launching Skype	20.3	6.4	13.9	68.5%
Playing online video games				
Launching Fortnite	192.0	70.9	121.1	63.1%
Launching Besiege	32.5	11.0	21.5	66.2%
Launching DOTA 2	71.3	21.3	50.0	70.1%
Launching Rocket League	56.2	34.1	22.1	39.3%
Loading All-Star Aerial Training in Rocket League	13.2	7.5	5.7	43.2%

Hand-timed tasks on laptops with Core i7 processors and 8GB RAM (Reported in Mbps)	Average HDD megabits of data	Average SSD megabits of data	Average time difference	Average SSD percentage win
Iometer results				
Read speed	95.7	368.6	N/A	74.0%
Write speed	73.8	271.9	N/A	72.9%

Hand-timed tasks on laptops with Core i7 processors and 8GB RAM (Reported in seconds)	Average HDD laptop wait time	Average SSD laptop wait time	Average time difference	Average SSD percentage win
Applying a Windows update				
Updating from Microsoft RS4 to 1903	2784.1	959.9	1824.2	65.5%
Checking your schedule				
Launching Calendar Microsoft app	6.3	1.2	5.1	81.0%
Collaborating through email				
Loading an Outlook video attachment	9.7	2.5	7.2	74.2%
Loading an Outlook image attachment	16.6	6.2	10.4	62.7%
Watching videos				
Opening and beginning playback of a 4.2GB HD video	7.8	2.4	5.4	69.2%
Listening to music				
Extracting a 1.6GB .zip WAV album from Bandcamp	49.1	18.0	31.1	63.3%
Managing finances				
Installing GnuCash	50.8	41.9	8.9	17.5%
Launching GnuCash	28.1	7.1	21.0	74.7%
Installing Money Manager Ex	2.0	1.4	0.6	30.0%
Launching Money Manager Ex	2.1	1.2	0.9	42.9%
Installing TurboCASH	20.0	13.4	6.6	33.0%
Launching TurboCASH	11.7	5.0	6.7	57.3%
Editing documents				
Opening a 13.5MB Word file	10.6	3.1	7.5	70.8%
Compressing a 13.5MB Word file	2.3	1.3	1.0	43.5%
Opening a 23.2MB Excel file	17.7	6.9	10.8	61.0%
Backing-up and transferring files				
Copying 40 GB of files between system folders	961.1	216.3	744.8	77.5%
Copying 40 GB of files from USB 3.0 to SSD/HDD	470.7	246.5	224.2	47.6%

Hand-timed tasks on laptops with Core i7 processors and 8GB RAM (Reported in seconds)	Average HDD laptop wait time	Average SSD laptop wait time	Average time difference	Average SSD percentage win
Keeping in touch				
Launching Skype	15.3	6.0	9.3	60.8%
Playing online video games				
Launching Fortnite	115.8	61.4	54.4	47.0%
Launching Besiege	23.8	9.6	14.2	59.7%
Launching DOTA 2	60.1	18.6	41.5	69.1%
Launching Rocket League	35.2	30.4	4.8	13.6%
Loading All-Star Aerial Training in Rocket League	6.6	5.7	0.9	13.6%

SSD vs. HDD storage performance result averages for each laptop

The table below presents our findings for each laptop in detail.

Iometer results for laptops with Core i3 processors and 4GB RAM (Reported in Mbps)	Dell Inspiron 13-5378 HDD storage	Lenovo IdeaPad S340 HDD storage	HP Laptop 15 DA0032WM HDD storage	Asus VivoBook Flip SSD storage	HP Notebook 14-cf0006dx SSD storage	Lenovo IdeaPad 330S SSD storage
Read speed						
Average	50.2	49.8	82.4	254.3	268.8	362.5
Write speed						
Average	13.5	29.2	19.2	102.6	113.8	152.9
Hand-timed tasks on laptops with Core i3 processors and 4GB RAM (Reported in seconds)	Dell Inspiron 13-5378 HDD storage	Lenovo IdeaPad S340 HDD storage	HP Laptop 15 DA0032WM HDD storage	Asus VivoBook Flip SSD storage	HP Notebook 14-cf0006dx SSD storage	Lenovo IdeaPad 330S SSD storage
Updating Windows from RS4 to 1903						
Average	4967.9	4935.8	3697.6	1786.2	1634.7	1282.3
Launching Calendar Microsoft App						
Average	6.8	5.9	7.7	2.9	3.1	2.4
Loading an Outlook video attachment						
Average	17.4	19.8	19.1	2.7	3.4	2.7
Loading an Outlook image attachment						
Average	26.0	17.9	30.6	6.7	35.0	9.2
Opening and beginning playback of a 4.2GB 1080p HD video						
Average	20.9	12.7	24.8	3.5	3.3	3.0
Extracting a 1.6GB .zip WAV album from Bandcamp						
Average	218.3	51.4	89.7	30.2	31.0	24.3
Installing GnuCash						
Average	124.5	114.2	84.3	69.5	76.6	65.2
Launching GnuCash						
Average	47.5	55.3	43.0	11.6	11.6	8.6
Installing Money Manager Ex						
Average	7.1	3.2	2.8	1.9	2.3	1.8
Launching Money Manager Ex						
Average	5.8	4.0	3.4	1.3	1.6	1.5

Hand-timed tasks on laptops with Core i3 processors and 4GB RAM (Reported in seconds)	Dell Inspiron 13-5378 HDD storage	Lenovo IdeaPad S340 HDD storage	HP Laptop 15 DA0032WM HDD storage	Asus VivoBook Flip SSD storage	HP Notebook 14-cf0006dx SSD storage	Lenovo IdeaPad 330S SSD storage
Installing TurboCASH						
Average	162.5	61.5	37.8	23.1	26.1	16.8
Launching TurboCASH						
Average	29.5	16.2	15.0	7.7	8.6	6.3
Opening a 13.5MB Word file						
Average	54.1	24.7	45.7	6.3	5.4	4.1
Compressing a 13.5MB Word file						
Average	3.5	4.1	3.8	2.8	1.5	1.1
Opening a 23.2MB Excel file						
Average	16.6	35.3	42.8	14.3	9.7	11.6
Coping 40 GB of files between system folders						
Average	1522.8	1484.4	1123.5	503.6	478.0	400.8
Copying 40 GB of files from USB 3.0 to SSD/HDD						
Average	783.8	560.1	481.2	432.9	390.0	285.3
Launching Skype						
Average	79.9	48.6	53.6	8.8	9.8	6.8
Launching Fortnite						
Average	559.7	737.3	784.0	121.6	134.2	104.0
Launching Besiege						
Average	110.3	70.2	76.1	16.3	18.6	12.1
Launching DOTA 2						
Average	174.2	101.5	141.9	30.9	32.2	23.4
Launching Rocket League						
Average	195.6	73.7	172.0	45.3	50.7	40.1
Loading All-Star Aerial Training in Rocket League						
Average	82.0	27.9	77.8	8.0	11.1	8.7

Iometer results for laptops with Core i3 processors and 8GB RAM (Reported in Mbps)	Dell Inspiron 13-5378 HDD storage	HP Laptop 15-DW0037WM HDD storage	Lenovo IdeaPad S340 HDD storage	Asus VivoBook Flip SSD storage	HP Notebook 14-cf0006dx SSD storage	Lenovo IdeaPad 330S SSD storage
Read speed						
Average	64.0	88.4	69.9	286.1	257.8	297.5
Write speed						
Average	28.7	20.3	16.6	210.5	55.2	212.8
Hand-timed tasks on laptops with Core i3 processors and 8GB RAM (Reported in seconds)	Dell Inspiron 15-3567 HDD storage	HP Laptop 15-DW0037WM HDD storage	Lenovo IdeaPad S340 HDD storage	Dell Inspiron 15-5570 SSD storage	HP Notebook 14-cf0014dx SSD storage	Lenovo IdeaPad S340 SSD storage
Updating Windows from RS4 to 1903						
Average	4351.8	2771.1	2864.8	1245.1	1488.3	1019.1
Launching Calendar Microsoft App						
Average	14.5	4.7	7.0	2.1	2.8	1.9
Loading an Outlook video attachment						
Average	17.8	11.0	7.4	1.8	2.7	2.3
Loading an Outlook image attachment						
Average	14.9	42.7	13.9	7.1	32.5	8.5
Opening and beginning playback of a 4.2GB 1080p HD video						
Average	21.6	13.2	10.6	3.1	3.7	2.1
Extracting a 1.6GB .zip WAV album from Bandcamp						
Average	112.7	42.3	88.0	20.7	25.0	19.1
Installing GnuCash						
Average	52.4	62.1	70.4	53.3	77.2	48.4
Launching GnuCash						
Average	66.4	30.2	39.1	7.8	10.0	7.0
Installing Money Manager Ex						
Average	1.4	2.2	3.0	1.5	2.1	1.6
Launching Money Manager Ex						
Average	1.0	2.0	3.5	0.9	1.6	1.2
Installing TurboCASH						
Average	69.9	24.2	27.5	16.5	22.1	16.0

Hand-timed tasks on laptops with Core i3 processors and 8GB RAM (Reported in seconds)	Dell Inspiron 15-3567 HDD storage	HP Laptop 15-DW0037WM HDD storage	Lenovo IdeaPad S340 HDD storage	Dell Inspiron 15-5570 SSD storage	HP Notebook 14-cf0014dx SSD storage	Lenovo IdeaPad S340 SSD storage
Launching TurboCASH						
Average	23.5	11.4	20.2	5.6	7.1	5.2
Opening a 13.5MB Word file						
Average	58.1	20.0	16.9	4.8	6.2	4.0
Compressing a 13.5MB Word file						
Average	6.6	3.0	3.5	1.3	1.8	1.0
Opening a 23.2MB Excel file						
Average	48.7	21.6	26.7	9.6	9.1	8.6
Copying 40 GB of files between system folders						
Average	1316.8	1004.7	1048.7	344.8	710.4	319.1
Copying 40 GB of files from USB 3.0 to SSD/HDD						
Average	632.5	382.0	443.6	244.2	658.8	240.8
Launching Skype						
Average	55.5	19.0	27.6	6.2	8.4	5.4
Launching Fortnite						
Average	142.2	124.1	102.4	76.2	114.2	71.2
Launching Besiege						
Average	31.4	28.0	25.0	12.8	13.0	8.1
Launching DOTA 2						
Average	106.7	64.6	55.7	22.3	27.5	18.9
Launching Rocket League						
Average	42.7	36.1	43.9	33.4	45.2	31.7
Loading All-Star Aerial Training in Rocket League						
Average	7.3	6.4	7.0	5.3	8.7	5.3

Iometer results for laptops with Core i5 processors and 8GB RAM (Reported in Mbps)	HP Pavilion 15-cs0051wm HDD storage	Lenovo IdeaPad 3305 HDD storage	ACER Spin 5 5P515 HDD storage	HP Laptop 15-dw0043dx SSD storage	Lenovo IdeaPad 3305 SSD storage	Microsoft Surface Laptop 2 SSD storage
Read speed						
Average	56.3	84.9	106.0	376.9	377.0	365.0
Write speed						
Average	21.8	39.5	83.6	174.7	169.4	170.9
Hand-timed tasks on laptops with Core i5 processors and 8GB RAM (Reported in seconds)	HP Pavilion 15-cs0051wm HDD storage	Lenovo IdeaPad 3305 HDD storage	ACER Spin 5 5P515 HDD storage	HP Laptop 15-dw0043dx SSD storage	Lenovo IdeaPad 3305 SSD storage	Microsoft Surface Laptop 2 SSD storage
Updating Windows from RS4 to 1903						
Average	3635.7	5238.0	2600.1	1043.9	1162.8	1104.0
Launching Calendar Microsoft App						
Average	5.4	4.7	4.2	1.2	1.2	1.3
Loading an Outlook video attachment						
Average	7.2	12.3	6.5	3.4	2.6	1.5
Loading an Outlook image attachment						
Average	11.3	13.7	9.6	5.4	7.1	16.6
Opening and beginning playback of a 4.2GB 1080p HD video						
Average	6.5	11.5	11.1	2.4	2.3	2.3
Extracting a 1.6GB .zip WAV album from Bandcamp						
Average	92.7	85.0	36.4	19.3	19.5	20.1
Installing GnuCash						
Average	252.3	68.9	49.8	44.6	44.2	56.7
Launching GnuCash						
Average	21.2	34.4	38.8	7.2	8.0	8.7
Installing Money Manager Ex						
Average	4.4	2.4	2.0	1.4	1.2	1.6
Launching Money Manager Ex						
Average	3.2	2.7	2.1	1.0	0.9	1.1
Installing TurboCASH						
Average	50.5	32.4	20.8	15.1	20.9	17.6

Hand-timed tasks on laptops with Core i5 processors and 8GB RAM (Reported in seconds)	HP Pavilion 15-cs0051wm HDD storage	Lenovo IdeaPad 330S HDD storage	ACER Spin 5 5P515 HDD storage	HP Laptop 15-dw0043dx SSD storage	Lenovo IdeaPad 330S SSD storage	Microsoft Surface Laptop 2 SSD storage
Launching TurboCASH						
Average	17.2	12.0	12.7	5.4	5.4	6.2
Opening a 13.5MB Word file						
Average	22.2	22.5	6.4	2.3	2.6	3.7
Compressing a 13.5MB Word file						
Average	5.4	3.4	1.7	1.2	1.4	1.5
Opening a 23.2MB Excel file						
Average	53.4	37.8	10.5	6.0	5.7	7.6
Copying 40 GB of files between system folders						
Average	970.4	1321.3	888.9	364.6	365.9	293.3
Copying 40 GB of files from USB 3.0 to SSD/HDD						
Average	433.1	491.4	427.4	252.7	257.8	253.3
Launching Skype						
Average	17.4	23.6	19.8	6.1	5.9	7.3
Launching Fortnite						
Average	338.7	122.7	114.7	63.9	68.6	80.1
Launching Besiege						
Average	40.4	33.3	23.7	11.0	11.5	10.5
Launching DOTA 2						
Average	75.6	75.4	62.9	20.0	22.5	21.3
Launching Rocket League						
Average	78.5	51.8	38.4	33.1	38.4	30.7
Loading All-Star Aerial Training in Rocket League						
Average	23.1	10.1	6.3	6.5	9.7	6.4

Iometer results for laptops with Core i7 processors and 8GB RAM (Reported in Mbps)	Lenovo IdeaPad L340 HDD storage	HP Pavilion 15t-cs200 HDD storage	Dell Inspiron 15-3580 HDD storage	HP Spectre x360 Convertible 13-ap0013dx SSD storage	Asus ZenBook S UX391U SSD storage	Lenovo Yoga C930-131KB SSD storage
Read speed						
Average	110.2	101.5	75.4	393.2	327.9	384.8
Write speed						
Average	106.1	97.4	17.9	328.1	210.5	277.0
Hand-timed tasks on laptops with Core i7 processors and 8GB RAM (Reported in seconds)	Lenovo IdeaPad L340 HDD storage	HP Pavilion 15t-cs200 HDD storage	Dell Inspiron 15-3580 HDD storage	HP Spectre x360 Convertible 13-ap0013dx SSD storage	Asus ZenBook S UX391U SSD storage	Lenovo Yoga C930-131KB SSD storage
Updating Windows from RS4 to 1903						
Average	2407.8	2334.3	3610.2	959.6	1004.6	915.5
Launching Calendar Microsoft App						
Average	10.6	3.6	4.8	1.1	1.3	1.2
Loading an Outlook video attachment						
Average	6.4	10.4	12.3	2.7	2.7	2.1
Loading an Outlook image attachment						
Average	10.5	12.6	26.6	8.4	2.2	8.0
Opening and beginning playback of a 4.2GB 1080p HD video						
Average	7.1	8.5	7.9	2.4	2.6	2.3
Extracting a 1.6GB .zip WAV album from Bandcamp						
Average	41.5	33.5	72.4	19.0	19.7	15.4
Installing GnuCash						
Average	50.0	57.8	44.5	39.2	47.1	39.5
Launching GnuCash						
Average	26.8	31.3	26.2	7.0	7.5	6.8
Installing Money Manager Ex						
Average	1.8	1.9	2.2	1.2	1.6	1.3
Launching Money Manager Ex						
Average	2.2	2.2	2.0	1.0	1.6	1.1
Installing TurboCASH						
Average	22.0	19.4	18.5	13.4	14.3	12.6

Hand-timed tasks on laptops with Core i7 processors and 8GB RAM (Reported in seconds)	Lenovo IdeaPad L340 HDD storage	HP Pavilion 15t-cs200 HDD storage	Dell Inspiron 15-3580 HDD storage	HP Spectre x360 Convertible 13-ap0013dx SSD storage	Asus ZenBook S UX391U SSD storage	Lenovo Yoga C930-13IKB SSD storage
Launching TurboCASH						
Average	11.8	12.8	10.6	4.7	5.5	4.8
Opening a 13.5MB Word file						
Average	6.8	10.1	15.0	3.2	2.5	3.7
Compressing a 13.5MB Word file						
Average	1.6	1.5	3.9	1.0	1.3	1.6
Opening a 23.2MB Excel file						
Average	8.7	8.5	36.0	6.2	7.3	7.1
Copying 40 GB of files between system folders						
Average	861.6	842.5	1179.1	147.1	340.7	161.1
Copying 40 GB of files from USB 3.0 to SSD/HDD						
Average	442.9	438.6	530.6	251.1	243.4	245.1
Launching Skype						
Average	16.3	16.8	12.7	5.2	6.8	5.9
Launching Fortnite						
Average	113.2	115.8	118.3	58.7	65.1	60.4
Launching Besiege						
Average	31.8	22.7	16.9	9.6	10.8	8.3
Launching DOTA 2						
Average	65.4	70.7	44.1	18.6	19.9	17.3
Launching Rocket League						
Average	36.5	37.0	32.1	33.6	29.3	28.2
Loading All-Star Aerial Training in Rocket League						
Average	6.8	6.7	6.3	7.6	4.8	4.6

System configuration information

The table below presents detailed information on the systems we tested.

System	Lenovo IdeaPad S340	Lenovo IdeaPad S340	Lenovo IdeaPad S340	Lenovo IdeaPad 330S
Processor				
Vendor	Intel	Intel	Intel	Intel
Name	Core i3	Core i3	Core i3	Core i3
Model number	8145U	8145U	8145U	8130U
Core frequency (GHz)	2.1 – 3.9	2.1 – 3.9	2.1 – 3.9	2.2 – 3.4
Number of cores	2	2	2	2
Cache	4 MB SmartCache	4 MB SmartCache	4 MB SmartCache	4 MB SmartCache
Memory				
Amount (GB)	4	8	8	4
Type	DDR4	DDR4	DDR4	DDR4
Speed (MHz)	2,400	2,400	2,400	2,400
Graphics				
Vendor	Intel	Intel	Intel	Intel
Model number	UHD Graphics 620	UHD Graphics 620	UHD Graphics 620	UHD Graphics 620
Storage				
Amount	1 TB	256 GB	1 TB	128 GB
Type	SATA HDD	SATA SSD	SATA HDD	SATA SSD
Connectivity/expansion				
Wired ethernet	N/A	N/A	N/A	N/A
Wireless ethernet	Qualcomm QCA377	Intel Wireless-AC 9462	Qualcomm QCA9377	Intel Wireless-AC 3165
Bluetooth	4.2	5.0	4.2	4.2
USB	2 x USB 3.1 1 x USB Type-C			
Video	HDMI	HDMI	HDMI	HDMI
Battery				
Type	3 cell Li-ion	3 cell Li-ion	3 cell Li-ion	2 cell Lithium-ion
Rated capacity	36 Wh	36 Wh	36 Wh	30 Wh
Display				
Size (in.)	15.6	15.6	15.6	15.6
Type	LCD	LCD	LCD	LED
Resolution	1366 x 768	1366 x 768	1366 x 768	1366 x 768
Touchscreen	No	No	No	No

System	Lenovo IdeaPad S340	Lenovo IdeaPad S340	Lenovo IdeaPad S340	Lenovo IdeaPad 330S
Operating system				
Vendor	Microsoft	Microsoft	Microsoft	Microsoft
Name	Windows 10 Home	Windows 10 Home	Windows 10 Home	Windows 10 Home
Build number or version	10.0.18362	10.0.18362	10.0.18363	10.0.18362
BIOS				
BIOS name and version	LENOVO V2.01	LENOVO V2.01	LENOVO ALCN27WW(V2.04)	LENOVO 7SCN32WW
Dimensions				
Height (in)	0.7	0.7	0.7	0.76
Width (in)	14.1	14.1	14.1	14.1
Depth (in)	9.6	9.6	9.6	9.6
Weight (lbs.)	3.96	3.96	3.96	4.12

System	Lenovo IdeaPad 330S	Lenovo IdeaPad 330S	HP Notebook – 14-cf0014dx	HP Notebook – 14-cf0006dx
Processor				
Vendor	Intel	Intel	Intel	Intel
Name	Core i5	Core i5	Core i3	Core i3
Model number	8250U	8250U	7100U	7100U
Core frequency (GHz)	1.6 – 3.4	1.6 – 3.4	2.4	2.4
Number of cores	4	4	2	2
Cache	6 MB SmartCache	6 MB SmartCache	3 MB SmartCache	3 MB SmartCache
Memory				
Amount (GB)	8	8	8	4
Type	DDR4	DDR4	DDR4	DDR4
Speed (MHz)	2,400	2,400	2,133	2,133
Graphics				
Vendor	Intel	Intel	Intel	Intel
Model number	UHD Graphics 620	UHD Graphics 620	HD Graphics 620	HD Graphics 620
Storage				
Amount	128 GB	1 TB	256 GB	128 GB
Type	SATA SSD	SATA HDD	SATA SSD	M.2 SSD

System	Lenovo IdeaPad 330S	Lenovo IdeaPad 330S	HP Notebook – 14-cf0014dx	HP Notebook – 14-cf0006dx
Connectivity/expansion				
Wired ethernet	N/A	N/A	Realtek PCIe GbE	Realtek PCIe GbE
Wireless ethernet	Qualcomm Atheros QCA9377	Qualcomm Atheros QCA9377	Realtek RTL8723DE	Realtek RTL8723DE
Bluetooth	4.2	4.2	4.2	4.2
USB	2 x USB 3.1 1 x USB Type-C			
Video	HDMI	HDMI	HDMI	HDMI
Battery				
Type	2 cell Lithium-ion	2 cell Lithium-ion	3 Cell Lithium-ion	3 Cell Lithium-ion
Rated capacity	30 Wh	30 Wh	41 Wh	41 Wh
Display				
Size (in.)	15.6	15.6	14	14
Type	LED	LED	WLED Backlit	WLED Backlit
Resolution	1366 x 768	1366 x 768	1366 x 768	1366 x 768
Touchscreen	No	No	No	No
Operating system				
Vendor	Microsoft	Microsoft	Microsoft	Microsoft
Name	Windows 10 Home	Windows 10 Home	Windows 10 Home	Windows 10 Home
Build number or version	10.0.18362	10.0.18362	10.0.18362	10.0.18362
BIOS				
BIOS name and version	LENOVO 7SCN32WW	LENOVO 7SCN32WW	Insyde F.14	Insyde F.37
Dimensions				
Height (in)	0.76	0.76	0.78	0.78
Width (in)	14.1	14.1	12.8	12.8
Depth (in)	9.6	9.6	8.9	8.9
Weight (lbs.)	4.12	4.12	3.15	3.15

System	HP Laptop – 15-dw0043dx	Asus ZenBook S UX391U	Asus VivoBook Flip	Microsoft Surface Laptop 2
Processor				
Vendor	Intel	Intel	Intel	Intel
Name	Core i5	Core i7	Core i3	Core i5
Model number	8265U	8550U	6100U	8350U
Core frequency (GHz)	1.6 – 3.9	1.8 – 4.0	2.3	1.7 – 3.6
Number of cores	4	4	2	4
Cache	6 MB SmartCache	8 MB Intel Smart Cache	3 MB	6 MB Intel Smart Cache

System	HP Laptop – 15-dw0043dx	Asus ZenBook S UX391U	Asus VivoBook Flip	Microsoft Surface Laptop 2
Memory				
Amount (GB)	8	8	4	8
Type	DDR4	LPDDR3	DDR4	LPDDR3
Speed (MHz)	2,400	2,133	2,133	1,866
Graphics				
Vendor	Intel	Intel	Intel	Intel
Model number	UHD Graphics 620	UHD Graphics 620	HD Graphics 520	UHD Graphics 620
Storage				
Amount	128 GB	256 GB	128 GB	128 GB
Type	SATA SSD	PCIe SSD	M.2 SSD	PCIe SSD
Connectivity/expansion				
Wired ethernet	Realtek PCIe GbE	N/A	Realtek PCIe GbE Family Controller	N/A
Wireless ethernet	Realtek RTL8821CE	Intel Wireless-AC 8265	Intel Dual Band Wireless-AC 7265	Marvell AVASTAR Wireless-AC
Bluetooth	4.2	4.2	4.0	4.2
USB	2 x USB 3.1 1 x USB Type-C	2 x Thunderbolt 1 x USB Type-C	1 x HDMI 2 x USB 3.0 1 x USB 1 x USB Type-C	1 x USB 3.0
Video	HDMI	N/A	N/A	1 x Mini DisplayPort
Battery				
Type	3 Cell Li-ion	4 cell Lithium-Ion	2 cell Polymer	4 cell Lithium-Ion
Rated capacity	42 Wh	50 Wh	38 Wh	45.2 Wh
Display				
Size (in.)	15.6	13.3	15.6	13.5
Type	LED Backlit	LED	LED	LED
Resolution	1366 x 768	1920 x 1080	1366 x 768	2256 x 1504
Touchscreen	Yes	No	Yes	Yes
Operating system				
Vendor	Microsoft	Microsoft	Microsoft	Microsoft
Name	Windows 10 Home	Windows 10 Pro	Windows 10 Home	Windows 10 Pro
Build number or version	10.0.18362	10.0.18362	10.0.18362	10.0.18362
BIOS				
BIOS name and version	Insyde F.13	American Megatrends Inc. UX391UA.204	American Megatrends Inc. TP501UAM.201	Microsoft Corporation 137.2706.768

System	HP Laptop – 15-dw0043dx	Asus ZenBook S UX391U	Asus VivoBook Flip	Microsoft Surface Laptop 2
Dimensions				
Height (in)	0.78	0.5	0.9	.57
Width (in)	14.11	12.2	14.8	12.13
Depth (in)	9.53	8.4	10	8.79
Weight (lbs.)	3.84	2.3	4.9	2.76

System	Lenovo IdeaPad L340-15IWL	Lenovo Yoga C930-13IKB	HP Spectre x360 Convertible 13-ap0013dx	HP Pavilion 15t-cs200
Processor				
Vendor	Intel	Intel	Intel	Intel
Name	Core i7	Core i7	Core i7	Core i7
Model number	8565U	8550U	8565U	8565U
Core frequency (GHz)	1.8 – 4.60	1.8 – 4.00	1.8 - 4.6	1.8 – 4.6
Number of cores	4	4	4	4
Cache	8 MB Intel Smart Cache	8 MB Intel Smart Cache	8 MB Intel Smart Cache	8 MB Intel Smart Cache
Memory				
Amount (GB)	8	8	8	8
Type	DDR4	DDR4	DDR4	DDR4
Speed (MHz)	2,666	2,400	2,400	2,667
Graphics				
Vendor	Intel	Intel	Intel	Intel
Model number	UHD Graphics 620	UHD Graphics 620	UHD Graphics 620	UHD Graphics 620
Storage				
Amount	1 TB	256 GB	256 GB	1 TB
Type	HDD	SSD	SSD	HDD
Connectivity/expansion				
Wired ethernet	Realtek PCIe GbE Family Controller	N/A	N/A	Realtek PCIe GbE Family Controller
Wireless ethernet	Qualcomm Atheros QCA9377	Intel Wireless-AC 9260	Intel Wireless-AC 9560	Intel Wireless-AC 9461
Bluetooth	4.2	5.0	5.0	5.0
USB	2 x USB 3.0 1 x USB Type-C	1 x USB 3.1 2 x Thunderbolt	1 x USB 3.1 1 x USB-C	2 x USB 3.1 1 x USB-C
Video	1 x HDMI	N/A	N/A	1 x HDMI
Battery				
Type	3 cell Lithium-Ion	4 cell Lithium-Polymer	Lithium-Ion	3 cell Lithium-Ion
Rated capacity	36 Wh	60 Wh	60 Wh	42 Wh

System	Lenovo IdeaPad L340-15IWL	Lenovo Yoga C930-13IKB	HP Spectre x360 Convertible 13-ap0013dx	HP Pavilion 15t-cs200
Display				
Size (in.)	15.6	13.9	13.3	15.6
Type	LED	IPS LED	WLED	WLED
Resolution	1366x768	1920x1080	1920 x 1080	1366 x 768
Touchscreen	No	Yes	Yes	Yes
Operating system				
Vendor	Microsoft	Microsoft	Microsoft	Microsoft
Name	Windows 10 Home	Windows 10 Home	Windows 10 Home	Windows 10 Home
Build number or version	10.0.18362	10.0.18362	10.0.18362	10.0.18362
BIOS				
BIOS name and version	ATCN14WW	LENOVO 8GCN32WW	AMI F.14	Insyde F.19
Dimensions				
Height (in)	0.9	.57	0.61	.7
Width (in)	14.3	12.7	12.16	14.24
Depth (in)	10	8.9	8.58	9.67
Weight (lbs.)	4.5	3.04	4.41	4.27

System	HP Pavilion 15-cs0051wm	Dell Inspiron 13-5378	Dell Inspiron 15-5570	Dell Inspiron 15-3567
Processor				
Vendor	Intel	Intel	Intel	Intel
Name	Core i5	Core i3	Core i3	Core i3
Model number	8250U	7100U	8130U	7130U
Core frequency (GHz)	1.6 – 3.4	2.4	2.2 - 3.4	2.7
Number of cores	4	2	2	2
Cache	6 MB Intel Smart Cache	3 MB Intel Smart Cache	4 MB SmartCache	3 MB SmartCache
Memory				
Amount (GB)	8	4	8	8
Type	DDR4	DDR4	DDR4	DDR4
Speed (MHz)	2,400	2,400	2,400	2,400
Graphics				
Vendor	Intel	Intel	Intel	Intel
Model number	UHD Graphics 620	HD Graphics 620	UHD Graphics 620	HD Graphics 620

System	HP Pavilion 15-cs0051wm	Dell Inspiron 13-5378	Dell Inspiron 15-5570	Dell Inspiron 15-3567
Storage				
Amount	1 TB	1 TB	256 GB	1 TB
Type	HDD	SATA HDD	SATA SSD	SATA HDD
Connectivity/expansion				
Wired ethernet	Realtek PCIe GbE Family Controller	N/A	Realtek PCIe FE Family Controller	Realtek PCIe FE Family Controller
Wireless ethernet	Intel Wireless-AC 7265	Qualcomm QCA61x4A	Intel Wireless-AC 3165	Qualcomm QCA9565
Bluetooth	4.2	4.2	4.2	4.0
USB	2 x USB 3.1 1 x USB-C	2x USB 3.0 1x USB 2.0	2x USB 3.0 1x USB 2.0	2x USB 3.1 1x USB 2.0
Video	1 x HDMI	HDMI	HDMI	HDMI
Battery				
Type	3 cell Lithium-Ion	3 cell Lithium-Ion	3 cell Lithium-Ion	4 cell Lithium-Ion
Rated capacity	42 Wh	42 Wh	42 Wh	40 Wh
Display				
Size (in.)	15.6	13.3	15.6	15.6
Type	WLED	WLED	LED	LED
Resolution	1366 x 768	1920 x 1080	1920 x 1080	1366 x 768
Touchscreen	Yes	Yes	Yes	No
Operating system				
Vendor	Microsoft	Microsoft	Microsoft	Microsoft
Name	Windows 10 Home	Windows 10 Home	Windows 10 Home	Windows 10 Home
Build number or version	10.0.18362	10.0.18362	10.0.18362	10.0.18362
BIOS				
BIOS name and version	Insyde F.04	Dell Inc. 1.27.0	Dell Inc. 1.2.3	Dell Inc. 2.9.0
Dimensions				
Height (in)	.7	0.8	.89	0.93
Width (in)	14.17	12.8	15	14.96
Depth (in)	9.45	8.8	10.2	10.25
Weight (lbs.)	4.25	3.7	4.9	4.95

System	Dell Inspiron 15-3580	Acer Spin SP515-51N	HP Laptop 15-DW0037WM	HP Laptop 15-DA0032WM
Processor				
Vendor	Intel	Intel	Intel	Intel
Name	Core i7	Core i5	Core i3	Core i3
Model number	8565U	8250U	8145U	8130U
Core frequency (GHz)	1.80	1.60	2.10	2.20
Number of cores	4	4	2	2
Cache	3 MB Intel Smart Cache	6 MB SmartCache	4 MB SmartCache	4 MB Intel Smart Cache
Memory				
Amount (GB)	8	8	8	4
Type	DDR4	DDR4	DDR4	DDR4
Speed (MHz)	2,400	2,400	2,400	2,400
Graphics				
Vendor	Intel	Intel	Intel	Intel
Model number	HD Graphics 620	UHD Graphics 620	HD Graphics 620	HD Graphics 620
Storage				
Amount	1 TB	1 TB	1 TB	1 TB
Type	SATA HDD	SATA HDD	SATA HDD	SATA HDD
Connectivity/expansion				
Wired ethernet	Realtek PCIe FE Family Controller	N/A	Realtek PCIe FE Family Controller	Realtek PCIe FE Family Controller
Wireless ethernet	Qualcomm QCA9377	Qualcomm Atheros QCA61x4A	RealTek RTL8821CE PCIe Adapter	Realtek RTL8821CE PCIe Adapter 4.2
Bluetooth	4.1	4.1	4.2	4.2
USB	2x USB 3.1 Gen1 1x USB 2.0	2x USB 3.0 1x USB 3.1 Gen1 1x USB 2.0	2x USB 3.1 Gen1 1x USB 2.0	2x USB 3.1 Gen1 1x USB 2.0
Video	HDMI	HDMI	HDMI	HDMI
Battery				
Type	3 cell Lithium-Ion	3 cell Lithium-Ion	4 cell Lithium-Ion	3 cell Lithium-Ion
Rated capacity	42 Wh	3320 mAh	41 Wh	41 Wh
Display				
Size (in.)	15.6	15.6	15.6	15.6
Type	LED	LED IPS	WLED	WLED
Resolution	1920 x 1080	1920 x 1080	1366 x 768	1366 x 768
Touchscreen	No	Yes	No	No

System	Dell Inspiron 15-3580	Acer Spin SP515-51N	HP Laptop 15-DW0037WM	HP Laptop 15-DA0032WM
Operating system				
Vendor	Microsoft	Microsoft	Microsoft	Microsoft
Name	Windows 10 Home	Windows 10 Home	Windows 10 Home	Windows 10 Home
Build number or version	10.0.18362	10.0.18362	10.0.18362	10.0.18362
BIOS				
BIOS name and version	Dell Inc. 1.5.1	Insyde Corp. 1.09	Insyde F.13	Insyde F.07
Dimensions				
Height (in)	0.89	0.70	0.89	0.9
Width (in)	14.96	15	14.80	14.8
Depth (in)	10.16	10.2	9.69	9.7
Weight (lbs.)	4.8	4.85	3.91	4.59

How we tested

Creating the background workload

To simulate typical system use, we ran a combination of news, email, chat, document viewing, music, and social media websites in the background. For websites that required accounts, we created test profiles and logged in the users on each device.

1. From the Desktop, open Chrome and Chrome settings.
2. Navigate to On Startup, and select Open a specific page or set of pages.
3. Select Open a specific page or set of pages, insert the following URLs, and click OK.
 - reddit.com/r/pics
 - instagram.com/microsoft
 - simple.wikipedia.org
 - mail.google.com
 - slack.com
 - drive.google.com
 - docs.google.com
 - youtube.com/feed/music
 - sheets.google.com
 - twitter.com/microsoft
 - facebook.com/microsoft
4. Restart the system before each test run. Before testing, navigate through each tab to ensure that the device has fully loaded all the content.

Collaborating through email

Loading an Outlook video attachment

1. Launch Outlook.
2. Navigate to the email with the video attachment.
3. Click the drop-down arrow on the video attachment, and click Open.
4. Simultaneously start the timer and click Open.
5. When video playback begins, stop the timer.
6. Restart the system, and repeat steps 1-5 two more times.

Loading an Outlook image attachment

1. Launch Outlook.
2. Navigate to the email with the image attachment.
3. On the image attachment, click the drop-down arrow.
4. Simultaneously start the timer and click Open.
5. When the image fully loads, stop the timer.
6. Restart the system, and repeat steps 1-5 two more times.

Watching videos

Opening and beginning playback of 4.2GB 1080p HD Video

1. Download and install VLC media player.
2. Simultaneously start the timer and open 4.2GB video with VLC media player.
3. When video playback begins, stop the timer.
4. Restart the system, and repeat steps 2-3 two more times.

Listening to music

Extracting a 1.6GB .zip WAV album from Bandcamp

1. Download 1.6GB WAV .zip album from Bandcamp.
2. Right-click the downloaded album.
3. Select Extract All...
4. Select the destination for the extracted files.
5. Simultaneously start the timer and click Extract.
6. When all files are extracted, stop the timer.
7. Restart the system, and repeat steps 2-6 two more times.

Managing finances

Installing GnuCash

1. Download GnuCash.
2. Open the GnuCash setup.
3. Click Yes to allow the app to make changes to your device.
4. Select language, and click OK.
5. Accept the agreement, and click Next.
6. Click Next two times.
7. Simultaneously start the timer and click Install.
8. When GnuCash fully installs, stop the timer.
9. Uninstall GnuCash.
10. Restart the system, and repeat steps 2-9 two more times.

Launching GnuCash

1. Simultaneously start the timer and launch GnuCash.
2. When GnuCash fully loads, stop the timer.
3. Restart the system, and repeat steps 1-2 two more times.

Installing Money Manager Ex

1. Download Money Manager Ex.
2. Open the Money Manager Ex Setup.
3. Click Yes to allow the app to make changes to your device.
4. Select language, and click OK.
5. Click Next.
6. Accept the agreement, and click Next.
7. Click Next five times.
8. Simultaneously start the timer and click Install.
9. When Money Manager Ex fully installs, stop the timer.
10. Click Next.
11. Uncheck Launch Money Manager Ex, and click Finish.
12. Uninstall Money Manager Ex.
13. Restart the system, and repeat steps 2-12 two more times.

Launching Money Manager Ex

1. Launch Money Manager Ex.
2. Click Open Existing Database.
3. Select the Test Database.
4. Simultaneously start the timer and click Open.
5. When the database fully loads, stop the timer.
6. Restart the system, and repeat steps 1-5 two more times.

Installing TurboCASH

1. Download TurboCASH 4.
2. Open the TurboCASH 4 setup.
3. Click Yes to allow the app to make changes to your device.
4. Select language, and click OK.
5. Click Next.
6. Accept the agreement, and click Next.
7. Click Next four times.
8. Simultaneously start the timer and click Install.
9. When TurboCASH 4 fully installs, stop the timer.
10. Uncheck all boxes at the end of the setup, and click Finish.
11. (First install only) Launch TurboCASH 4.
12. (First install only) Select language, and click OK.
13. (First install only) Close TurboCASH 4.
14. (First install only) Uninstall TurboCASH 4.
15. Uninstall TurboCASH 4.
16. Restart the system, and repeat steps 2-9 two more times.

Launching TurboCASH

1. Simultaneously start the timer and launch TurboCASH 4.
2. When the splash screen disappears, stop the timer.
3. Restart the system, and repeat steps 1-2 two more times.

Editing a document

Opening a 13.5MB Word file

1. Simultaneously start the timer and open the sample large Word file.
2. When the Word file fully loads, stop the timer.
3. Restart the system, and repeat steps 1-2 two more times.

Compressing a 13.5MB Word file

1. Right-click the sample large Word file.
2. Navigate to Send to.
3. Simultaneously start the timer and click Compressed (zipped) folder.
4. When the Word file fully compresses, stop the timer.
5. Restart the system, and repeat steps 1-4 two more times.

Opening a 23.2MB Excel file

1. Simultaneously start the timer and open the sample large Excel file.
2. When the Excel file fully loads, stop the timer.
3. Restart the system, and repeat steps 1-2 two more times.

Backing up and transferring files

Copying 40 GB of files between folders

1. Copy the folder with 40 GB of test files.
2. Open file explorer, and navigate to the desired destination.
3. Simultaneously start the timer and paste the folder into the new destination.
4. When the transfer is complete, stop the timer.
5. Delete and remove the copy of the 40 GB of test files.
6. Restart the system, and repeat steps 1-5 two more times.

Copying 40 GB of files from USB 3.0 to SSD/HDD

1. Connect a USB 3.0 drive with 40GB folder to a USB 3.0 port on system.
2. Copy the 40GB folder from the USB 3.0 drive.
3. Simultaneously start the timer and paste the folder onto the desktop.
4. When the transfer is complete, stop the timer.
5. Delete and remove the 40 GB of test files.
6. Restart the system, and repeat steps 1-5 two more times.

Keeping in touch

Launching Skype

1. Download and install Skype for Windows.
2. After going through the first-time login or account setup, close Skype.
3. Simultaneously start the timer and launch Skype.
4. When Skype fully loads, stop the timer.
5. Restart the system, and repeat steps 3-4 two more times.

Playing online video games

Before running these tests, we downloaded and installed the Steam app as well as the Epic Games Launcher for Windows to download and install the games needed.

Launching Fortnite

1. Open the Epic Games Launcher.
2. Download and install Fortnite.
3. Once Fortnite is installed, simultaneously start the timer and click launch to launch Fortnite.
4. Stop the timer when Fortnite fully loads and reaches the main menu.
5. Restart the system, and repeat steps 3-4 two more times.

Launching Besiege

1. Open Steam.
2. Navigate to Library.
3. Download and install Besiege.
4. Once Besiege is installed, simultaneously start the timer and click Play to launch Besiege.
5. Stop the timer when Besiege fully loads and reaches the main menu.
6. Restart the system, and repeat steps 4-5 two more times.

Launching DOTA 2

1. Open Steam.
2. Navigate to Library.
3. Download and install DOTA 2.
4. Once DOTA 2 is installed, simultaneously start the timer and click play to launch DOTA 2.
5. Stop the timer when DOTA 2 fully loads and the character appears on the main menu.
6. Restart the system, and repeat steps 4-5 two more times.

Launching Rocket League

1. Open Steam.
2. Navigate to Library.
3. Download and install Rocket League.
4. Once Rocket League is installed, simultaneously start the timer and click play to launch Rocket League.
5. Stop the timer when Rocket League launches, and the Unreal Engine logo appears.
6. Restart the system, and repeat steps 4-5 two more times.

Loading All-Star Aerial Training in Rocket League

1. Open Steam.
2. Navigate to Library.
3. Launch Rocket League.
4. On the main menu, click Training.
5. Click Aerial.
6. Simultaneously start the timer and click All-Star.
7. When the level fully loads, stop the timer.
8. Restart the system, and repeat steps 1-7 two more times.

Checking your schedule

Launching the Microsoft Calendar app

1. In the Start Menu, navigate to the Calendar app.
2. Simultaneously start the timer and launch the Calendar Microsoft app.
3. When the Calendar app fully loads, stop the timer.
4. Restart the system, and repeat steps 1-3 two more times.

Updating Windows from RS4 to 1903

1. Insert USB with RS4 image.
2. Boot the system, and click the corresponding button on the system to go to the one-time boot screen.
3. Select the USB to boot from the USB, and click Enter.
4. When prompted, type 2, and click Enter to install a clean version of Windows Pro RS4.
5. Once the image is applied, type exit, and click Enter.
6. Follow the instructions to complete the Windows setup.
7. Immediately following the Windows setup, navigate to <https://www.microsoft.com/en-us/software-download/windows10>.
8. To download the Windows Update Assistant, click Update Now.
9. Open the Windows 10 Update Assistant.
10. Click Update Now.
11. Click Next.
12. Once the update is finished, simultaneously start the timer and click Restart Now.
13. Stop the timer when the updates are installed and the Windows desktop appears.
14. Restart the system, and repeat steps 1-13 two more times.

Running the Iometer test

1. Launch Iometer.
2. In the Topology section, expand the Desktop to see the listed Workers.
3. Disconnect all but one Worker.
4. On the Disk Targets tab, click C: Local Disk to select it as the test disk.
5. Under Maximum Disk Size, for the number of Sectors, type 39,062,500.
6. For the # of Outstanding I/Os per target, type 8.
7. Navigate to the Access Specifications tab.
8. Under Global Access Specifications, select 4KiB; 100% Read; 0% random, and click Add.
9. Under Global Access Specifications, select 4KiB, 0% Read; 0% random, and click Add.
10. Navigate to the Results Display tab.
11. Change the Update Frequency to 5 seconds.
12. Navigate to the Test Setup tab.
13. Under Run Time, input 8 in the Minutes section, while leaving Hours and Seconds set to 0.
14. Under Ramp Up Time, type 60.
15. To start the tests, click the green flag.
16. Select a destination and file name for the results document, and click Save.
17. Restart the system, and repeat steps 1-16 two more times.

This project was commissioned by Microsoft.



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