PassMark® SOFTWARE

VPN Products Performance Benchmarks (Edition 1)

Windows 10

March 2021

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Revision History

Rev	Revision History	Date
Edition 1	Initial version of report	3 March 2021

References

Ref #	Document	Author	Date
1	How does Speedtest measure my network speeds?	Overturf, C	n.d.

Executive Summary

PassMark Software® conducted objective performance testing on ten VPN products on Windows platform. This report presents our results and findings as a result of performance benchmark testing conducted on these products.

The aim of the benchmark is to compare the performance of Norton Secure VPN with its competitors' products. To test the VPN performance, we used the following eight performance metrics:

- Download Speed
- Upload Speed
- Latency
- Jitter
- Packet Loss
- Network Throughput
- File Download Time
- Data Transfer Rate

We conducted the benchmarks on Windows machines located in three different countries, connecting the VPN servers in five different geographic locations.

Overall Score

PassMark Software assigned every product a score depending on its ranking in each metric compared to other products in the same category.

In the following table the highest possible score attainable is 80; in a hypothetical situation where a product has attained first place in all 8 metrics. The table below shows the VPN products ranked by their overall scores:

Product Name	Overall Score
Norton Secure VPN	70
NordVPN	67
Private Internet Access	56
Surfshark	53
ExpressVPN	45
IPVanish	42
Hotspot Shield	31
Avast SecureLine VPN	28
CyberGhost	26
PureVPN	22

Products and Versions

The tested VPN products names and versions are as follows:

Product Name	Product Version
Norton Secure VPN	4.0.0.408
NordVPN	6.33.10.0
Surfshark	2.8.0
ExpressVPN	10.0.9
IPVanish	3.6.5.0
Hotspot Shield	10.12.2
Avast SecureLine VPN	5.8.5262
CyberGhost	8.2.1.7176
Private Internet Access	2.6.1 (build 05824)
PureVPN	1.1.74.0

Performance Metrics

We have selected a set of objective metrics which provide a comprehensive and realistic indication of a VPN's performance. The following section lists the details of each performance metric.

Benchmark 1 – Download Speed

This metric measures the download speed over a VPN connection. The test was run by using *Speedtest CLI by Ookla* (Version 1.0.0.2) tool. After a VPN connection with a region was established from the VPN software, the Speedtest command was executed from command line to test the speed and performance of the Internet connection. The higher download speed value indicates the faster VPN's downloading performance.

Benchmark 2 – Upload Speed

Similar to the Download Speed test, the *Speedtest CLI by Ookla* tool was used to measure the upload speed of the VPN connection. The testing client establishes multiple TCP connections with the specified Speedtest server and transfers data to the server for a certain amount of time for measuring the uploading speed. The higher upload speed value indicates the faster VPN's uploading performance.

Benchmark 3 – Latency

This metric was also measured using the *Speedtest CLI by Ookla* tool. Latency measures the amount of time it takes a packet from the client to reach the server, and the server replies to the request and the reply message arrives at the client. The lower latency value shows the better VPN performance.

Benchmark 4 – Jitter

The delay jitter over a VPN connection was measured by the *Speedtest CLI by Ookla* tool, and the jitter value indicates the variance in the packet delay. The lower of the value shows the better VPN performance.

Benchmark 5 – Packet Loss

Packet loss is the packet loss rate of the TCP connection measured by the *Speedtest CLI by Ookla* tool. It represents the failure rate of transmitted packets to arrive at the destination server.

Benchmark 6 – Network Throughput

The metric measures the amount of time it takes to download a sample set of files from a Web server using *GNU Wget*. The test runs with Hypertext Transfer Protocol (HTTP) which is the main protocol used on the web for browsing, linking and data transfer.

Benchmark 7 – File Download Time

This metric measures the amount of time it takes to download a sample set of files from a Web server using *WebClient.DownloadFile* method. The test runs with Hypertext Transfer Protocol (HTTP) which is the main protocol used on the web for browsing, linking and data transfer.

Benchmark 8 – Data Transfer Rate

The metric measures the data transfer rate over VPN connection. This benchmark testing runs with *PerformanceTest* (Version 10.0) and uses the Advanced Network Test module of the software to test the data transfer rate between two computers communicating to each other using TCP/IP.

VPN Locations

VPN Entry Point

VPN products were installed on the Windows 10 client machines located in three different regions:

- United States
- United Kingdom
- Australia

For the US and UK regions, we used virtual machines hosted on Microsoft Azure to set up the test environment. In Australia, we ran VMs on a physical machine using VMware software.

VPN Exit Point

The following five countries were selected to set as VPN exit nodes.

- United States
- United Kingdom
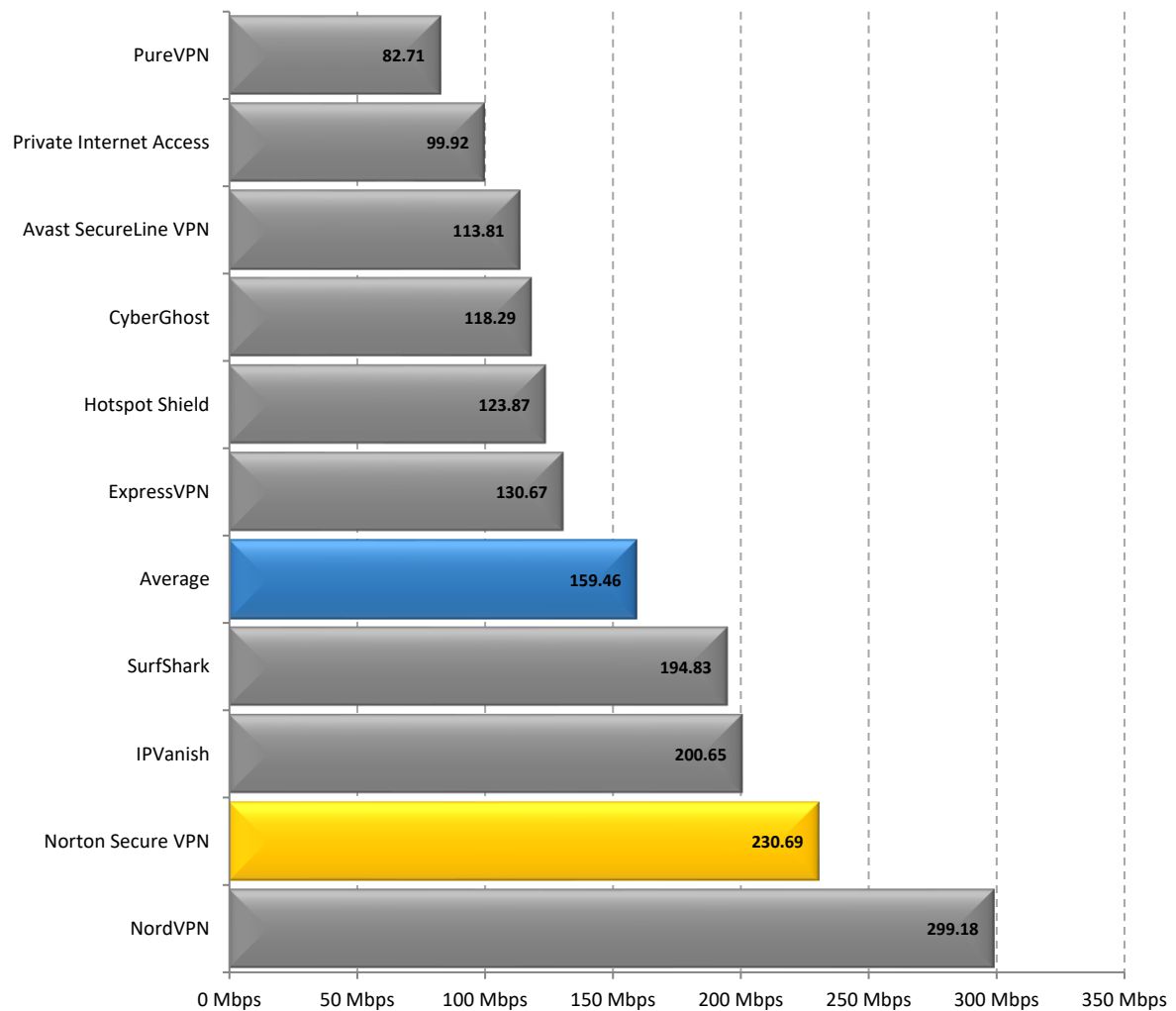- Germany
- Japan
- Australia

Speedtest servers located in the above five locations were selected and used for *Speedtest CLI by Ookla* test. We created VMs on Microsoft Azure in the above five different locations and ran Web servers on Windows Server 2016 operating systems installed on each VM. *PerformanceTest* software was also installed on the VMs to run the Data Transfer Rate test.

Test Results

In the following charts, we have highlighted the results we obtained for Norton Secure VPN in orange color. The average has also been highlighted in blue for ease of comparison.

Benchmark 1 – Download Speed (Mbps)

The following chart compares the average download speed of VPN connections of each VPN product tested. Products with higher download speed values are considered better performing products.

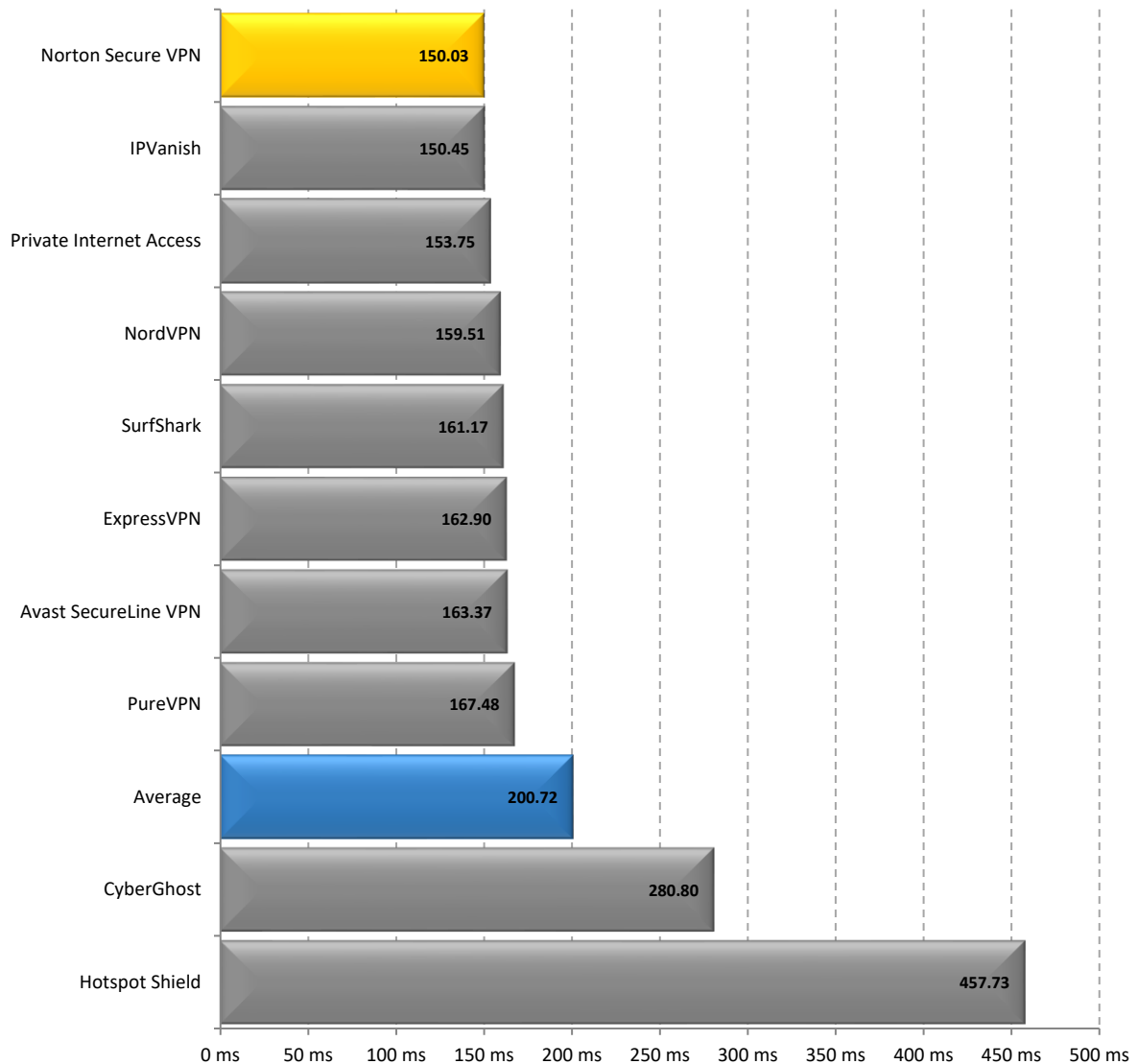| Product	Download Speed (Mbps)
PureVPN	82.71
Private Internet Access	99.92
Avast SecureLine VPN	113.81
CyberGhost	118.29
Hotspot Shield	123.87
ExpressVPN	130.67
Average	159.46
SurfShark	194.83
IPVanish	200.65
Norton Secure VPN	230.69
NordVPN	299.18

Benchmark 2 – Upload Speed (Mbps)

The following chart compares the average upload speed of VPN connections of the VPN products. The higher upload speed values mean the better performing products.
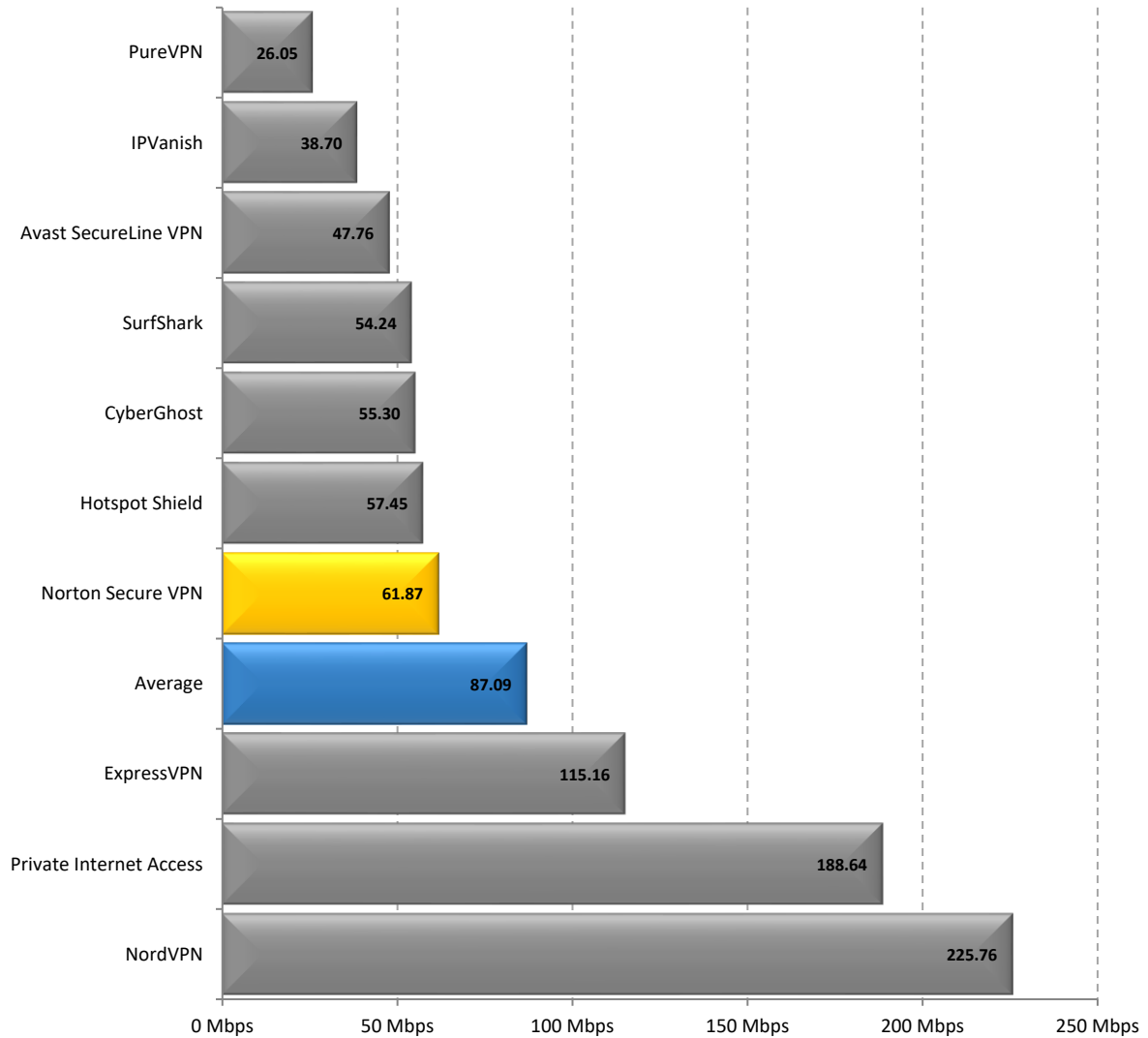
Benchmark 3 – Latency (ms)

The following chart compares the average packet delay values measured over the VPN connections. Products with lower latency are considered better performing products in this category.

Product	Latency (ms)
Norton Secure VPN	150.03
IPVanish	150.45
Private Internet Access	153.75
NordVPN	159.51
SurfShark	161.17
ExpressVPN	162.90
Avast SecureLine VPN	163.37
PureVPN	167.48
Average	200.72
CyberGhost	280.80
Hotspot Shield	457.73

Benchmark 4 – Jitter (ms)

The following chart compares the average delay jitter over the VPN connections. Products with lower jitter are considered better performing products in this category.

VPN Product	Jitter (ms)
Private Internet Access	0.38
Norton Secure VPN	0.38
SurfShark	1.79
NordVPN	2.39
Avast SecureLine VPN	3.15
ExpressVPN	6.94
IPVanish	7.38
PureVPN	13.74
Average	54.78
CyberGhost	133.76
Hotspot Shield	377.90
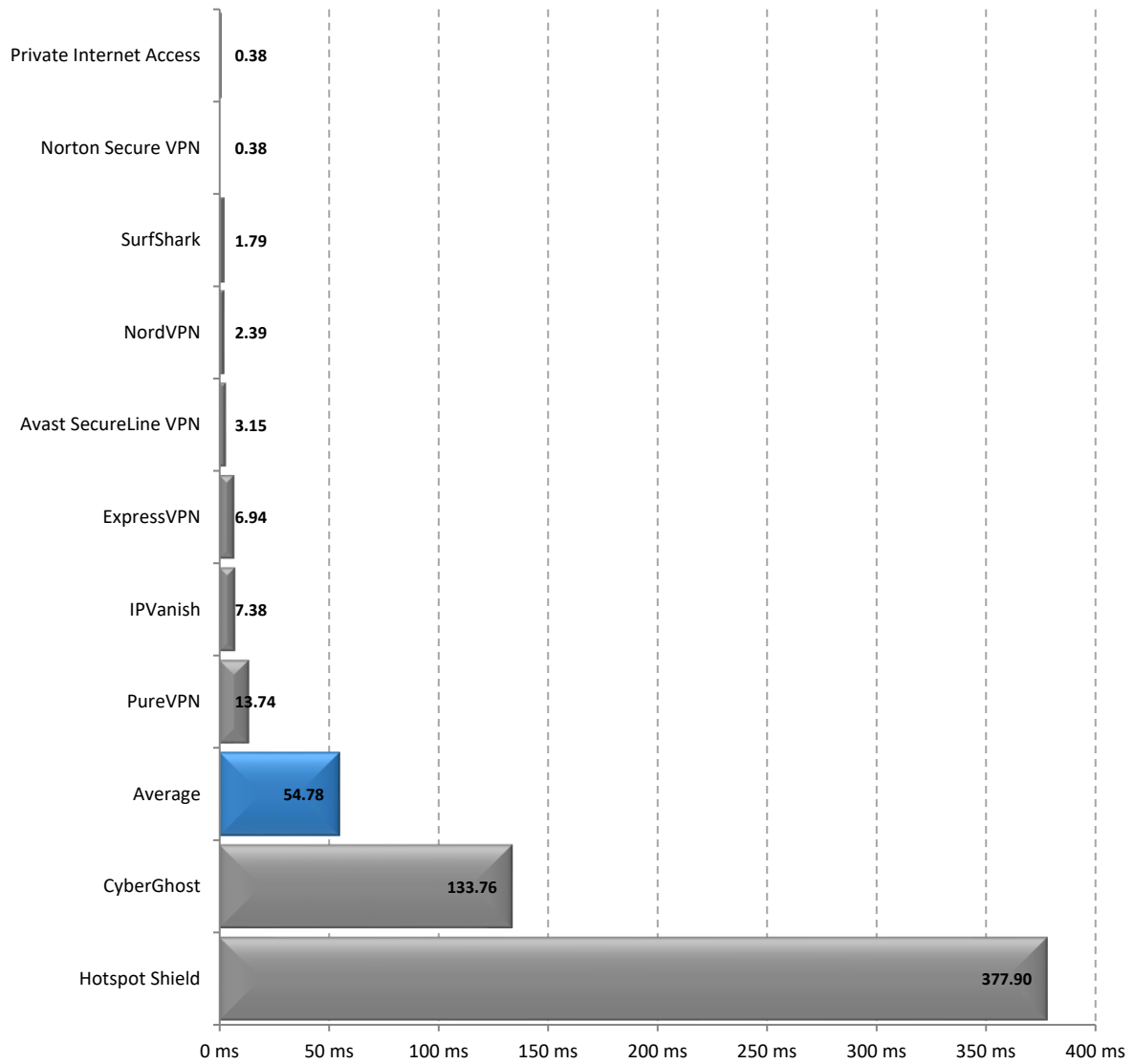
Benchmark 5 – Packet Loss (%)

The following chart compares the average packet loss rate of the VPN connections measured in the test using *Speedtest CLI by Ookla*. Products with lower packet loss rate are considered better performing products in this category.
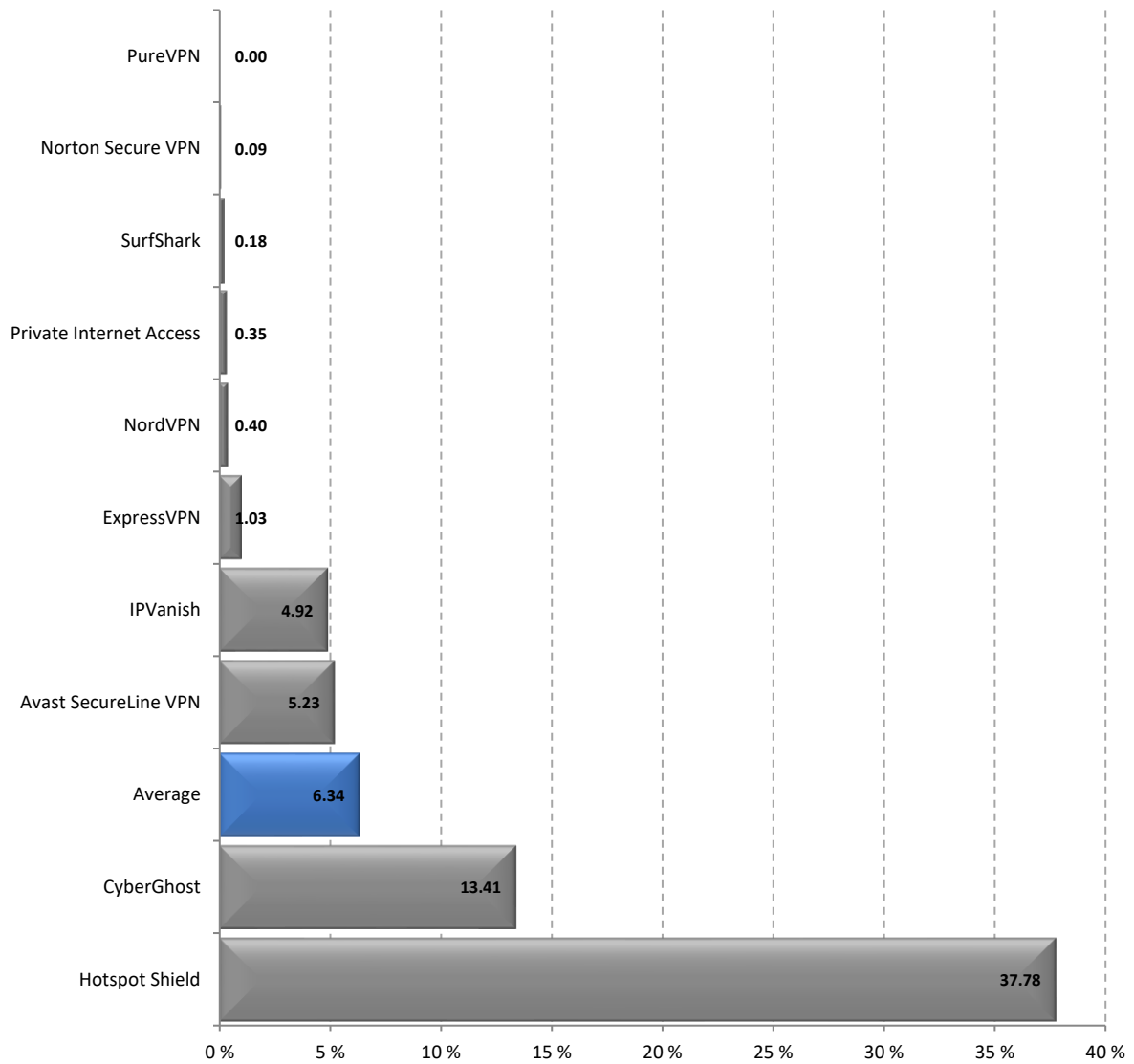
Benchmark 6 – Network Throughput (sec)

The following chart compares the average time taken to download a sample files from the Web servers using VPNs. Products with lower download times are considered better performing products in this category.

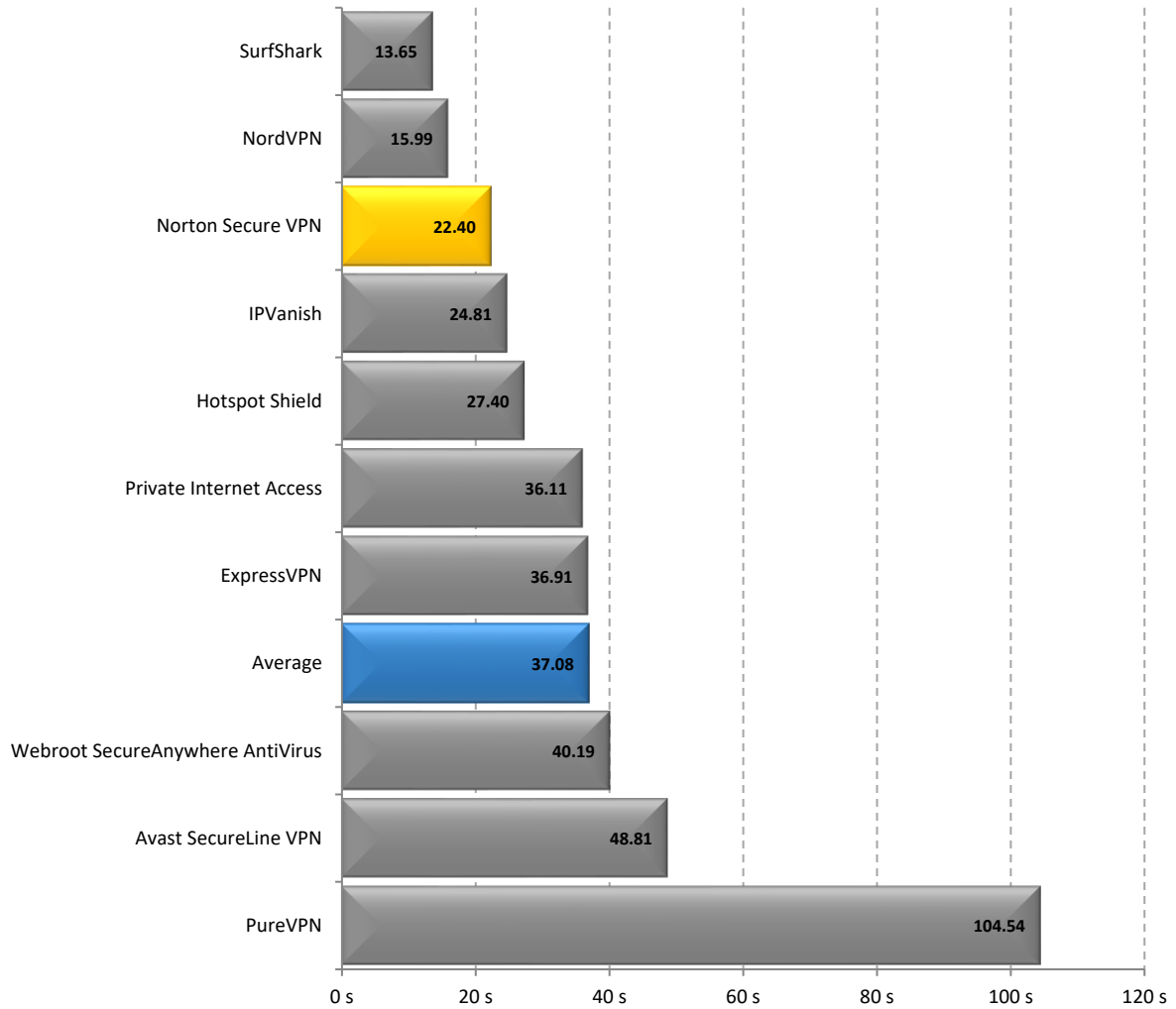| VPN Product	Time (s)
SurfShark	13.65
NordVPN	15.99
Norton Secure VPN	22.40
IPVanish	24.81
Hotspot Shield	27.40
Private Internet Access	36.11
ExpressVPN	36.91
Average	37.08
Webroot SecureAnywhere AntiVirus	40.19
Avast SecureLine VPN	48.81
PureVPN	104.54

Benchmark 7 – File Download Time (sec)

The following chart compares the average file download times measured using *FileDownload* tool with the VPNs connected. Products with lower times are considered better performing products in this category.

| Product	Time (sec)
Norton Secure VPN	13.7
SurfShark	25.7
NordVPN	29.4
Hotspot Shield	30.0
Private Internet Access	68.9
Average	75.7
ExpressVPN	83.0
Avast SecureLine VPN	84.8
IPVanish	89.9
CyberGhost	93.0
PureVPN	238.1
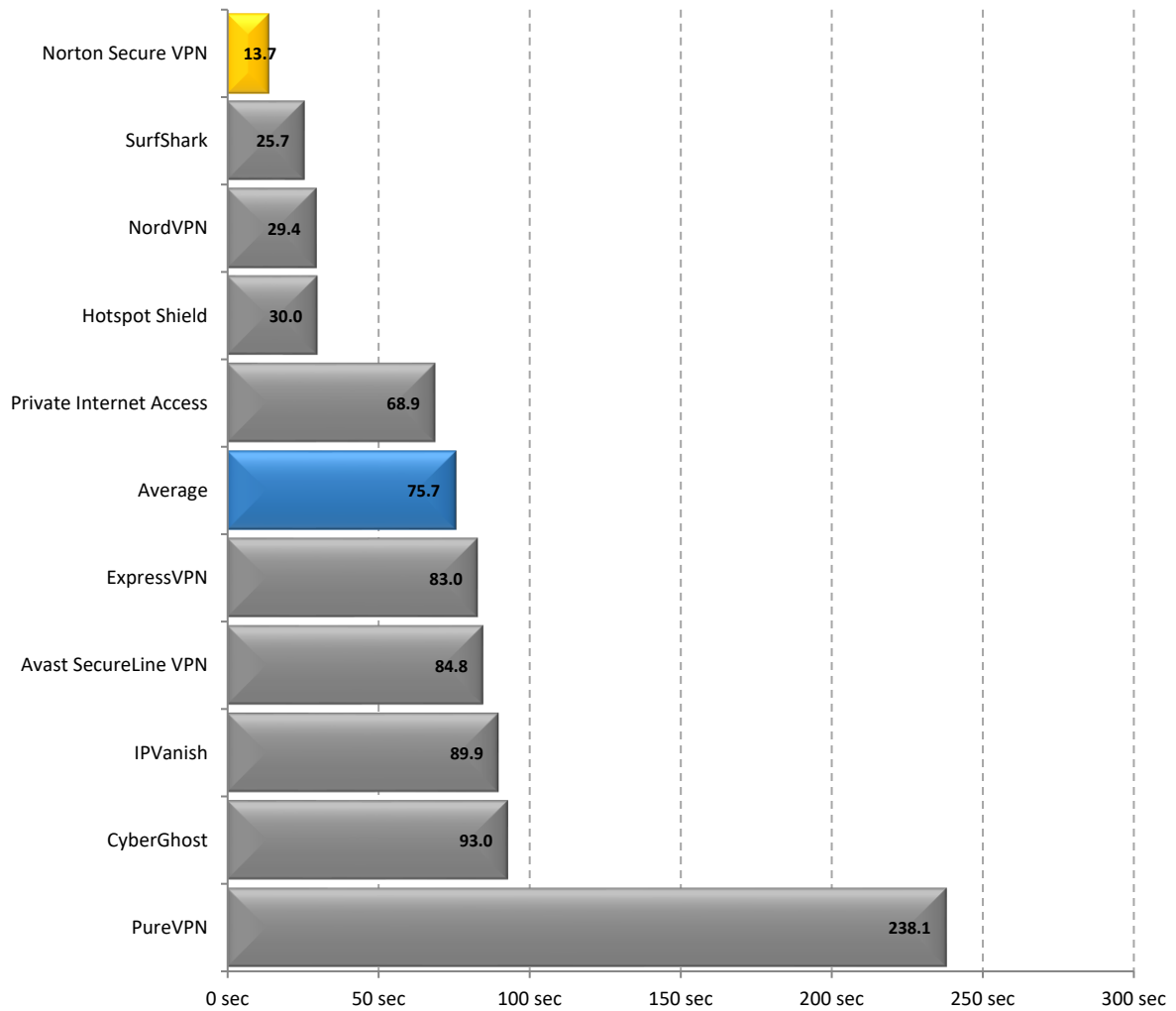
Benchmark 8 – Data Transfer Rate (Mbps)

The following chart compares the average data transfer rate tested using *PerformanceTest*. Products with higher results are considered better performing products in this category.
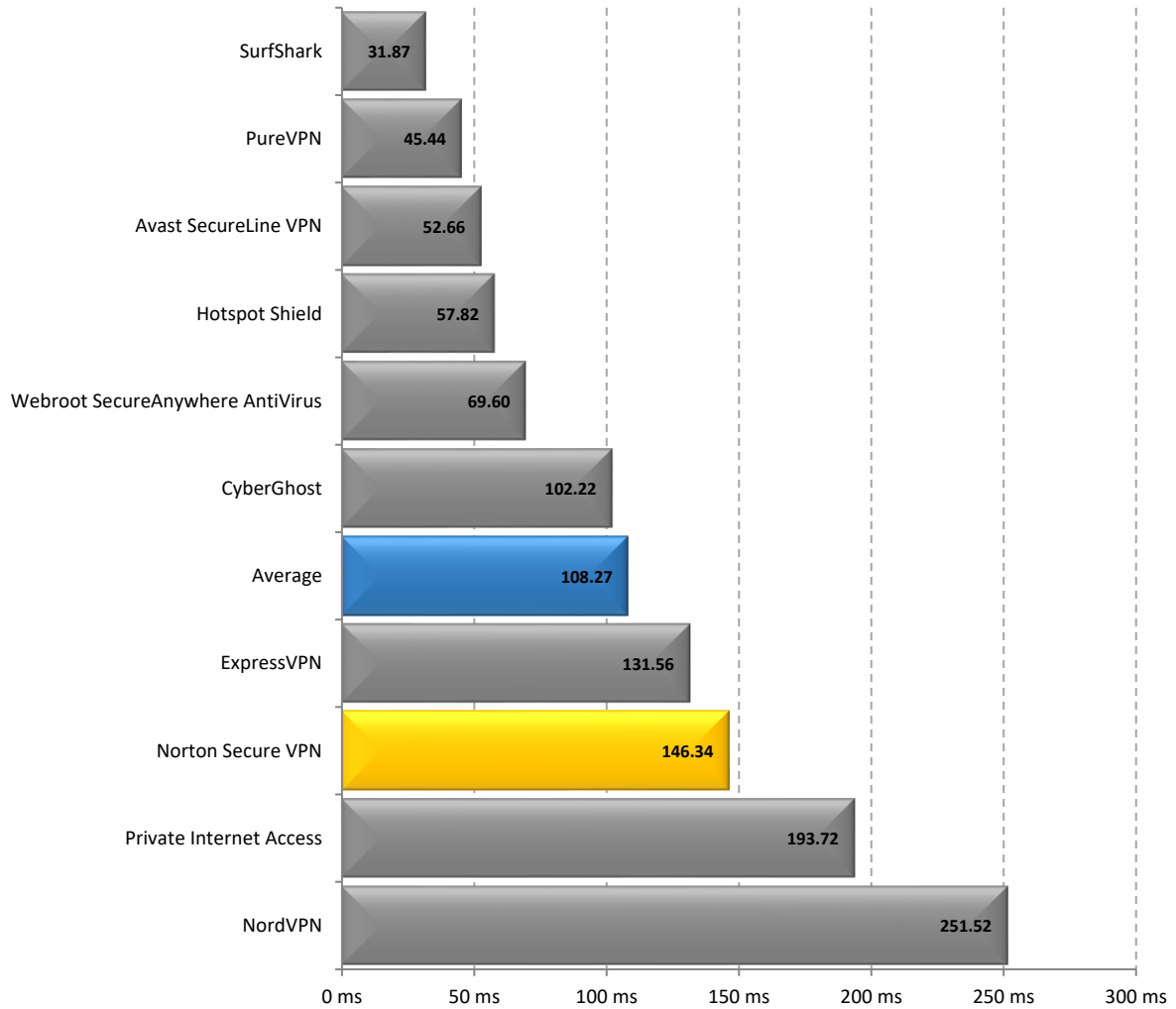
Disclaimer and Disclosure

This report only covers the versions that are listed in the "Products and Versions" section of this report.

Disclaimer of Liability

While every effort has been made to ensure that the information presented in this report is accurate, PassMark Software Pty Ltd assumes no responsibility for errors, omissions, or out-of-date information and shall not be liable in any manner whatsoever for direct, indirect, incidental, consequential, or punitive damages resulting from the availability of, use of, access of, or inability to use this information.

Disclosure

NortonLifeLock Inc. funded the production of this report. The products list, performance metrics, and the VPN locations included in the report were selected by NortonLifeLock.

Trademarks

All trademarks are the property of their respective owners.

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Appendix 1 – Test Environment

VPN entry nodes virtual machines instance details are as follows:

Azure Region:	West US / UK South
VM Size:	Standard D2s v3
vCPUs:	2
RAM:	8 GiB
Storage Type:	Premium SSD
Disk Size:	127 GiB
Network:	Default settings
OS Image:	Windows 10 Pro Version 2004 – Gen1

The VMs in Australian entry point were ran on the physical machine with the following hardware specifications:

CPU:	Intel Core i7-6700K @ 4.00GHz
Motherboard:	ASRock Fatal1ty Z170 Gaming K6
Video Card:	ASUS Strix GeForce GTX 960 4GB
RAM:	G.Skill DDR4-2133MHz 2x8GB
Main Boot Drive:	Samsung 950 Pro M.2 NVMe 256GB
2nd Drive:	Crucial BX500 SATA SSD 1TB
Network:	1Gbps (Connected via Gigabit Ethernet cable)
OS:	Windows 10 Pro Version 2004 (OS Build 19041.508)

VPN exit nodes virtual machines instance details are as follows:

Azure Region:	Central US / UK South / Germany West Central / Japan East / Australia East
VM Size:	Standard D2s v3
vCPUs:	2
RAM:	8 GiB
Storage Type:	Premium SSD
Disk Size:	127 GiB
Network:	Default settings
OS Image:	Windows Server 2016 Datacenter – Gen1

Appendix 2 – Methodology Description

We conducted the performance test for five rounds in total. The first three rounds were run from machines located in Australia, the fourth round was run from United Kingdom, and the fifth-round test was completed in United States.

For each VPN product installed on the machine in each location, we established VPN connections with five VPN servers in different locations United States, United Kingdom, Germany, Japan, and Australia. We ran the benchmarks three times with each VPN connection and averaged the numbers to obtain a final result for the round.

The final results that used to calculate the over score were from the average of the first three rounds tests from Australia, then averaging that average with the fourth and fifth round results from United States and United Kingdom.

Benchmark 1 – Download Speed

The download speed over VPN connections was measured by *Speedtest CLI by Ookla* (Version 1.0.0.2) tool. After a VPN connection with a region was established from the VPN software, the Speedtest command was executed from command line to test the speed and performance of the Internet connection.

For each VPN region, we listed the nearest Speedtest servers and picked one from them. In case the selected Speedtest server became not available for any reason, we chose a different one and kept on using the new one for the remaining tests. When executing the Speedtest command we specified the selected server using its server id. List of Speedtest servers selected are as follows:

VPN Region (Exit Point)	Speedtest Server ID
United States	37261
United Kingdom	7352, 6032
Germany	10010, 30907
Japan	8407
Australia	2629, 21417

Benchmark 2 – Upload Speed

Similar to the download speed test, the upload speed was measured by *Speedtest CLI by Ookla* tool.

Benchmark 3 – Latency

Similarly, the latency was measured by *Speedtest CLI by Ookla* tool.

Benchmark 4 – Jitter

Jitter was measured by *Speedtest CLI by Ookla* tool.

Benchmark 5 – Packet Loss

Packet loss was also measured by *Speedtest CLI by Ookla* tool.

Benchmark 6 – Network Throughput

The metric measures the amount of time it takes to download a sample set of files using *GNU Wget* (Version 1.10.1). This benchmark uses *GNU Wget* software package to download the sample files hosted on Web servers in different regions. The *CommandTimer.exe* is used in conjunction with *GNU Wget* to measure the time. The sample data set details are as shown in the table below:

File Type	Number	Size
Video Files	2	26.8 MB
PDF Files	9	15.4 MB
Compressed Archive Files	2	16.1 MB
Total	**13**	**58.3 MB**

Benchmark 7 – File Download Time

This metric measures the amount of time it takes to download a sample set of files using *WebClient.DownloadFile* method. The test uses *FileDownload* (by PassMark Software) tool developed using Microsoft Windows Webclient.DownloadFile() API to download files from the Web servers located in different regions. The *CommandTimer.exe* is used in conjunction with the tool to measure the download execution time. The data set includes the following:

Filename	Size
TeamViewer_Setup.exe	26.7 MB
GeForce_Experience_v3.20.5.70.exe	121 MB
Total	**147.7 MB**

Benchmark 8 – Data Transfer Rate

PerformanceTest software was installed on both VPN entry and exit machines and the data transfer rate of the two computers was measured using the software Advanced Network Test module. In the *PerformanceTest* Advanced Network Test settings, the VPN entry node was configured as client mode the VPN exit machine was set as server mode, the sending data block size was set as fixed 32,768 Bytes, the test duration was set to 40 seconds with the thread number set to 10, and IPv4 and TCP protocols were selected by default. The test will allow the data to be sent from the client to server at the highest transfer rate possible for the duration of the test over TCP connection with VPN enabled.