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Defining the Always On, Always Connected PC

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Executive Summary

The computing world is changing. Users are demanding more from their PC experiences and a rebirth of innovation is starting. While fears of the smartphone and tablet taking over the PC market have waned, the influence these devices have on the expectations from consumers is profound. Windows notebooks already offer performance and form factors that buyers love, but what they are missing is *the feeling of being truly mobile*.

The future of the notebook PC lies in merging the familiarity of Windows with experiences and capabilities that are unique to smartphones. This should include a renewed emphasis on battery life, targeting days rather than hours of real-world usage. Deep sleep and hibernate states that force portions of the system to be inaccessible for dynamic updating and that slow the ability for the user to interact with PC should be eliminated. Ubiquitous internet access through high speed, Gigabit-class LTE can provide uninterrupted data support without the hassle and reliability concerns of Wi-Fi and comes with a connected standby experience where your data is ready when you need it.

But what can this new category of Always On, Always Connected PCs bring to the consumer? In this paper we attempt to answer just that, and then measure some of the first attempts at building for this new segment of the market.

Defining the Always On, Always Connected PC

Changes in the world of personal computing can come in two flavors: evolution and revolution. While the revolutionary changes are ones that get the most attention (think of the first notebooks PCs, the first hardware graphics chip, or the first IBM-compatible computer) it is the evolutionary designs that push the industry forward and create and develop markets that consumers demand.

Over the course of the last 10-15 years we have seen a tepid evolution take hold in the PC space. A drive to develop thinner, lighter, more powerful, and longer-lasting notebooks has been the push from technology providers, though with limited success. Consumers want more options and more capability in their devices without having to worry about aspects of battery life, connectivity, or an ability to run applications how they have been used to.

The ultra slim and convertible PC market is growing faster than almost any other segment of the personal computing space, with IDC predicting a 12% growth rate through 2022. Device usage patterns still vary from consumer to consumer, but the majority of notebook usage centers around the core of productivity, web browsing, social media, and entertainment. But all consumers need ubiquitous connectivity and long battery life for a truly mobile experience.

Along with extended battery life demands, a growing area of interest from consumers is anytime, anywhere connectivity. Because the revolution that smartphones have created in consumer mindset and how they interact with devices, the ability to stay connected continuously even on a product like a PC is critical. So much of typical usage patterns depends on being internet connected, it is hard to

imagine a machine without access. Streaming video content, access to your favorite sites, web-based productivity solutions from Microsoft, instant access to answers on Google, sharing media on social platforms, personal AI assistants—all of this requires connectivity.

It culminates in an evolutionary shift in the mobile PC. The Always On, Always Connected PC is a new category of notebook and 2-in-1 devices that promises consumers the ability to combine the expected experience of their mobile devices with the productivity, interface, and capability of a Windows PC. Because this new initiative combines the capabilities of two existing groups, its *evolutionary* status might appear to make it a simple transition. Is that really the case?

Battery Life

Though the term that has been used in various places is "beyond all-day battery life" we would like to see a more definitive language for our purposes. A minimum of 20 hours of usable life on a notebook would generally equate to two full days of use, if not more, depending on the screen on-time for the consumer. Having enough usable battery to get through full-length transpacific flights is another key benchmark. "Usable" battery life means that the system needs to avoid running at unrealistically low screen brightness levels and not simply with continuous, low resolution video playback (that can be computed incredibly efficiently).

Instead, 20 hours of battery life should include a combination of productivity programs like Word and Excel, social communication with applications like Skype, general web browsing, and video streaming through services like YouTube or Netflix equivalents. The balance and ratios of these are going to be important as well, and I think we will showcase reasonable facsimiles of standard user workloads in this paper.

Just as important as in-use efficiency towards the goal of usable battery life is maintaining that battery life in a standby state. Always On, Always Connected PCs should be able to handle significant time spans with the screen off and the machine in a low power state (such as an overnight stay on a desk in a hotel) and maintain as much battery capacity as possible to truly meet the goal of multi-day usage.

Always connected, without a sacrifice on speed

Despite the growth of Wi-Fi networks across the globe, the only way for a device to be truly Always Connected is through cellular connectivity. A small number of machines have included cellular connectivity previously, though mostly in the enterprise class device category, and it will take significant push by key hardware providers to supply every consumer and every notebook with an LTE-capable modem. Ubiquity of connectivity is critical to avoid many of the hurdles and headaches of using a PC compared to modern smartphones.

The connected state of this new class of notebook needs to be fast. Though hardware like the Amazon Kindle created a unique opportunity for itself as an always connected device, it did so with slow network speeds and limited capability. As consumer home broadband continues to drag its feet on performance upgrades thanks to limited competition, the wireless carriers and wireless network providers are

continuing to push the bar forward, with devices capable of 1.0 Gbps performance. That is 3-7x faster than the average home internet connection (FCC), though obviously dependent on the cellular network you are using and the capacity it provides.

As compute models and workloads change for the consumer, moving to more data-demanding subjects like 4K and HDR video content, 360 degree content, mixed reality gaming and productivity, and more latency dependent streaming gaming services, the value of Gigabit-class LTE connectivity will expand.

Including an LTE connected modem, and in the future support for 5G, gives the consumer connectivity without the hassle. You no longer need to base your working location on which coffee shops have Wi-Fi or deal with the hassle of logging into an account to validate an internet connection you may only utilize for 10-20 minutes.

Instant On

Beyond battery life, another area of shifting consumer demand for the move to Always On, Always Connected PCs is “instant on” capability. This means a notebook that has been idle for some time, either left on a desk at work during lunch or picked back up after an overnight rest, should be able to turn on the display and accept user input the moment a keyboard button is pressed or a wake button on the device is pushed.

Most modern machines default to entering a sleep state after a small amount of time (in the 30-90-minute range) and then a deeper state of hibernation after a couple of hours. This allows current architectures to save valuable battery during extended periods of non-use. As a result, it can take from 20-60 seconds for the machine to become responsive for authentication or user input, depending on the hardware configuration, memory capacity, and storage devices in use.

The world of the smartphone has altered consumer expectations. Users that have been trained to use phones for payment processing and quick-trigger photo taking require the devices to not exhibit sluggish behavior of any kind. Simply tapping the screen or picking a smartphone up is enough to wake it, turn on the screen, and begin authentication steps. After the adoption of PCs with always connected configurations take hold, the demand for these machines to be power efficient enough to also allow for instant-on capability comes with it.

Connected standby

With an always-on network connection powered by LTE and an always-on machine that wakes up instantly without sleep and hibernation delays, the need to have your content and notifications immediately available is critical. Connected Standby is a feature that allows your email, social networks, and other applications to stay updated even while the screen is off and the PC is in its standby state.

The benefit of connected standby has been promised by Windows at various points in the evolution of the operating system, but has never been fully realized. Technical difficulties stemming from increased power consumption for waking components to check for Wi-Fi connectivity, and its effect on overall

battery life, was the primary issue. By combing the capability of an instant-on hardware configurations with always connected LTE services, the future of the Always On, Always Connected PC will provide the ability for connected standby to be integrated.

A potential hurdle for initial systems will be software support; what applications will have access to the capability to push updates even in a standby state? This is a solved problem on mobile operating systems but will take some time for Windows developers.

Location aware

A more mobile device with wireless connectivity and battery life that doesn't preclude itself from being used at any point throughout the day will demand more location awareness. A GPS system that is fast and accurate will mean that Always On, Always Connected PC users have the option to utilize these notebooks and tablets with improved corporate IT device management or "find my hardware" features. The more these devices act like the smartphone in a customer's pocket, the more buyers are going to demand like-for-like capability.

Quiet, cool, fanless

Devices that are exceedingly mobile oriented from a technology standpoint need to be built like mobile devices. This does not mean consumers are looking for movement away from the keyboard and trackpad input options, but instead more emphasis on thinner and lighter designs that don't generate excessive heat while at idle or in use, will be necessary. The more often you remove a notebook or tablet from your bag, the more likely you are to care about the weight and size of the device.

A Windows computing experience consumers are familiar with

The last time an evolutionary step was attempted in the world of Windows PCs, it faltered due to the inability of consumers to understand the various changes required for its adoption. Windows RT never offered a compelling enough solution, and had more than its share of technical hurdles, and it quickly faded. For a solution to succeed today, consumers demand they be able to take the PC experience they know on the go, without having to adapt their workflow to a new product or category.

Being able to run under the same Windows and application sets that buyers are familiar with is imperative, including legacy applications and Windows Store applications. Running Windows 10 with the expected features of the taskbar, Explorer, Ink, Hello, and Cortana is critical.

How new devices meet these definitions

One of the first devices to attempt to address these requirements for an Always On, Always Connected PC is the HP Envy x2, powered by the Qualcomm Snapdragon 835 Mobile Platform that utilizes Arm-based technology.

	HP Envy x2 (12-e011nr)
Processor	Qualcomm Snapdragon 835
Graphics	Qualcomm Adreno 540 GPU
Display	1920x1280, 12.3”
RAM	8GB LPDDR4-1866
Storage	256GB UFS
OS	Windows 10 v1709
Connectivity	802.11ac + Snapdragon X16 LTE
Battery	49.33 WHr

Another currently available product being considered for the Always On, Always Connected category is the ASUS NovaGo, a convertible notebook that also uses Arm-based technology and the Qualcomm Snapdragon 835 SoC.

	ASUS NovaGo (TP370QL)
Processor	Qualcomm Snapdragon 835
Graphics	Qualcomm Adreno 540 GPU
Display	1920x1080, 13.3”
RAM	6GB LPDDR4-1866
Storage	256GB UFS
OS	Windows 10 v1709
Connectivity	802.11ac + Snapdragon X16 LTE
Battery	52 WHr

As we start down the path of defining the evolutionary steps to the Always On, Always Connected PC, it is important to note that not all hardware presuming to meet these standards may be capable of doing so. With the innovation cycle of mobile processors and designs providing frequent iteration, improvement and refining will occur. It is the goal of this product definition to place the standards high, and to hopefully impact the direction of suppliers and OEMs to accelerate in the correct direction.

For our competitive comparisons we will be utilizing three different machines that represent the current landscape of small form factor, thin and light notebooks. The Huawei MateBook E is a tablet-based detachable machine that utilizes an Intel Core m3-7Y30 processor, 8GB of memory, and a powerful PCIe 512GB SSD. Because of its thinness, however, it suffers from a smaller battery with a capacity of just 33.7 WHr.

The baseline Microsoft Surface Pro is powered by the same Intel Core m3 processor, but has half the available system memory and a quarter of the storage. It is able to offer a more substantial battery solution at 45 WHr. Finally, the Dell XPS 13 is the convertible 2-in-1 option powered by the Intel Core i7-7Y75 processor and 8GB of system memory. It has a lower resolution screen (1080p) than the other competing Intel solutions and pairs that with the largest battery in the below configurations.

	Huawei MateBook E
Processor	Intel Core m3-7Y30
Graphics	Intel HD Graphics 615
Display	2160x1440, 12.0”
RAM	8GB LPDDR3-1866
Storage	512GB PCIe
OS	Windows 10 v1709
Connectivity	802.11ac
Battery	33.7 WHr

	Dell XPS 13 2-in1 9365
Processor	Intel Core i7-7Y75
Graphics	Intel HD Graphics 615
Display	1920x1080, 13.3”
RAM	8GB LPDDR3-1866
Storage	256GB PCIe
OS	Windows 10 v1709
Connectivity	802.11ac
Battery	46 WHr

	Microsoft Surface Pro (FJR-00001)
Processor	Intel Core m3-7Y30
Graphics	Intel HD Graphics 615
Display	2736x1824, 12.3”
RAM	4GB LPDDR3-1866
Storage	128GB NVMe
OS	Windows 10 v1709
Connectivity	802.11ac
Battery	45 WHr

Measuring battery life

Evaluating the battery life of a notebook is a complicated process and can be undertaken in numerous ways. While industry standard testing like MobileMark works for direct comparisons of like-architecture configurations, it doesn’t properly run on the Qualcomm-powered systems we are testing today due to differences in drivers. Another method is to simply loop local video playback. We will look at battery life measured in two different scenarios.

One attempt to measure real-world battery life is to setup a scenario of working day tasks that a consumer would face with a notebook PC. This will include idle time, web browsing, productivity and work tasks, video conferencing, streaming video, and standby time. Each task is defined as:

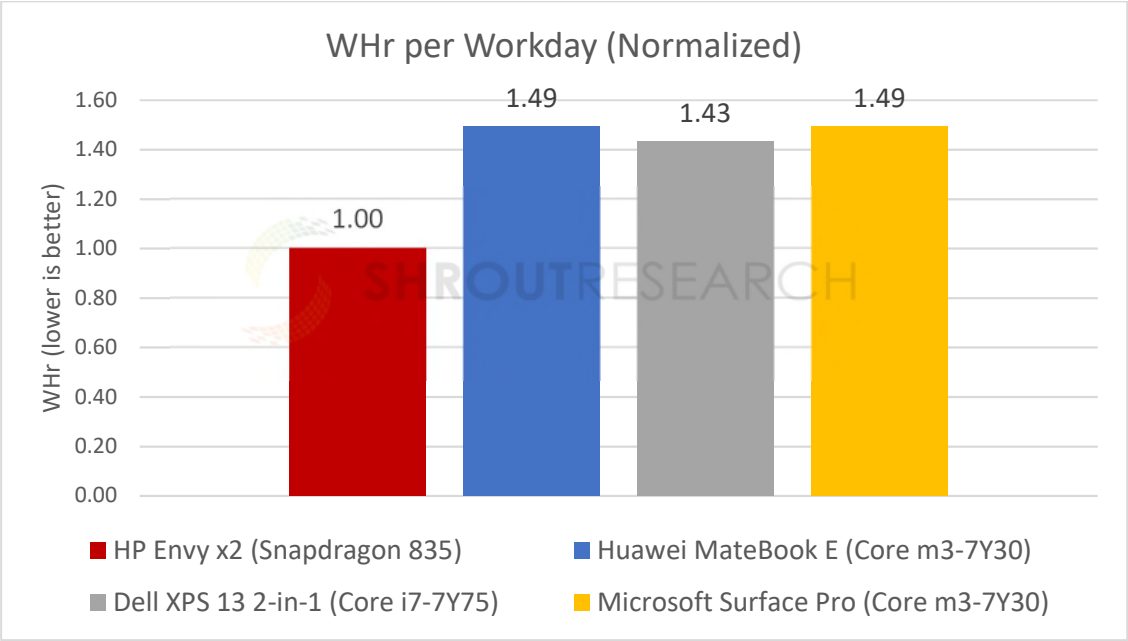
- Idle time: At Windows 10 desktop, all other windows closed, LTE and Wi-Fi connected
- Web browsing: Using Edge we have 6 tabs open, all with web sites loaded, and cycle between them every 60 seconds, scrolling is emulated as well
- Work productivity: Two documents are open in MS Word, one spreadsheet open with 50k lines in Excel, typing is entered into the word documents, cells are calculated with percentile measurements
- Video conferencing: Skype video and audio call
- Streaming media: YouTube streaming at 1080p30
- All testing done with screen at 180 lux brightness

For our testing, we first determined the per-use-case battery drain for each task by performing it individually on the system and measuring battery life. From that information we can calculate a "drain rate" for each device performing each task.

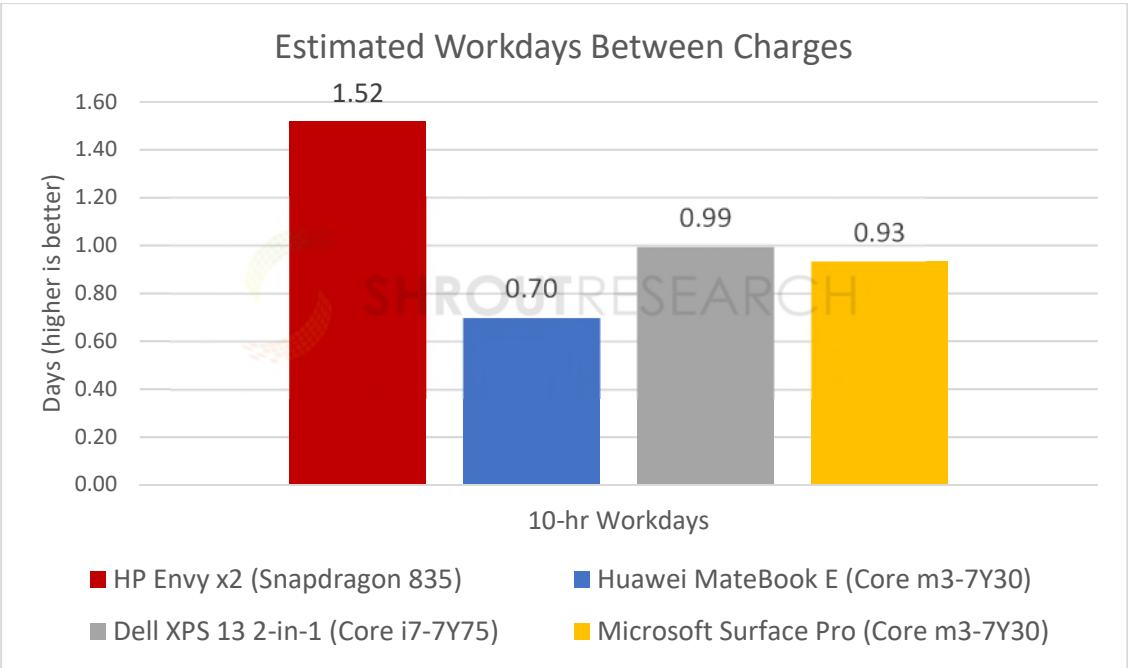
Next, we apply a weight to each task based on our experiences as consumers, attempting to estimate the amount of time each working day that a user would perform each of the above tasks. Our breakdown is as follows:

- Idle time: 25%
- Web browsing: 25%
- Work productivity: 35%
- Video conferencing: 5%
- Streaming media: 10%

If we apply these weights to a 10-hour work day, along with the battery drain rates we had previously calculated, we arrive at a power draw result that tells us how much battery life each provide over a typical user workday.



Normalized to the HP Envy x2 to simplify presentation, this graph shows the power draw differences between these systems when averaged over the entire 10-hour workday described above. The Snapdragon-powered Windows PC has the lowest average battery consumption, which will give it better battery life when using like-sized batteries. The Intel-powered machines use 43-49% more power than the HP Envy x2 (though the Dell XPS 13 2-in-1 is the most efficient of those offerings).

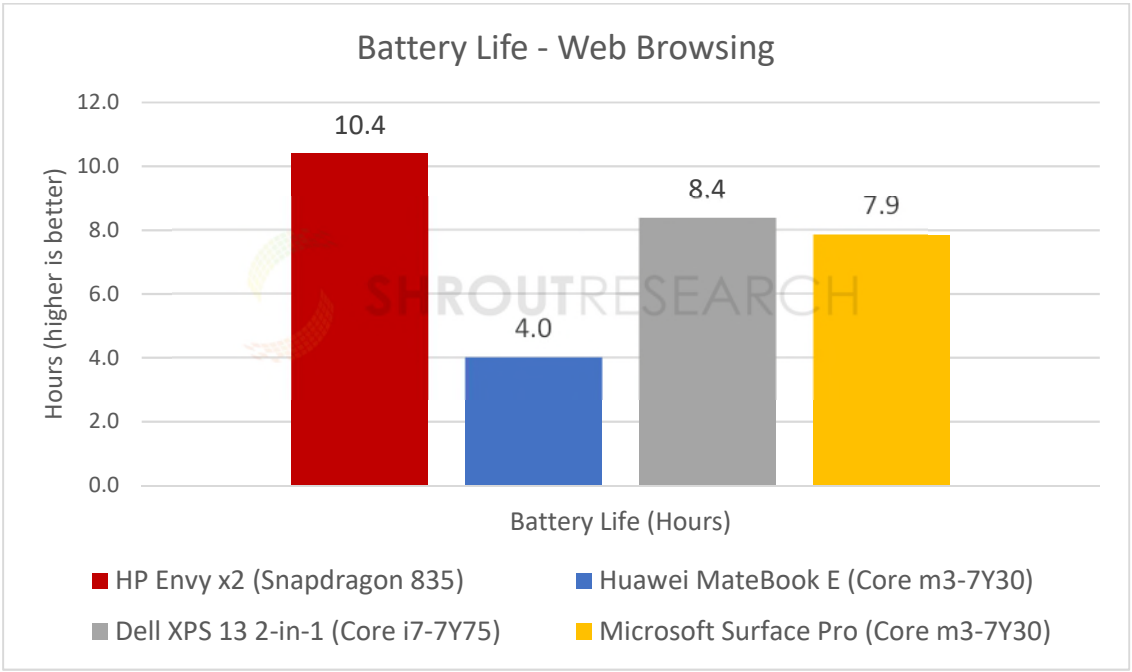


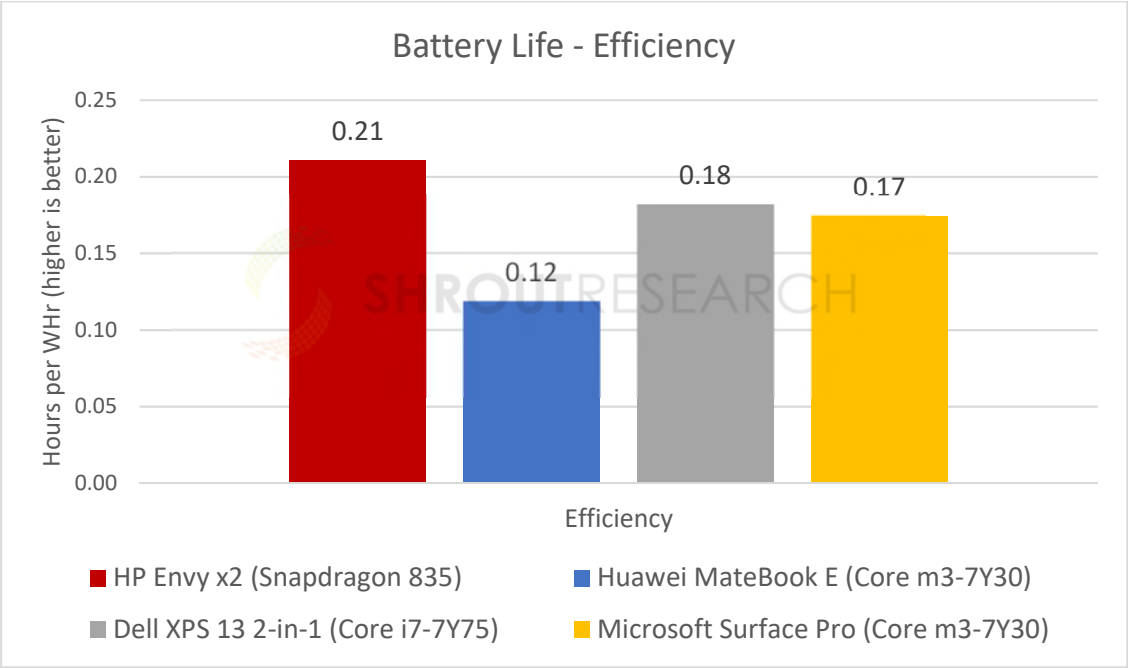
If we add in the battery sizes for each system to the equation we can estimate how many of the 10-hour workdays each Windows PC would be able to complete without requiring a battery charge. The HP Envy

x2 is leading the pack with more than 1.5 days available to it, meaning a consumer would be able to work for more than one full day without requiring access to a power outlet. The Huawei machine has the lowest result at 0.61 days, noticeably lower than the other competitors because of its small battery size (just 33 WHr). The Dell XPS 13 2-in-1 and Microsoft Surface Pro provide 0.99 days and 0.93 days, respectively; they would not be able to make it through our 10-hour scenario without some mid-day charging.

During this configured scenario the screen is powered on the entire time, even during the idle sequences. Allowing the system to go into a Sleep state during >10 minute idle periods would extend the resulting “workdays between charges” data. Based on standby power testing we would estimate that the Snapdragon-powered systems would increase their efficiency advantage over the Intel-powered systems.

As a more direct and simplistic test, the Shrout Research in-house developed battery life test that emulates continuous web browsing in Edge under Windows 10 was used. It circulates between 20 different websites, scrolls, and navigates through them on a 30 second timer, then moves on to the next site, repeating the pattern until the battery is drained. This scenario gives us a look at the “worst case” battery life for a typical user. (Again, all testing was done at 180 lux brightness.)





In our 100% browsing based test, the HP Envy x2 powered by the Qualcomm Snapdragon 835 platform brings in the longest run time by 23.8%. The Huawei MateBook E, which has the most similar design and form factor to the HP, gets just 4 hours of battery life compared to 10.2 hours for the Snapdragon-powered system. The Dell XPS 13 2-in-1 and Microsoft Surface Pro have better results, with 7.9-8.4 hours each, but still fall 23% behind.

It is worth noting that this test represents a *continued usage pattern*, and does not have significant idle time or shifts in the workload. The Qualcomm chipset shows the biggest advantages during standby-type situations of expanded idle time. As a result, I would consider the above testing to actually be a "worst case" for the HP Envy x2 over the competitors.

Testing instant on

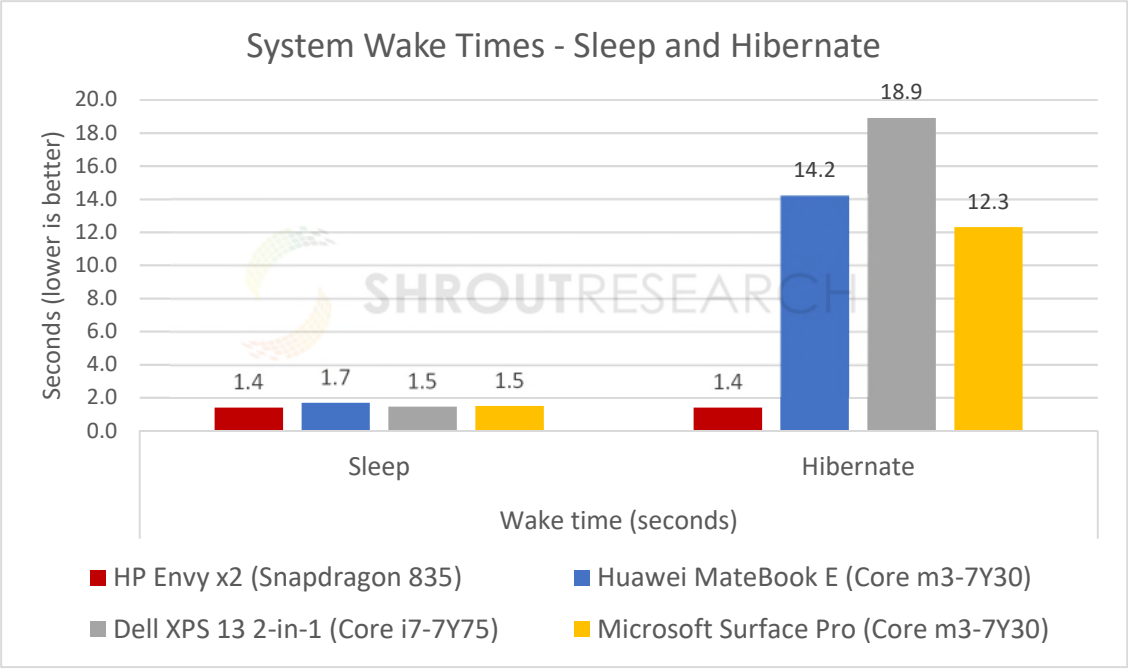
Evaluating the instant on capability of devices is fairly straight forward, but needs to take place in at least two different states based on the Windows 10 power settings. The wake-up period should be evaluated after the sleep time and hibernate time.

The out-of-box experiences for how aggressive these timings are on these power settings can vary from vendor to vendor and even inside the same vendors' product line. I have seen some machines enter into Sleep after just 4 minutes of idle time and full Hibernate after just 30 minutes of idle. Other notebooks will wait as long as 15 minutes for Sleep and 180 minutes for Hibernate. This will have noticeable impact on the "standby" time of the notebook and will also affect the ability for hardware to wake up quickly or have a connected standby experience.

Here are the default settings for our testing hardware.

- HP Envy x2: Sleep @ 10m, Hibernate @ Never (not enabled by default)
- Huawei MateBook E: Sleep @ 10m, Hibernate @ 40m
- Dell XPS 13 2-in-1: Sleep @ 4m, Hibernate @ 30m
- Microsoft Surface Pro: Sleep @ 5m, Hibernate @ 180m

Our testing process is straight forward. We turned on the machines at the Windows desktop in an idle state. We waited 15 minutes and attempt to wake them by pressing the power button, recording the time from the button press to our return to the desktop. (Security authentication was disabled.) We then let 185 minutes pass (allowing for the other machines to enter hibernate) and press the power buttons, recording the time until a return to the desktop.



When Windows 10 PCs go into the Sleep state, the wake up process is very fast, 1.7 second or less in our testing for all four machines. But as we mentioned above, most of today's PCs depend on the Hibernate state in order to extend battery life when away from the power outlet. In those instances, all three of our legacy PCs using current Intel processors take 12 seconds or more to wake up enough to allow for user input. The Dell XPS 13 2-in-1 takes 6 seconds longer than Surface Pro.

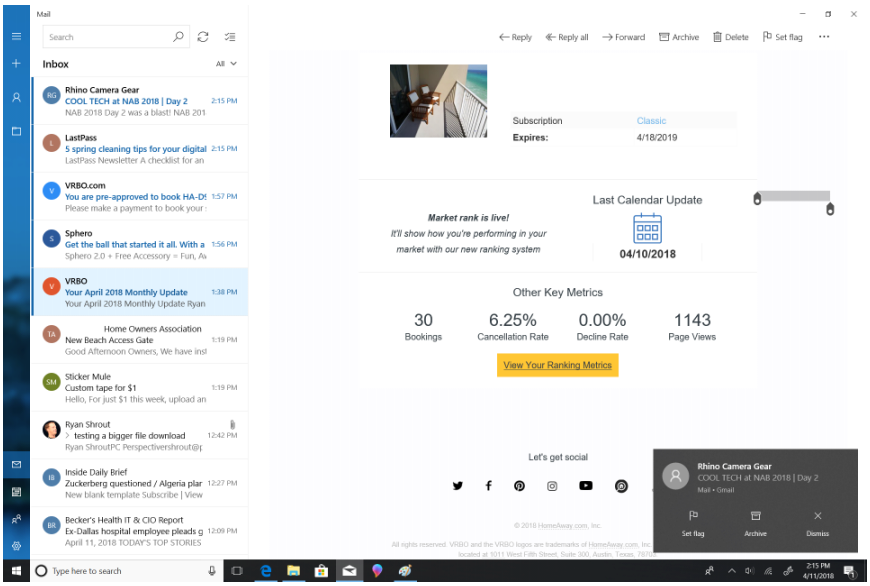
The HP Envy x2 powered by the Qualcomm Snapdragon 835 platform using Arm-based cores does not enter a Hibernate state even after days of non-use. As a result, the wake time for this machine is still just 1.4 seconds, providing a more smartphone-like experience than any other PC.

Connected standby capability

Applications that can utilize a Windows 10 PC with true connected standby support are still expanding. Developers had little desire to spend resources on properly integrating it without true hardware support

available, but as the Always On, Always Connected PC market grows, the audience will demand updated software to include it.

The Microsoft Mail app from the Windows 10 Store is a perfect example of how an always connected device can change the way you work and interact with a PC. When configured with an Outlook for Gmail powered account, Mail can be configured to enable background downloading of emails and attachments even with notebook closed and in its “sleep” mode.



After waking up our tested HP Envy x2 powered by the Snapdragon 835 platform from being asleep for more than hour, emails were immediately present in the Mail app, with images and attachments ready.

There is obvious need for expansion on proper software support for connected standby, including at the browser level for Edge to allow network access for sites like G-Suite services and Outlook.com. The promise of what this feature could add for a Windows 10 mobile PC environment is impressive though, and only hardware that deliver optimized sleep power states, without going into a disconnected hibernate mode, will have the ability to take advantage of it.

Continuous connectivity

Without a clear way to benchmark or evaluate the impact that continuous connectivity can have for a consumer experience with a Windows PC, we must depend on some use cases for the always connected PC that demonstrate advantages it can provide. Though some people assume that the availability of Wi-Fi is ubiquitous enough to lessen the need for cellular LTE connectivity, the truth is that the makeup of free and for-pay Wi-Fi connections still presents plenty of hassle, complexity, and cost to consumers.

Travelling is a constant source of headache for connectivity on notebooks and users face a collection of hurdles to remain connected. Using airport provided internet connections via Wi-Fi will often require registration, providing a private email address, or even a cell phone message to validate the user before the connection is granted. In many airports this connectivity isn’t free, and users will be asked to not

only register but pay as much as $10/day, even if they only have an hour before a flight departure to utilize it.

Checking in to your hotel room and connecting to the provided Wi-Fi network will often present its own costs and registration, tacking on another $12-20/day for a connection that is frequently incredibly slow, measuring in the single-digit megabit per second data rates.

How many times have you attempt to connect your Windows PC to a Wi-Fi network at a coffee shop, convention hall, or office park only to find that the registration portal wasn't working?

The typical consumer solution is to reach into their pocket, pull out a smartphone, enter the settings and find the mobile hotspot feature. If you even have the capability to enable that on your device, I often find that my notebook is unable to find my phone's network until I stop and restart the service, sometimes more than once. It is a cumbersome process.

Even when visiting the confines of a friend's or family's home, you will find that homeowners have often forgotten the passwords to their own Wi-Fi connection. The amount of effort required to find the lost notepad sheet or to find the router with its taped-on password exceeds the patience of many.

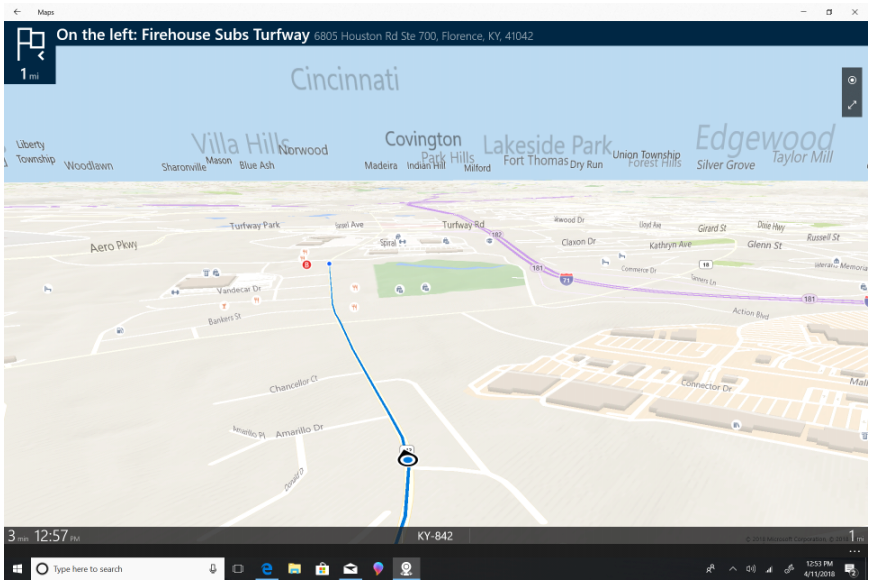
Don't forget about the security advantages being always connected provides. Rather than connecting to unencrypted Wi-Fi networks at airports or hotels, the LTE connectivity provided by the Snapdragon platform to your cellular carrier by-passes that potential for security concerns. An always connected Windows PC essential provides the same level of security as being attached to your ISP.

Buying a Windows PC that is always connected via an LTE cellular connection means that you don't have to wait for (or pay for) often unreliable, unsecure, and slow Wi-Fi connections. Instead, you simply can open the machine and know you are already connected, just like you would expect with your cell phone. No more waiting, no more doubts.

On a recent trip that combined work and personal time, I noted some of the instances where the always connected capability of the HP Envy x2 saved me either time or money. Through three days I was able to save $39 in hotel internet charges while also providing faster service through LTE. I was able to avoid the hassle of asking security at the company I was visiting for directions on how to access the in-building guest Wi-Fi networks and instead simply opened the PC and utilized the cellular connection. When I needed to reply to an email with an attachment quickly while in a cab to the airport I was able to do so without cycling the hotspot feature on my phone or waiting to find a Wi-Fi connection.

Location aware

Being location aware is vital data point as the form factors, use cases, and experiences of mobile PCs shift as a result of by constantly connected. Though we believe that device tracing and IT management is the true direction that a location aware Windows 10 machine will head, one early example is the ability for the Microsoft Maps application to use the GPS provided by the Qualcomm platform for turn by turn directions.



While navigation in current system designs might be a secondary avenue of use for location aware status, as form factors evolve thanks to the innovation provided by the mobile processor cadence and cycle, utilizing accurate GPS data will be more critical.

Other Windows applications and websites will be able to utilize the location awareness for improved functionality with retailers, restaurants, social media, tourism, and much more.

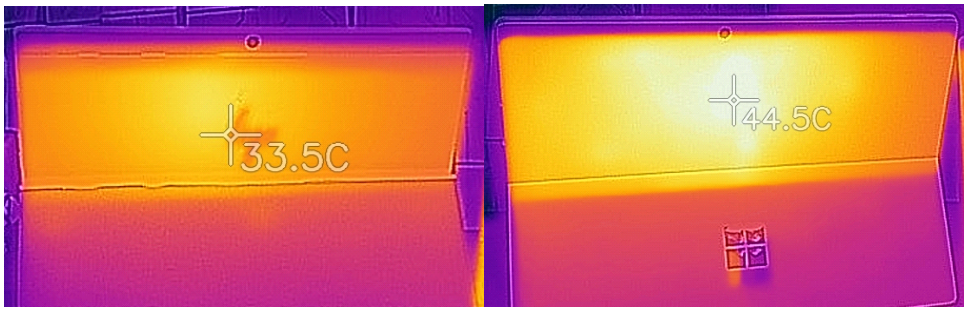
Temperature testing

Evaluating the impact of temperature and power efficiency of these systems is an important indicator of the capability for the processors and platforms to provide consistent and high quality user experiences. That includes both the on-screen experience and the human factor of skin temperature. Holding a hot tablet or resting a warm notebook on your legs can create unwelcome results.

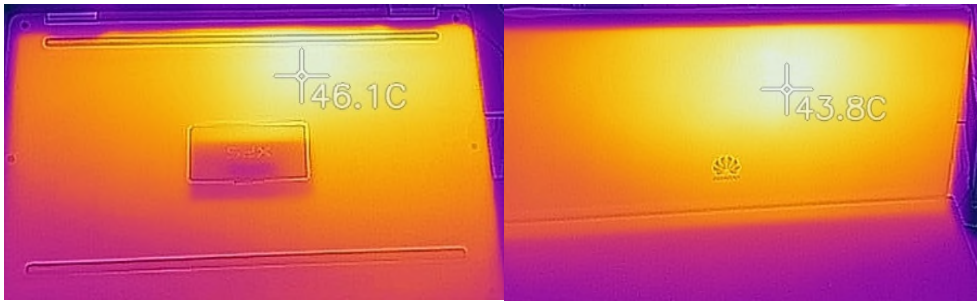
Our scenario involved utilizing both the CPU cores and GPU core for all competitors by playing back a long-form 4K video from YouTube while also loading up the Windows 10 Store version of Minecraft to run in the foreground. This ensures that as much of each SoC is as active as reasonably possible. We interacted with each to ensure playable and comparable frame rates in the game and 4K video playback (there were) and allowed 15 minutes to pass to ensure the systems were in a stable state.

From left to right: HP Envy x2, Microsoft Surface Pro 4, Dell XPS 13 2-in-1, Huawei MateBook E
Note: the Dell XPS 13 2-in-1 was placed in a "tent" mode to show the hotspot on the bottom of the machine.

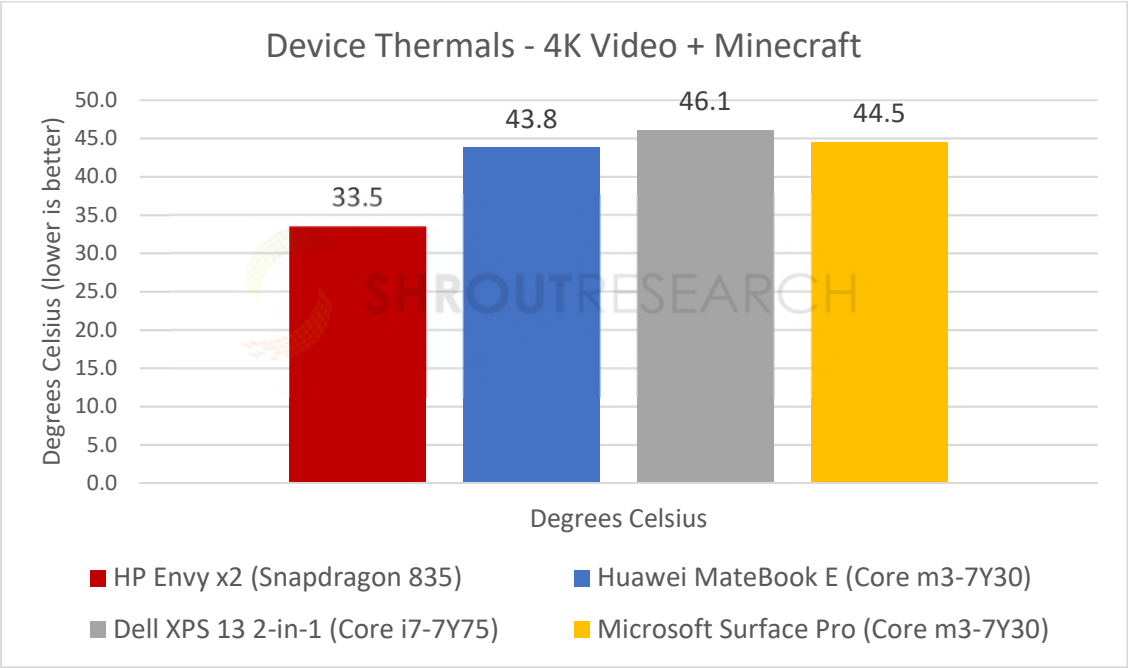
It is clear just from this first image captured through a FLIR camera that the device on the far left is running with the least generated heat. A close of up each machine allows us to pinpoint the peak temperature levels.



Left: HP Envy x2 (Snapdragon 835), Right: Microsoft Surface Pro (Core m3-7Y30)



Left: Dell XPS 13 2-in-1 (Core i7-7Y75), Right: Huawei MateBook E (Core m3-7Y30)



The HP Envy x2 using the Snapdragon 835 is able to run this heavy workload scenario as smoothly as the competitors, while generating 10C less heat, an indicator of the architectural efficiency provided by the platform.

A path to the future

After years of stagnation and limited progression, the mobile computing space is finally witnessing a rebirth of change. Windows-powered notebooks have lacked innovation in many of the key areas we discussed in-depth in this paper, especially in relation to how the demands and expectations of mobile consumers have shifted in the age of the smartphone.

Smartphones have provided massive change in the computing markets and many in the industry believed that smartphones and mobile-OS powered devices would be the replacement of the PC industry. In fact we have seen a different story: though the impact from smartphones remains substantial, the drive is pushing features developed and perfected in the phone space back into the PC.

These are easy to see and understand. Consumers gravitated towards smartphones due to their ability to remain connected without cumbersome Wi-Fi connections and hotspots and that battery life targeted a true “all day” use case rather than a several hour mentality that had haunted notebooks. Smartphones are available at the tap of a screen or touch of a button, without having to wait for a reboot or resume function, with data and notifications ready immediately. Smartphones are thin, sleek, and silent, without the need for high power processors that require fans and noise.

Many hardware and platform vendors will eventually provide designs capable of meeting these goals, of providing the user experiences that are required. But for the immediate window, mobile processors like

Qualcomm Snapdragon, powered by Arm-based core designs, have a marked advantage. As the mobile performance and capability iteration cadence continues on its march of annual (or quicker) releases, their ability to provide more battery life, more performance, and more features to Windows users will be unmatched.

It is inevitable that these innovations move to the Windows PC. The Always On, Always Connected PC is the categorical definition of these traits and though we cannot predict shifts and movement in the category itself, as a starting point for a new generation of hardware, the details we have laid out are clear, painting a very specific future for Windows hardware.

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Appendix

The following test system configuration were used in the preparation of this paper:

	HP Envy x2 (12-e011nr)
Processor	Qualcomm Snapdragon 835
Graphics	Qualcomm Adreno 540 GPU
Display	1920x1280, 12.3”
RAM	8GB LPDDR4-1866
Storage	256GB UFS
OS	Windows 10 v1709
Connectivity	802.11ac + Snapdragon X16 LTE
Battery	49.33 WHr

	ASUS NovaGo (TP370QL)
Processor	Qualcomm Snapdragon 835
Graphics	Qualcomm Adreno 540 GPU
Display	1920x1080, 13.3”
RAM	6GB LPDDR4-1866
Storage	256GB UFS
OS	Windows 10 v1709
Connectivity	802.11ac + Snapdragon X16 LTE
Battery	52 WHr

	Huawei MateBook E
Processor	Intel Core m3-7Y30
Graphics	Intel HD Graphics 615
Display	2160x1440, 12.0”
RAM	8GB LPDDR3-1866
Storage	512GB PCIe
OS	Windows 10 v1709
Connectivity	802.11ac
Battery	33.7 WHr

	Dell XPS 13 2-in1 9365
Processor	Intel Core i7-7Y75
Graphics	Intel HD Graphics 615
Display	1920x1080, 13.3”
RAM	8GB LPDDR3-1866
Storage	256GB PCIe
OS	Windows 10 v1709
Connectivity	802.11ac
Battery	46 WHr

	Microsoft Surface Pro (FJR-00001)
Processor	Intel Core m3-7Y30
Graphics	Intel HD Graphics 615
Display	2736x1824, 12.3”
RAM	4GB LPDDR3-1866
Storage	128GB NVMe
OS	Windows 10 v1709
Connectivity	802.11ac
Battery	45 WHr