Cooler, Quieter, and More Productive

Dell Latitude and HP EliteBook refresh with Intel's Tiger Lake

2020 will go down as a year in infamy for many profoundly impactful reasons. Social and work ecosystems were forced to undergo rapid adaptation. While we hope that many of those adaptations are temporary, for better or worse, some of them are here to stay. One trend that arose from Covid-19 that appears to be gaining a permanent foothold in society is the decentralization of the office (aka remote/virtual workplace). Replacing an 8+ hour workday's worth of team meetings, presentations, whiteboard design sessions, cubical-to-cubical information dissemination, and lab work with remote, cloud-based alternatives is creating unprecedented demands upon mobile compute hardware. Consequently, the market size and opportunity for innovation in the productivity-oriented business-class notebook segment is red hot!

In our previous article, The Cool, the Quiet, and the Productive, we attempted to break down some of the less understood design tradeoffs that notebook engineers and product planners must navigate in order to successfully bring a new platform to the market. We briefly touched on some of the fundamental physics that drive product feature tradeoffs. For example, we know that application performance requires CPUs to consume power and dissipate that power as heat. As notebooks get thinner and lighter, there is less space available for heatsinks to dissipate that CPU heat so fan speeds get louder and/or surface temperatures get hotter when using demanding applications. While some customers might say, "I don't care how long it takes to open my Office applications so long as I never have to listen to an annoying fan" there are others who would say "My kids are screaming in the background anyway so bring on maximum application performance and maybe some of that fan noise will drown out the distractions in my pseudo home office".

Today, we are continuing our series on intelligent design tradeoff strategies in business-class notebooks by investigating two product refreshes leveraging Intel's latest 10nm CPUs codenamed "Tiger Lake":

- Dell Latitude 7420 (follow on to the Latitude 7410)
- HP EliteBook 840 G8 (follow on to the EliteBook 840 G7)

The axiom *Cool, Quiet, and Productive: pick any two* has, traditionally, been debated and decided by an OEM product planning team with the hope that their decision captures the largest possible customer base. Sometimes, these product planning teams make inaccurate predictions of how customers truly prioritize features (see netbooks).

In the Latitude 7420, Dell has attempted to empower the decision of balancing skin temperature, sound output, and application performance directly into the customer's hands with an innovative feature they refer to as "User Selectable Thermal Tables". Let us find out if we really can eat our cake and have it too.

Test Introduction

At the heart of notebook thermal design is the energy efficiency of the CPU. The CPU (or Central Processing Unit) is directly linked to virtually all aspects of notebook performance as it is responsible for running software applications, accessing stored data, and executing background computations that allow for the system to 'run'. Not surprising given it's host of responsibilities, the CPU is also the single largest producer of heat within a notebook. The sustained limit of thermal energy (heat) dissipated by the CPU is typically referred to as "Thermal Design Power" or TDP. Improvements in CPU silicon manufacturing techniques (lithography) allow for more computational work to be completed with less energy consumed and thereby less heat dissipated which can either manifest as lower TDP for similar performance or similar TDP at increased performance levels. Intel's transition from 14nm Comet Lake to 10nm Tiger Lake promises a substantial shift forward in computational efficiency; meaning that the heat generated from common workloads should be reduced. It is by this CPU efficiency promise that we should expect the latest generation of business-oriented notebooks to be cooler, quieter, and more productive.

Both Dell and HP have refreshed their portfolio of productivity-oriented notebooks using the latest Tiger Lake CPUs from Intel.

The objectives of this study are two-fold:

1. Quantify the Thermal Performance Indicator (TPI) improvements for both Dell and HP business-class notebooks in their respective product refreshes from Intel's 10th generation (Comet Lake) to 11th generation (Tiger Lake) CPU architecture on:

    - Application Performance
    - Skin Temperature
    - Sound Output
    - Battery Performance

2. Evaluate the effectiveness of Dell's innovative ***User Selectable Thermal Tables*** to allow meaningful customer choice on the aforementioned TPIs.

Table 1. System configuration details for the two new notebooks under investigation and their previous generation references.

	Intel Comet Lake		Intel Tiger Lake	
	Dell Latitude 7410	**HP EliteBook 840 G7**	**Dell Latitude 7420**	**HP Elitebook 840 G8**
Chassis Material	Aluminum	Aluminum	Aluminum	Aluminum
Processor	Intel Corei7-10610U	Intel Corei7-10610U	Intel Core i7-1185G7	Intel Core i7-1185G7
Memory	16GB DDR4 2666MHz	16GB DDR4 2666MHz	16GB LPDDR4 4267 MHz	16GB DDR4 3200 MHz
Storage	256GB PCIE NVMe	256GB PCIE NVMe	256GB PCIE NVMe	480 GB PCIE NVMe
Battery Capacity	68Wh	53Wh	63Wh	53Wh
Display Type	14" FHD 1920x1080	14" FHD 1920x1080	14" FHD 1920x1080	14" FHD 1920x1080
BIOS Version	1.3.1	1.01.05	89.93.2	1.01.04
Windows Power Slider Bar	Better Performance	Better Performance	Better Performance	Better Performance
Windows Version	Win 10 Pro Build 19042	Win 10 Pro Build 19042	Win 10 Pro Build 19042	Win 10 Pro Build 19042

Enter the Tiger Lake

Over the past half century, Intel has earned a reputation for being incredibly consistent in their generational CPU improvement rollouts. Not coincidentally, the cadence for Intel releasing an improved microarchitecture followed by a shrink in the silicon lithography, like the beats of a grandfather clock, came to be referred to as “tick” and “tock”, respectively. At a high-level, “tick” phases would reflect a shrink in the transistors that comprise a CPU allowing for more transistors (think work cells or core count) to be placed on the die. “Tock” phases typically brought improvements in CPU instruction efficiency, meaning that the work completed in each CPU cycle would increase. PC and notebook OEMs effectively synchronized their product release cadences to the steady tempo of Intel’s generational CPU updates. This clock effectively stopped ticking in 2015 when Intel failed to achieve production quality targets for 10nm CPUs and remained stuck on their aging 14nm manufacturing process for the next 7 CPU refreshes.

While Intel did successfully launch their Ice Lake CPUs on an early version of their 10nm node, low yields and limited generational improvements over the preceeding Comet Lake prevented the CPU from seeing broad adoption. Intel’s Tiger Lake, launched in the fall of 2020, marks an important landmark for the world’s largest x86 CPU manufacturer as OEMs were able to refresh their entire notebook portfolio with the long awaited 10nm CPU process and all of the potential compute efficiency benefits it brings with it.

Dell Latitude 7410 to 7420 Updates:

For their Tiger Lake follow on of the Latitude 7410, Dell made some very notable changes in the Latitude 7420. Figure 1 below shows a comparison of the Latitude 7410 (left) and the Latitude 7420 (right). The CPU heatsink is nearly a full two times larger and the previous 60mm blower has been replaced with a much higher airflow 70mm blower. Recalling from our previous article about the absence of any “free lunches” when it comes to physical space inside a notebook, the CPU cooling solution appears to have grown at the expense of battery capacity which took a slight hit dropping from 68 Wh in the 7410 down to 63 Wh in the 7420. Without further testing, it is immediately obvious that Dell has made substantial investments into the Latitude 7420 cooling solution all of which should net a cooler, quieter, and faster notebook.

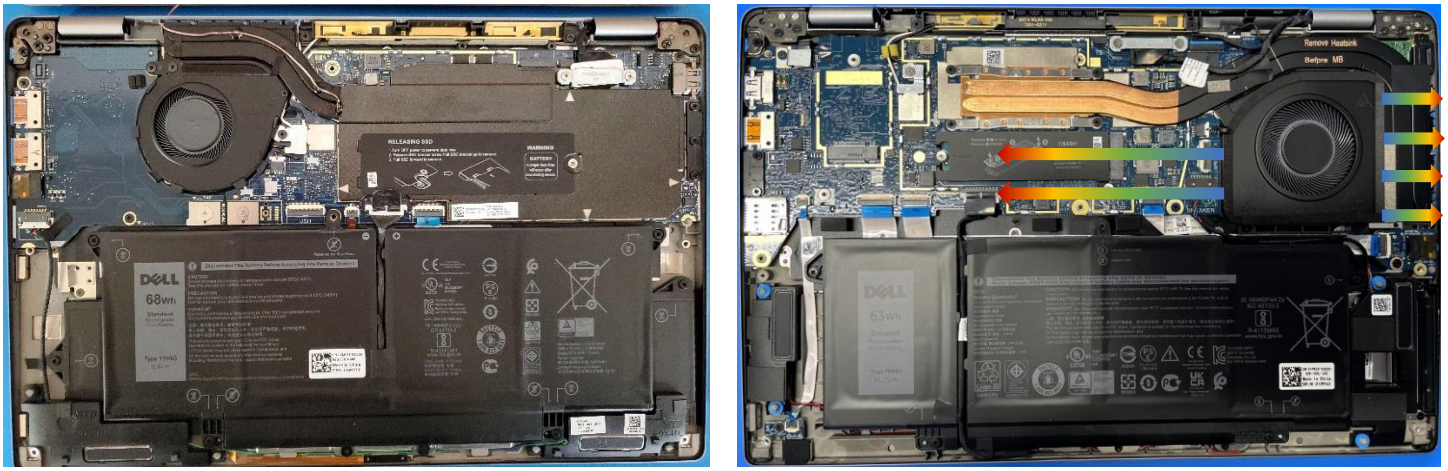

Figure 1. Comet Lake-based Dell Latitude 7410 shown (left) and Tiger Lake-based Dell Latitude 7420 shown (right)

Dual Opposite Outlet Fan (DOO)

Aside from simply using a larger air mover, the Latitude 7420 is sporting Dell’s recently announced Dual Opposite Outlet (DOO) Fan technology. What is interesting about the DOO technology, from a thermal engineering perspective, is that it effectively allows for a secondary airstream off the backside of blower for free or without significant penalty to the airflow delivered from the primary outlet. In the case of 7420, the secondary air stream is being used to push cooling airflow across the bottom cover of the notebook in an attempt to reduce touch temperatures along the base (see right image of Figure 1 above). Skip ahead to the “Skin Temperatures” section of this article to get a quick look at how far this technology went in reducing touch temperatures on the Latitude 7420. **Dell User Selectable Thermal Tables (USTT)**

In addition to the larger CPU cooler, the Latitude 7420 boasts one of Dell’s more recent innovations in user-customization which Dell refers to as “User Selectable Thermal Tables”. As discussed in depth in the previous article in this series (see

The Cool, the Quiet, and the Productive for a more thorough explanation), there is a fair amount of ambiguity when establishing the user-experience design constraints of any given platform. How loud is too loud for a system cooling fan? How warm is too warm for the skin temperature of a notebook that might be resting upon one's lap? Is it acceptable to a user to bend upon those previously established limitations when running an important application? Would you be willing to give up some thermal or acoustic comforts to have your nearly due photo rendering job complete faster? In a survey of 100 different business-notebook users encompassing a variety of industries and job functions one is likely to encounter 100 different combinations of answers to these questions. Dell's answer is to give these impactful thermal choices back to the customer, with limits, of course.

Either through the Dell Power Manager utility found in Windows 10 OS or by hitting F2 during system boot on the Latitude 7420 and navigating to the "Power" menu, the user will encounter a menu titled "Thermal Management". Within this menu there are 4 unique thermal management modes which each alter the system's rules for self-governing processor speed, skin temperatures, and sound output (i.e., fan noise). Each mode is attempting to provide personality to the notebook that more uniquely aligns to user sitting in front of it. Though it is certain that customers would prefer to "have it all" when it comes to products that are quiet, cool, high performance, and portable, thermodynamics oppose the coexistence of each parameter in notebooks that are reasonably cost-effective to mass produce. Fortunately, Dell is at least giving the user the choice of which tradeoff they are willing to make rather than deciding for them.

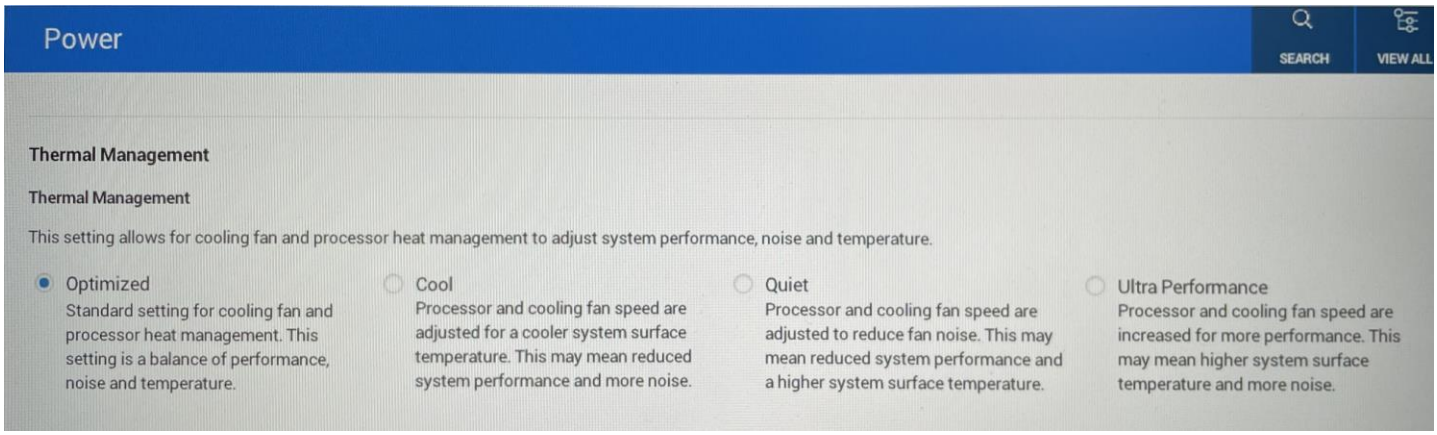

Figure 2. User-Selectable Thermal Tables in Dell Latitude 7420 pre-boot setup menu.

The 4 thermal management modes are as follows:

- **Optimized**: Factory Default – balance of all 3 competing thermal performance influencers.
- **Cool**: Choose this mode if a warm palm rest, keyboard, or notebook on your lap really annoys you.
- **Quiet**: Prefer for your notebook to be seen and not heard? *Quiet* mode attempts to drop notebook fan noise.
- **Ultra Performance**: Under pressure to complete your job as soon possible and don't care if sound output and surface temperatures creep up because you're listening to house music through headphones and use a BT keyboard anyway? *Ultra-Performance* mode is designed to relax some of the physics constraints around noise and skin temperature to provide maximum application performance.

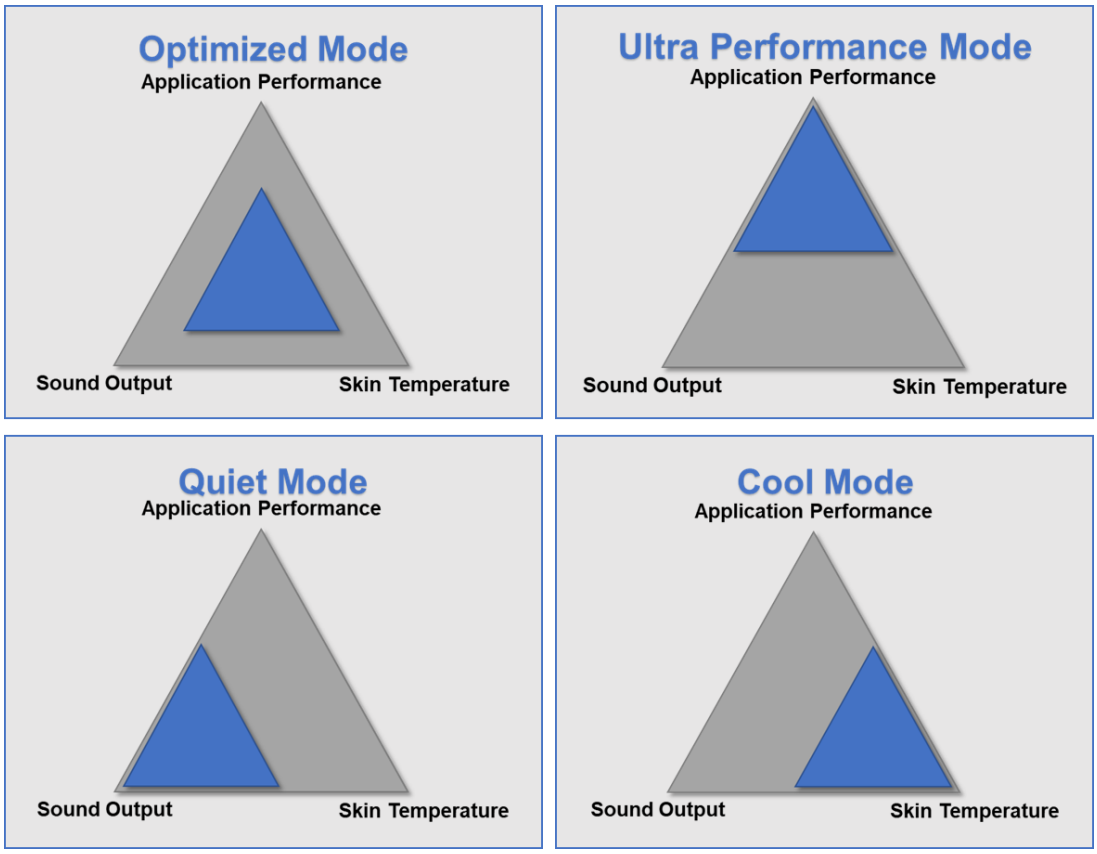

Figure 3. Infographic illustration of the various thermal feature priorities offered by the Dell Latitude's USTT.

HP EliteBook 840 G7 to G8 Updates:

This segment will be short and sweet. HP's EliteBook series is a high quality, well-rounded, productivity-oriented notebook that has received high praise from many sources on tactical elements ranging from aesthetics to touchpad integrity. Having said that, the Tiger Lake refresh (G8) is virtually unchanged from the Comet Lake release (G7) from a thermal perspective. This is not a bad thing as the EliteBook 840 G7 had the highest cooling capacity heat sink and blower combination of all three Comet Lake notebooks included in our previous study.

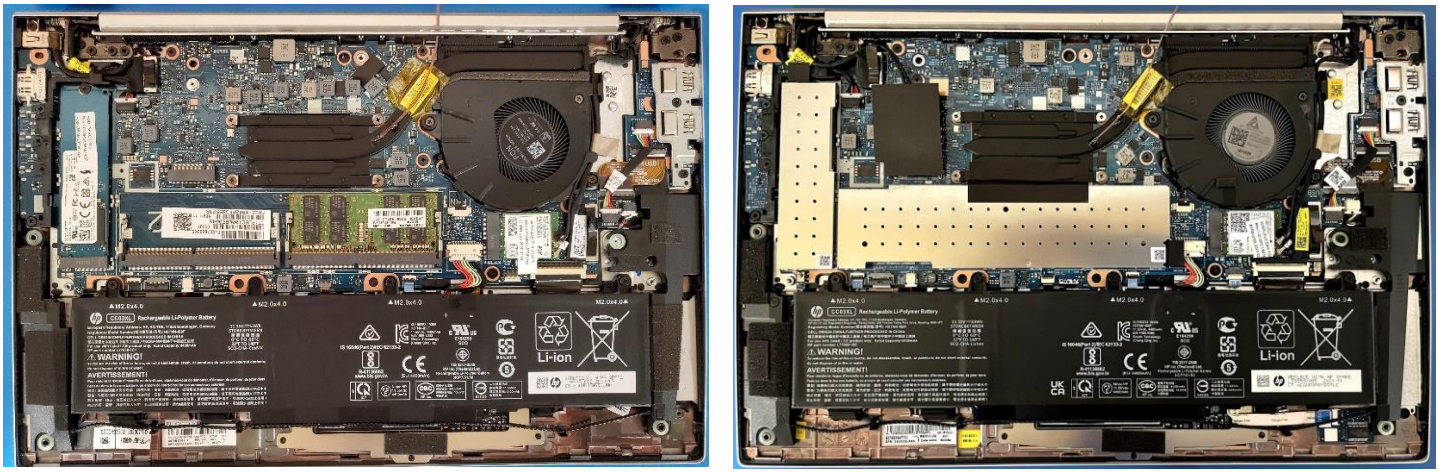

Figure 4. Comet Lake-based HP EliteBook 840 G7 shown (left) and Tiger Lake-based HP EliteBook 840 G8 shown (right)

Cooling Solution Comparison

The previous article in this series dives into some of the fundamental principles behind cooling solution design and the curious reader is encouraged to check out that article to gain some familiarity with these systems. With that in mind, both the Dell and HP notebooks included in this study leverage the same high-level cooling scheme that was found in their respective predecessors: a single blower (air mover) attached to a heat sink fin stack that is coupled to the CPU via heat pipe(s). In the Comet Lake 10th generation, the HP EliteBook had over 2x the heat sink surface area and a substantially larger blower compared to the Dell Latitude notebook affording HP a much higher steady state cooling capability.

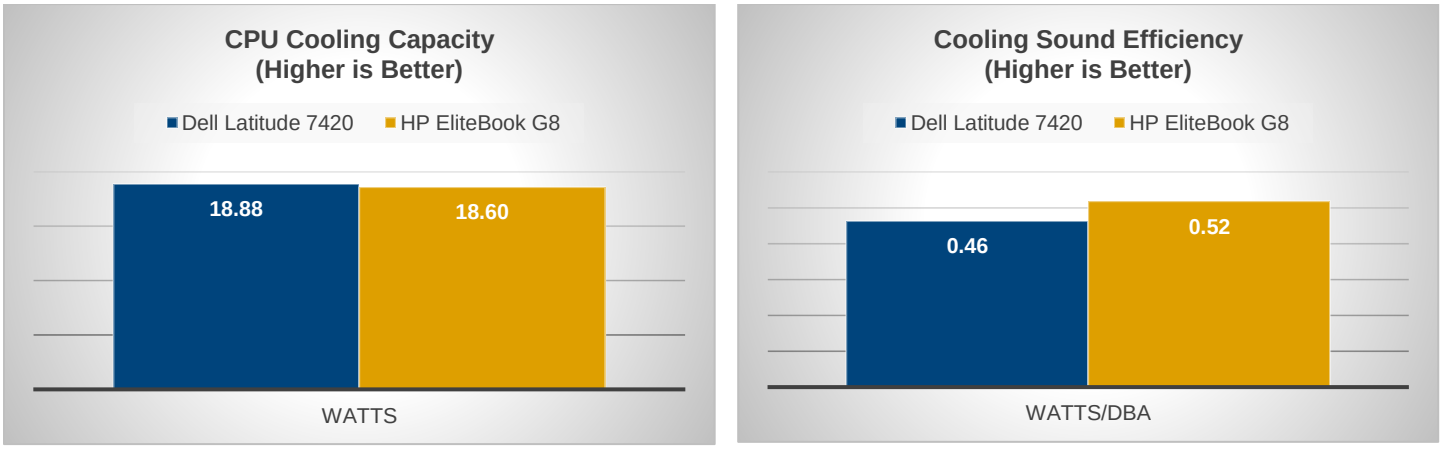

Figure 5. Steady state cooling capacity comparison (left) and cooling sound efficiency (right)

As seen in Figure 5, Dell appears to have leveled the playing field with HP in steady state cooling capacity but accomplishes that cooling capacity at a higher system blower speed which causes them to trail in sound efficiency (heat removed in Watts per dBA of sound output). In the previous generation Latitude 7410, Dell's thermal engineering team was able achieve wins in application performance and sound output despite having a smaller cooler than the Elitebook 840 G7 because of impressive thermal tuning of the CPU PL1 limits. With the 7420, Dell's thermal team will have the benefit of established excellence in PL1 tuning combined with a substantially larger CPU heatsink. Based upon the thermal implications of these changes, the results are expected to be impressive.

Thermal Performance Indicators (TPIs)

In the next few sections of the article, each of the four primary TPIs will be evaluated on the Dell Latitude 7420 and the HP EliteBook 840 G8. Where possible, the previous product generation (Comet Lake) TPI will be included to illustrate the relative performance improvements the latest products offer to the customer. Furthermore, because Dell has attempted to create value through innovation with their User Selectable Thermal Tables, the performance of the Dell 7420 operating within its respective optimization mode for each TPI will also be included to understand exactly how good the Dell platform is at providing user choice.

Application Performance

Up first in the TPI index is Application Performance, aka, *Productivity*. This category tends to consistently rate highly amongst business customers who, above all, are needing to get more work done in a shorter period of time. Without question, application performance has become more critical to the business-oriented consumer than ever before throughout the past year where many individuals who were already running Microsoft's Outlook, Word, PowerPoint, Excel, and 18 tabs of Google Chrome in the background faced the new requirement to simultaneously include a full-featured video conference application such as Zoom. Users who experienced the firsthand frustrations of trying to host a Zoom video call while presenting their 10+ sheet Excel workbook only to have the video session lag or crash entirely will want to tune into this section very closely.

To quantify system application performance, the same 3 productivity-oriented benchmark utilities were utilized. Those application benchmarks are:

- PCMark 10:
  - Mixed-use office productivity including video conferencing, web browsing, app start-up, word processing, spreadsheets, photo editing, video editing, and professional graphics.
- SYSMark 25
  - Library of pre-recorded usage scenario scripts on actual copies of the most commonly used office software suites including Microsoft Office, Adobe Creative Suite, Google Chrome, and more.
- Cinebench R20
  - Timed photo rendering using the popular Cinema 4D image rendering engine.

Each of these three applications is explained in detail in the previous article (here).

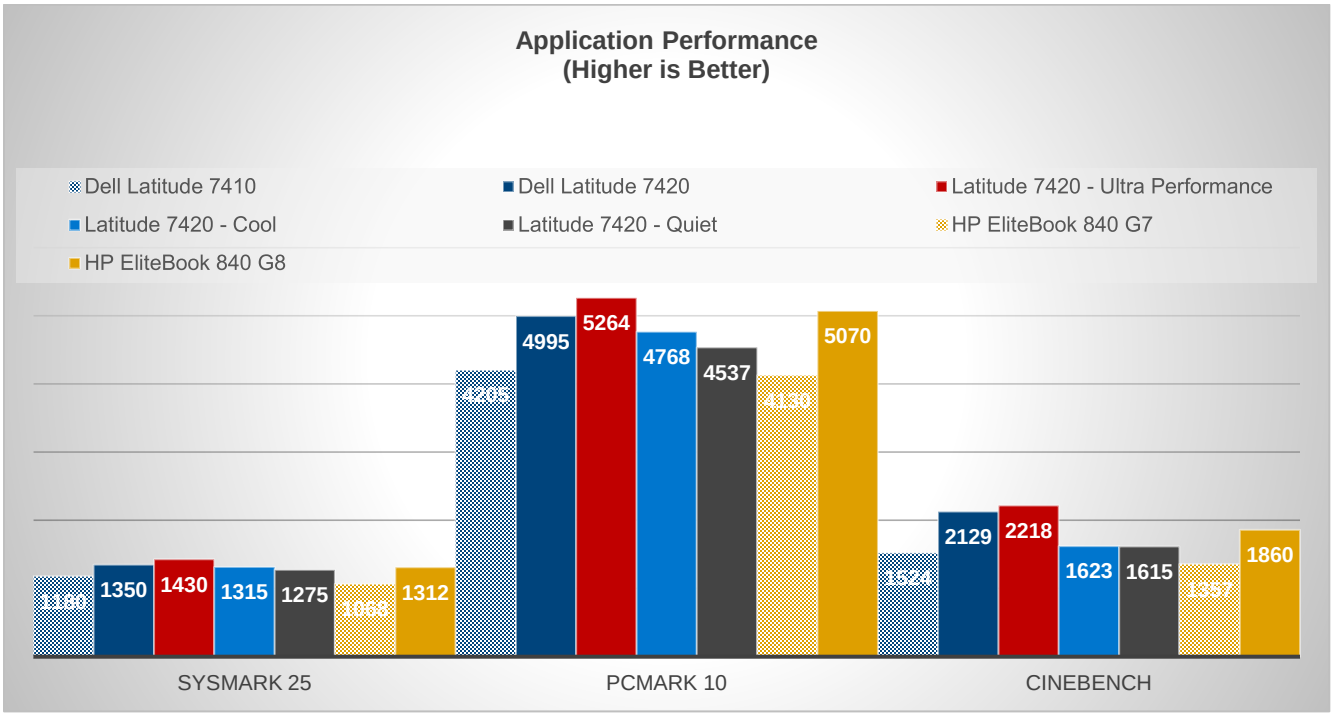

Figure 6. Top-level benchmark results for each of the 3 applications for current generation (Tiger Lake) and previous gen (Comet Lake).

The data in Figure 6 helps immediately answer the question: "***is the next generation product actually more productive?***"

The answer is indisputably "***Yes***". As seen in the performance data, both Dell and HP average nearly **20% increase in performance for the mixed-use office** application benchmarks SYSMark 25 and PCMark10 while boasting even more impressive gains to the tune of **38% in the CPU-intensive rendering application Cinebench**.

Figure 6 also shows how each of Dell's User Selectable Thermal Tables affects application performance. *Ultra-Performance* mode allows the Dell Latitude 7420 to put significant distance between itself and the HP Elitebook 840 G8 in all three benchmark applications while *Cool* and *Quiet* modes take an expected hit in performance to deliver upon their aptly named user preferences.

Without question, both systems supporting Intel's latest mobile CPU architecture Tiger Lake are faster. The next question we ask is "**is the next generation product any more efficient**"? The answer to that question is "***yes and no***".

Figure 7 below shows generation over generation change in both power (on the left) and performance (on the right) for the Dell and HP notebooks in the Cinebench R20 benchmark. As previously noted, both systems post impressive gains in performance for this type of workload. The HP EliteBook 840 G8 sees a 37% increase in performance while only a 25% increase in CPU power consumption. This indicates that the HP solution is providing more compute performance per Watt of CPU power than their previous generation. On the other hand, the Dell Latitude 7420 is consuming roughly 64% more CPU power to deliver a 40% increase in performance indicating a lower computational efficiency solution.

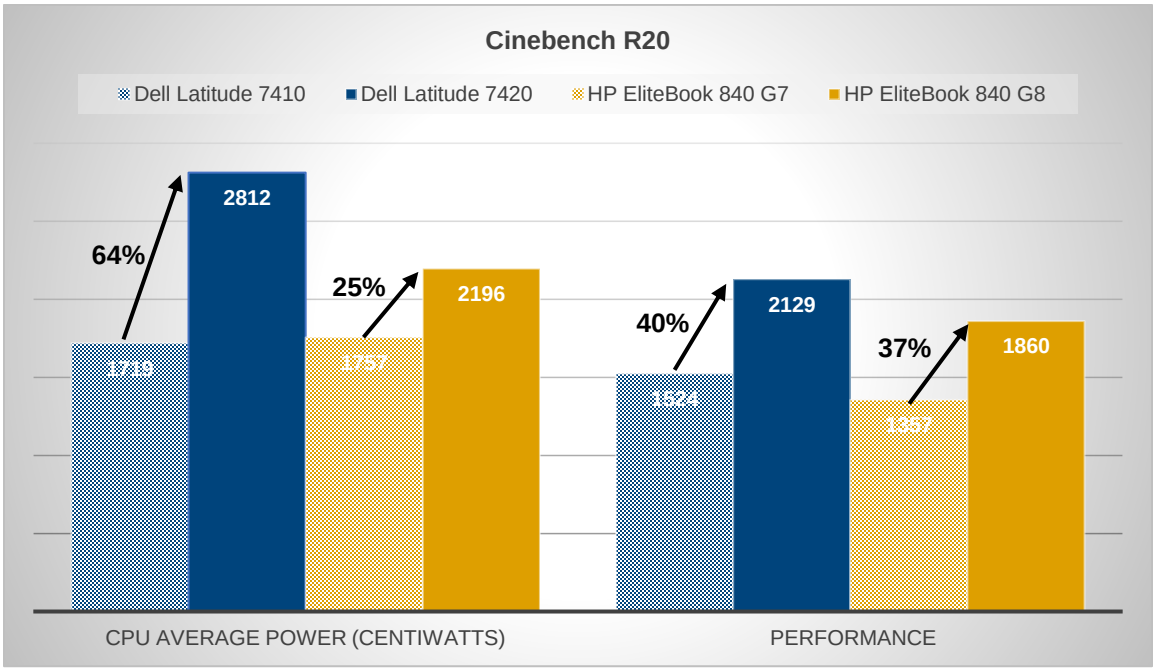

Figure 7. Generation over generation comparison of CPU power and performance

To better visualize this data, Figure 8 shows the CPU Package Power for both the Dell and HP notebooks recorded during the duration of the Cinebench R20 benchmark. It is clear that Dell is pursuing high marks in application performance by their CPU power level algorithm allowing for significantly higher power dwell than HP's EliteBook. Recall from the previous article that notebook OEMs have the ability to dynamically or statically alter the CPU's maximum power threshold which effectively allows for them to govern operating frequency (performance) limits. The Dell Latitude 7420 consumes 32% more power than the HP EliteBook 840 G8 while delivering 14% increase in performance. Conversely, though the Dell notebook does consume extra CPU power, it also finishes the single-image rendering job in 2 minutes 23 seconds compared to 2 minutes 48 seconds that it takes the HP notebook. If your job required you to do process a large number of images throughout the day, saving 25 seconds on each image would likely be well worth the tradeoff in efficiency.

This data illustrates a very important physics limitation often misunderstood by consumers: CPU power consumption increases exponentially with frequency while performance only increases linearly. What this means is that there is a point where increasing the power limit of the CPU results in very large increases in power consumed with only minimal increases in performance; in other words, diminished returns. The EliteBook appears to be operating very near this point of diminished returns while the Latitude has attempted to push beyond it for that last bit of application speed. That said, as we will later see, the Dell system has the battery capacity and cooling capabilities to enable this pursuit, so the net result appears to be a win for Dell.

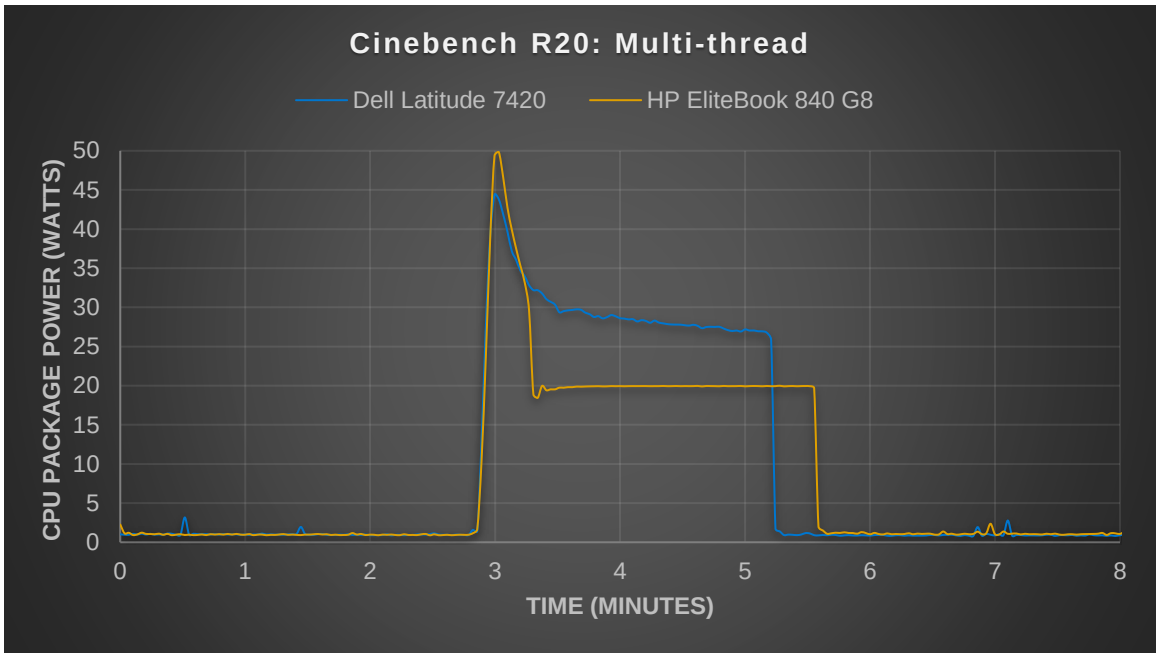

Figure 8. CPU Power consumption profile for a single run of Cinebench R20

In final consideration of the application performance results, here are the key takeaways:

- For office applications, the Dell Latitude 7420 and HP EliteBook 840 G8 are neck and neck. The Dell system picks up the edge in SYSMark 25 while the HP notebook has the slight edge in PCMark 10. Dell soundly bests HP in the CPU tractor-pull of Cinebench R20 giving it the overall lead in application performance benchmarks.
- **Dell's *Ultra-Performance* setting within their pre-boot *User Selectable Thermal Tables* provides significant performance increases in all 3 benchmarks tested**.
- Using Dell's *Cool* and *Quiet* modes both result in some application benchmark performance degradation which matches expectations given our collective understanding of the competing physics in skin temperature, sound output, and CPU power.

Productivity Winner: **Dell Latitude 7420**

Skin Temperature

The next TPI category to be considered is product skin temperature. Depending upon how the user typically operates throughout the day (whether they are often sitting with their notebook in their lap or if they use a docking station with an external monitor and keyboard) will have a huge impact on how that customer perceives and values notebook skin temperature ranging from “critically important” down to “couldn’t care less”.

Figure 9 and 10 below summarize the process for capturing notebook skin temperatures. In both cases, the process is to stress the hardware with a CPU-intensive application (in this case Cinebench R20 works nicely), utilize an IR camera to identify all of the critical hot-spots on the surfaces, and then apply thermocouples to each of the points of interest capturing worst case skin temperature hot spot locations.

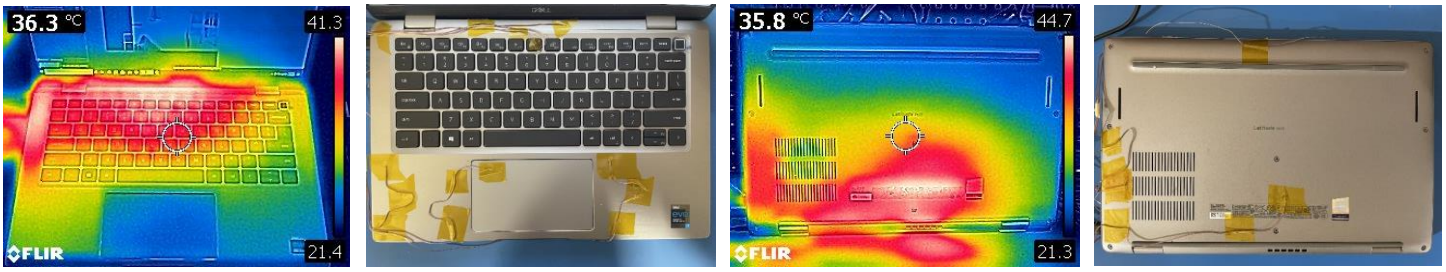

Figure 9. Skin temperature mapping and instrumentation for Dell Latitude 7420

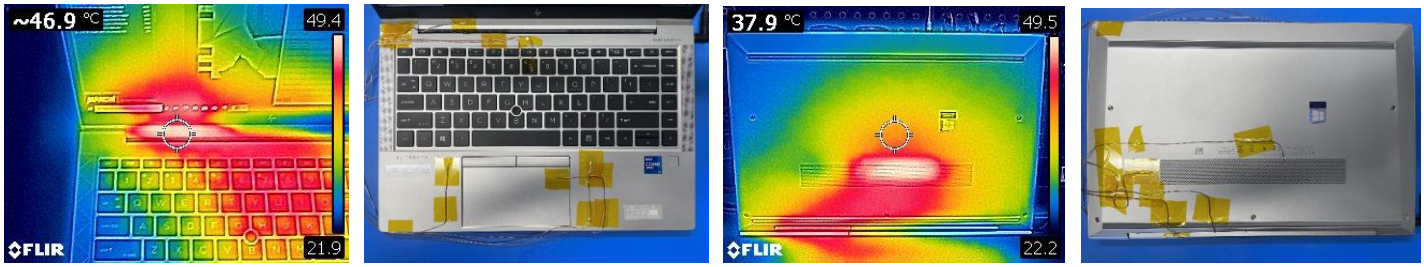

Figure 10. Skin temperature mapping and instrumentation for HP EliteBook 840 G8

Figure 11 below shows the results of the skin temperature study for each of the three benchmark applications including performance from the previous generation systems and Dell’s *USTT Cool Mode* shown in green. The EliteBook 840 G8, having virtually no cooling changes from the 840 G7 sees nearly identical temperatures from the previous generation. The Dell Latitude 7420, on the other hand, sees significant generational drops in maximum skin temperatures on the bottom of the notebook due, in large part, to the use of the Dual Opposite Outlet blower.

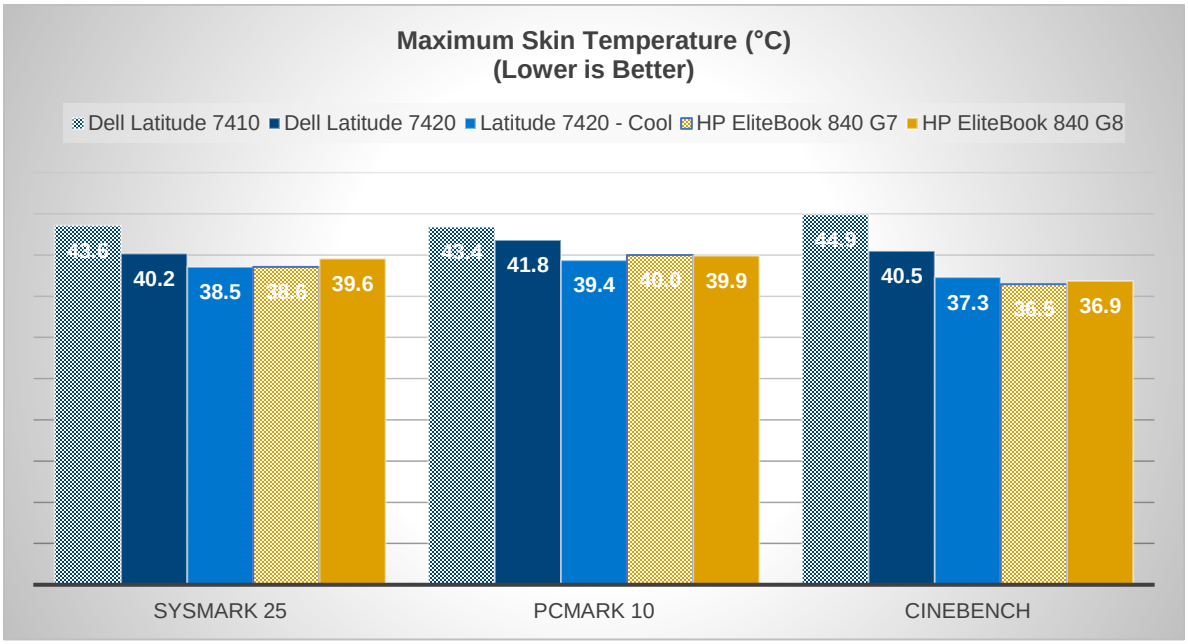

Figure 11. Skin temperature comparisons between current generation (Tiger Lake) and previous gen (Comet Lake).

As with Dell's *Ultra-Performance* mode, *Cool* Mode seems to work quite nicely – dropping skin temperatures noticeably in each of the benchmarks. Where the HP EliteBook boasts lower temperatures than the Latitude in the default *Optimized* mode, by switching into *Cool* mode the Latitude can run two out of three benchmarks with cooler skin temperatures than the EliteBook 840 G8. As expected, there is a modest performance tradeoff on the Latitude 7420 when the user elects to prioritize cooler skin temperatures which can be view in Figure 12 below showing the slight drop in SYSMark 25 performance scores. Though *Cool* mode does affect SYSMark office application performance, the Latitude 7420 is able to outperform the Elitebook 840 G8 while offering cooler skins.

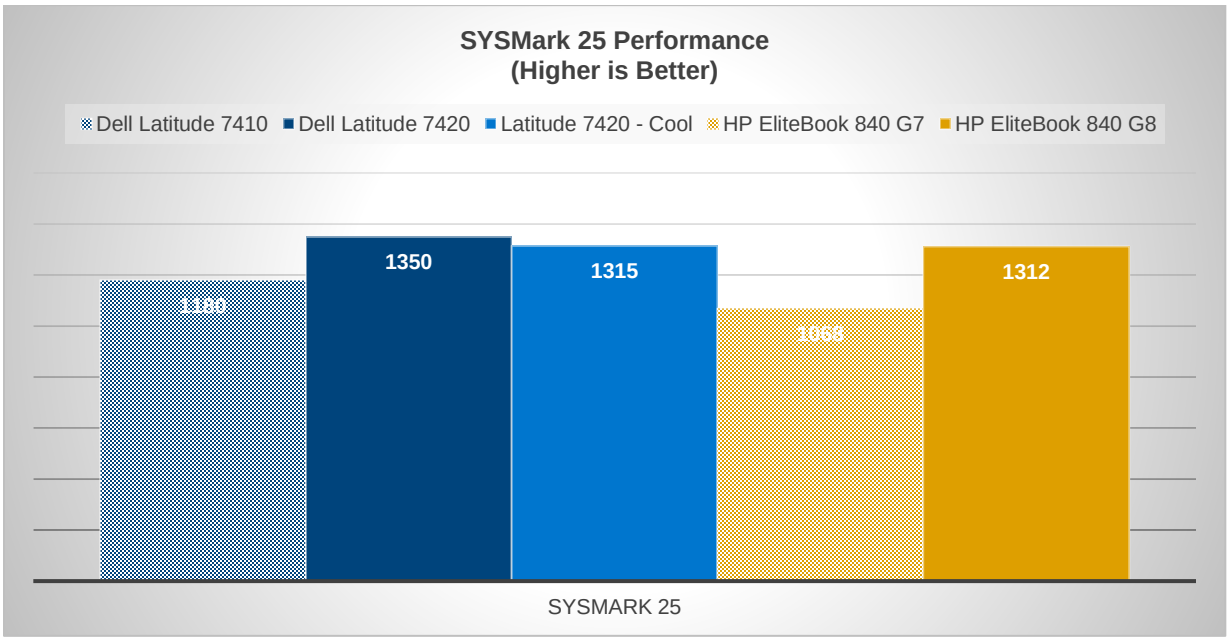

Figure 12. SYSMark 25 performance scores showing the slight performance tradeoff in Dell's "Cool" mode.

Skin Temperature Winner: **Dell Latitude 7420**

Sound Output

The next TPI to be considered in this study is sound output (acoustics). Like skin temperature, customer concern for this category ranges dramatically from “critical concern” to “couldn’t care less” which will ultimately depend upon the environment the user operates within and how sensitive they are to sound emissions. For this portion of the study, each of the notebooks was setup within the Strategic Thermal Labs pseudo-anechoic chamber pictured below in Figure 13. Sound emissions from the notebooks were captured for each benchmark application with a digital sound level data acquisition system.

Figure 13. HP EliteBook 840 G8 shown inside of the STL pseudo-anechoic chamber.

Figure 14 shows the results of the acoustic testing for all three benchmarks and both product generations. In the preceding section on application performance, we already uncovered that both Tiger Lake based systems are dissipating more heat than their Comet Lake predecessors, so it is, therefore, not surprising that both HP and Dell notebooks, across the board, are emitting more noise than their previous generations to cool this additional processor heat. In some cases, significantly more noise. ***Dissipating more heat requires moving more airflow, which requires higher fan speeds, which emits more noise***.

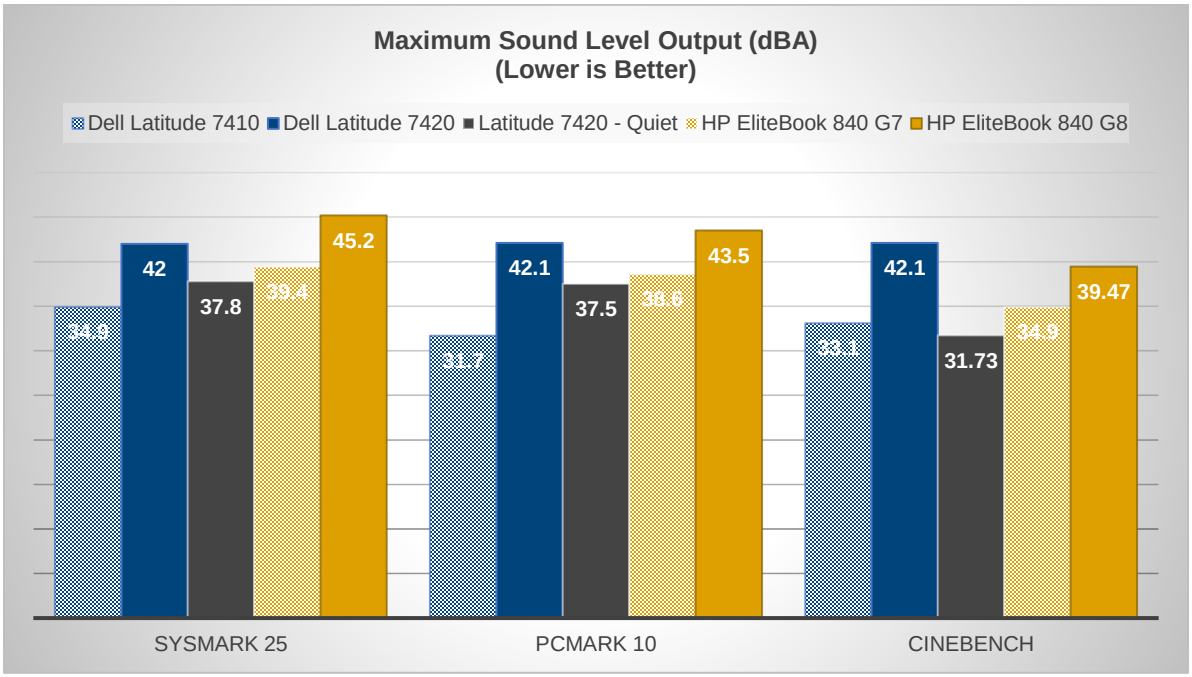

Figure 14. Sound Level comparisons between current generation (Tiger Lake) and previous gen (Comet Lake).

The good news for Dell in this case, however, is that where both Tiger Lake platforms are emitting higher sound levels, the *USTT Quiet* mode, like *Cool* and *Ultra-Performance*, seems to work exceptionally well. *Quiet* mode doesn't quite reduce system noise emission to the levels of the previous generation in most of the benchmarks, it does make the Latitude substantially quieter than the EliteBook in all three tests, though, again, at the expense of application performance as shown in Figure 15 below where being "quieter" does cause the Latitude 7420 to fall behind the Elitebook 840 G8 in SYSMark 25 application performance.

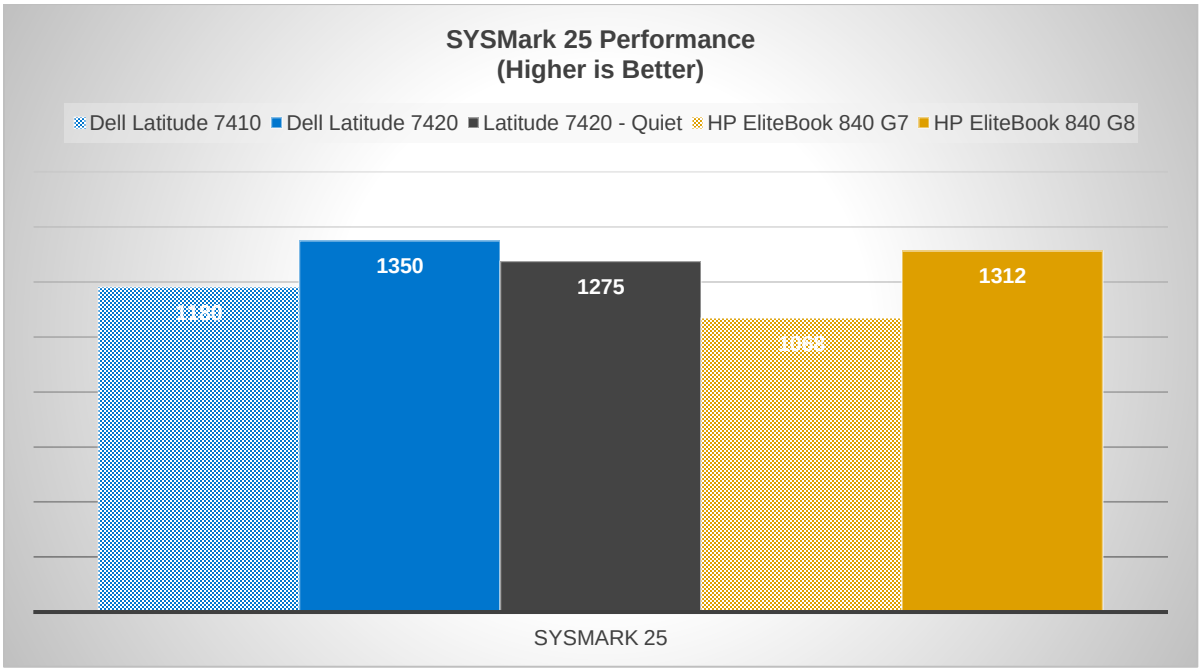

Figure 15. SYSMark 25 performance scores showing the slight performance tradeoff in Dell's "Quiet" mode.

Sound Output Winner: **Dell Latitude 7420**

Battery Performance

The final category in the TPI study, and introduced for the first time to the series, is battery performance. While some might debate how relevant battery life is within the context of notebook thermal engineering, the reality is that the two are highly interdependent. In the case of size-constrained mobile compute products, the battery and the cooling solution compete with one another for space so having a higher capacity battery often means a reduced capacity CPU heat sink.

This happens to be the case for the Dell Latitude where the previously noted two-fold increase in CPU heatsink appears to have driven the battery capacity down by roughly 8% as noted in Figure 16. For HP there is no change in the current generation.

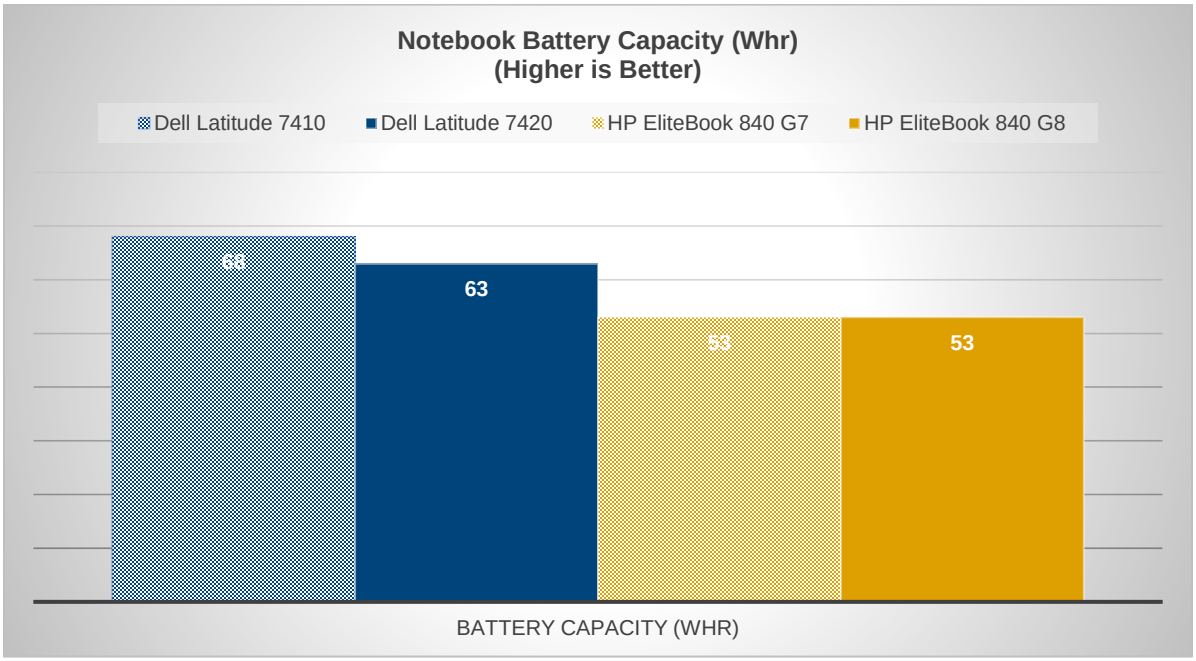

Figure 16. Battery capacity comparison between current generation (Tiger Lake) and previous gen (Comet Lake).

Was the exchange of battery capacity for cooling capacity worth it? As showcased in the previous sections, the updated Latitude 7420 has managed to claim victory in application performance, skin temperature, and sound output. We also know that raw battery capacity is not the only parameter that dictates real world battery life. OEM system designers have the ability to tune performance parameters such as CPU frequency to squeeze out as much battery life as possible with various battery-saver algorithms.

So what did Dell give up in battery performance? To answer this question, two battery performance tests were utilized. The first was a semi-rudimentary Zoom video conference call. In this test, 9 systems were brought into the same video conference call, each with an active virtual background as shown in Figure 17. The systems were allowed to run the Zoom conference call until the system's low battery protection automatically forced the system to enter sleep mode and removed the user from the call. The second test utilized the PCMark 10 Modern Office battery test suite. The Modern Office test runs a loop of the most common office applications (word processing, web browsing, spreadsheets, etc) and records how long the notebook is capable of executing those applications before it goes to sleep due to low battery. The results for both the Zoom conference call test and PCMark 10 Modern Office battery benchmark are shown in Figure 18. In both tests, the Latitude 7420 is able to keep the user productive for several hours longer than the EliteBook 840 G8.

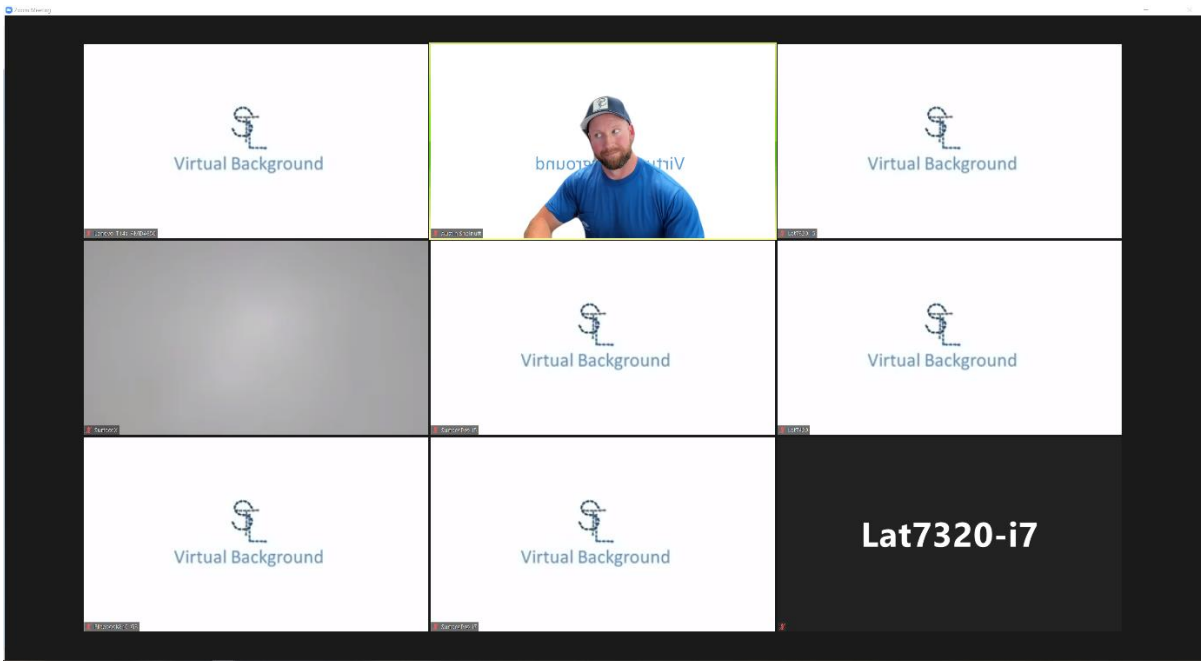

Figure 17. Battery capacity comparison between current generation (Tiger Lake) and previous gen (Comet Lake).

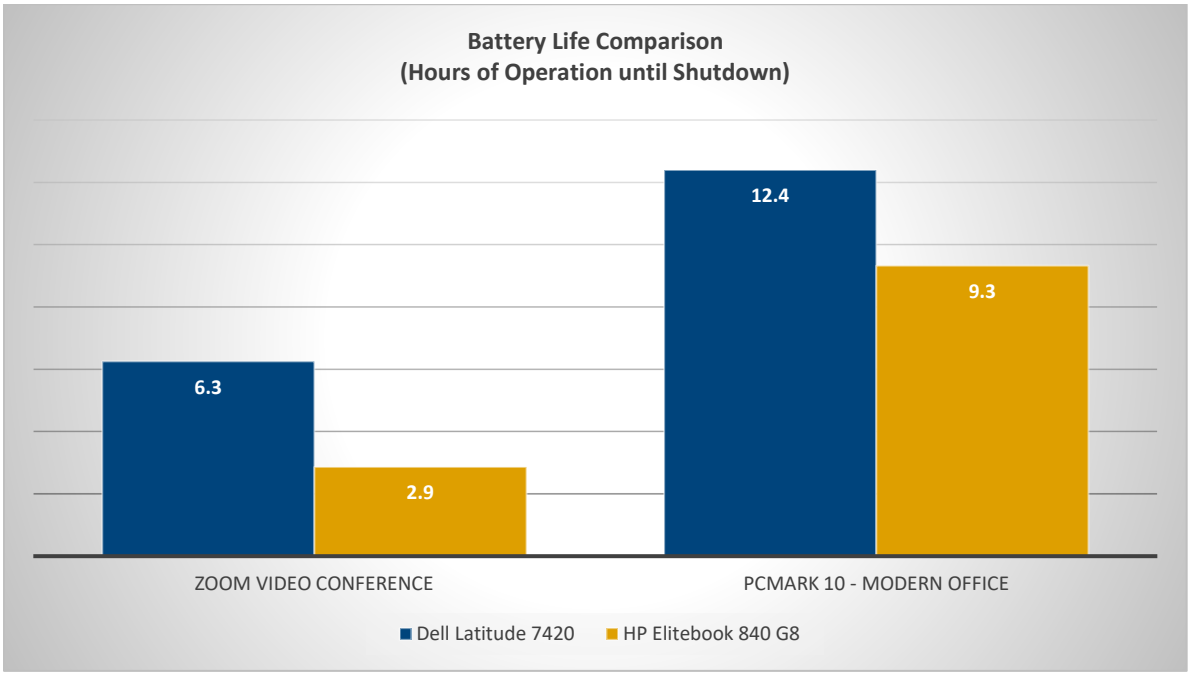

Figure 18. Battery capacity comparison between current generation (Tiger Lake) and previous gen (Comet Lake).

Battery Performance Winner: **Dell Latitude 7420**

Final Thoughts

Most of the foundation for this investigation was laid in the previous article, with the intention being to quantify exactly how much generation over generation improvement went into these respective business-class notebooks. With that in mind, here are the key takeaways (aka **TLDR** for those who wanted to skip to the end):

- Both the Dell Latitude 7420 and HP EliteBook 840 G8 show impressive generation over generation **application performance improvements averaging 19% for mixed-use office applications and 38% for CPU-intensive applications** such as Cinebench.
- Dell made notable investments into the CPU cooling solution in the Latitude 7420 and it paid off with the ability to support 64% more CPU power during the Cinebench workload compared to the Latitude 7410. Conversely, HP made virtually no generational thermal improvements to their G8 platform.
- The Latitude 7420 made concessions in battery size to support a larger CPU heatsink which appears to have been a worthwhile tradeoff as **the Dell notebook was still able to continue operating on battery for over 3 hours longer than the HP EliteBook 840 G8.**
- **Testing Dell's User Selectable Thermal Tables revealed that by choosing the *USTT* mode aligned to a given Thermal Performance Indicator allows the Latitude 7420 to claim victory in all 4 categories.** Having said that, Dell's *USTT* does not bend the rules of physics and there is still the necessity of a tradeoff in each mode. Dell's *Cool* and *Quiet* modes do give the user their preferred operating condition but there are penalties to application performance associated with both modes. By that same physics limitation, Dell's *Ultra-Performance* mode delivers significant boosts in performance, but the tradeoff is warmer surface temperatures and increased sound emissions. None of this should come as a surprise given what we know about the competing limits imposed by temperature, sound, and application performance.
- With the dually established dominance of Latitudes CPU PL1 tuning from the previous generation Latitude 7410, the enhanced cooling potential of Dell's larger heatsink and Dual Opposite Outlet fan, and the promised benefits of user-choice in the User Selectable Thermal Tables, the expectations for the Latitude 7420 product were high from a thermal engineering perspective. Through STL's empirical investigation, Dell's claims for thermal engineering supremacy appear to be confirmed as the Latitude 7420 has been found to truly be *Cooler*, *Quieter*, and *More Productive* than its competitor in this heads-up comparison.

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