

Made by Google '19

Company Participants

- Ivy Ross, Vice President Design at Google
- Lily Lin, Manager of Global Communications & Public Affairs at Google Inc.
- Marc Levoy, VMware Founders Professor
- Rick Osterloh, Senior Vice President of Devices at Google
- Rishi Chandra, Vice President of Product and General Manager of Google Nest
- Sabrina Ellis, Vice President of Product Management at Google

Other Participants

- Annie Leibovitz, American Photographer

Presentation

Rick Osterloh {BIO 15100996 <GO>}

[Video Presentation]

Good morning. Good morning. Thanks so much for joining us here in New York City. And for those on the live stream for joining us around the world, thanks so much. We're going to spend the next hour talking about the problems we're working to solve for our users and the ways we're delivering help for -- the way people need it, when they need it. We'll also take you into our labs with writer and cultural commentator Baratunde Thurston to hear from the folks at Google who personally develop, design, and bring these products to life.

Now if you look across all of Google's products, from search to maps, Gmail to photos, our mission is to bring a more helpful Google for you. Creating tools that help you increase your knowledge, success, health and happiness. Now, when we apply that mission to hardware and services, it means creating product like these. New Pixel phones, wearables, laptop and Nest devices for the home. Each one is thoughtfully and responsibly designed to help you in your everyday without intruding on your life. Now, in the mobile era, smartphones change the world. It's super useful to have a powerful computer everywhere you are, but it's even more useful when computing is anywhere you need it always available to help.

Now you've heard me talk about this idea with Baratunde that helpful computing can be all around you, ambient computing. Your devices work together with services and AI. So help is anywhere you want it and it's fluid. The technology just fades into the background when you don't need it. So the devices aren't the center of the system, you are. That's our vision for ambient computing.

The Google Assistant plays a critical role here. It pulls everything together and gives you a familiar natural way to get the help you need. Our users tell us they find the Google Assistant to be smart, user friendly, and reliable and that's so important for ambient technology; interactions have to feel natural and intuitive.

Here is an example. If you want to listen to music, the experience should be the same whether you're in the kitchen, you're driving in your car or hanging out with friends. No matter what you're doing, you should just be able to say the name of a song and the music just plays without you having to pull out a phone and tap on screens or push buttons.

So think about how this vision plays out in the home where ambient technology can make life so much easier. When you wake up in the morning, your home knows what you need to start your day. You can get your commute, find out when your first meeting starts, maybe play some music on whatever speaker or screen is nearby. And when you leave your house, your lights, thermostat, door locks, security cameras, they all just know what to do. And your devices go silent and turn off notifications at night when you want to relax without technology interrupting or distracting you. So, throughout your home, technology works as a single system, instead of a bunch of devices doing their own thing.

Now we can bring this ambient computing vision to gaming as well. With Stadia, our new generation cloud gaming platform, we're aiming to deliver the best games ever made to almost any screen in your life. So, I'm excited to share an update with you all. Stadia will be available on November 19. So you'll be able to play games wherever you want, on your TV, your laptop, even your Pixel, which will be the first phone to support Stadia when it launches.

We're also creating a few areas to create more human interactions with technology like motion sense and the new Google Assistant for Pixel 4. So instead of being glued to your phone, you can use quick gestures and voice commands and then get back to your day. That push for quicker, more natural interactions is leading us in new hardware directions too, extending the phone's capabilities in new ways. Let's take a look.

[Video Presentation]

All right, that was a sneak peek at the all-new Google Pixel Buds. So you can start to get an idea of what ambient computing feels like. With Pixel Buds, help is there when you want it and the experience just comes to you, even when your phone is not in your hands. For instance, you can get hands-free access to the Assistant. So instead of turning to your phone for quick tasks, you can just say, Hey Google and ask the Assistant for whatever you need; resume your podcast, send a quick text, get directions or even understand another language with Google Translate.

Pixel Buds even have a long-range Bluetooth connection, which keeps you connected even when your phone isn't by your side. So you can wear them in the

yard when your phone might be charging inside or leave your phone in a locker if you're working out in a gym. Indoors, Pixel Buds will stay connected up to three rooms away and outside, they work across an entire football field.

Of course Pixel Buds won't be truly helpful unless there are also great headphones. They have to have excellent sound quality, they've got to be comfortable to wear all the time, and they need to last long enough to be useful. That's a lot to ask of a pair of headphones, especially because they also need to be unobtrusive too. So we did some intricate origami with Pixel Buds to make sure everything fit; custom speakers, sensors, custom battery. That's usually what makes these wireless earbuds stick so far out of your ears.

But Pixel Buds gives you plenty of battery life. You'll have five hours of continuous listening time on a single charge and up to 24 hours when you're using a wireless charging case. Now, even with all those components and long battery life, you can see Pixel Buds fits almost flush with the ear. They are so small and light, it's easy to forget you're wearing them.

At the same time, Pixel Buds deliver excellent sound quality. Now, you typically have to choose between great sound and awareness of the world around you, but Pixel Buds gives you both with a unique hybrid design. The earbuds gently seal the ear for rich bass and clear highs, and the spatial vent underneath reduces that plugged ear feeling and let's through just the right amount of environmental sound.

On the software side, Pixel Buds respond to your surroundings with the new adaptive sound. The volume dynamically adjusts as you move from the quiet of your home to a subway or a noisy cafe and you don't have to constantly raise or lower the volume. When you're on a call, beamforming mics focus on your voice, while voice accelerometers detect speech through your jawbone. So a loud restaurant or a windy day won't get in the way of your conversation. Pixel Buds will be available in the spring of next year and we'll share more details in the coming months, including a few of the helpful experiences that make good use of the on-device machine learning chips.

So, as you can see, this ambient computing era is going to bring all kinds of new interfaces, services and devices, but it's also introducing new challenges. When computing is always available, designing for security and privacy becomes more important than ever. You need to know that your data is safe. Protecting your data and respecting your privacy are at the core of everything we do. We've designed strong protections across our hardware family, like the Titan Security Chip in our phones and laptops. Titan protects your most personal on device information, your OS data, passwords, even information in third-party apps. And we know that privacy is personal, which is why you have the controls, so that you can choose the settings you want that are right for you. We make it easy to access simple on-off controls, including turning cameras and mics on your Nest devices off. And you can now delete Assistant data just by asking. Everything is designed with your privacy in mind and you'll see examples of that throughout today's presentation.

Now, we're also going to talk today about our work to create more sustainable products and processes. Developing sustainable solutions to mass production and consumption is one of the biggest challenges we face today as an industry. It impacts all of us and it will for generations to come. Now, we believe Google has both the ability and the responsibility to create systemic change. As a Company, we've been focused on sustainability for a long time.

Google's operations have been carbon-neutral since 2007. And for the past two years we've matched all of Google's energy consumption with a 100% renewable energy. Now, we're continuing to expand access to clean energy to more people, including our suppliers and the communities where our products are made. So today, we're announcing that Google is committing to invest another \$150 million in renewable energy projects in key manufacturing regions.

Our investment alongside financial and manufacturing partners aims to catalyze \$1.5 billion of capital. Now, this will generate approximately same amount of renewable energy as the electricity used to manufacture made by Google products. So when you choose to buy hardware products from Google, you're contributing to bringing renewable energy to communities around the world. Sustainable, secure and private, and of course, helpful; that's the Google way to make hardware and services. Now, we're excited to share with you how we build these principles into our products.

And here is Ivy Ross, who leads our design team, who is going to talk about some of our recent work in responsible manufacturing and design.

Ivy Ross {BIO 6144292 <GO>}

Thanks, Rick. I'm happy to be back in New York to discuss our design philosophy at Google and tell you about a few things that we've been working on. I grew up not too far from here in the Bronx. And my dad was a designer, industrial designer too, and he worked for the legendary industrial designer Raymond Loewy on automobiles and a lot of other consumer goods. When I was little, he even made me my own little Roadster. I can remember spending hours in his studio as a kid tinkering with different tools and materials.

And something I learned early on is, at its core, design is about solving problems for people. Whether you're designing a building, an automobile, packaging, or even a phone, the goal is to create unique solutions to the world's challenges. And sustainability is one of the fundamental challenges of our generation. When you look at how most things are made today, it just doesn't make sense. In all too many cases, devices are manufactured with dirty energy from precious minerals and materials that are rapidly depleted and with technology that becomes obsolete in a short time and then thrown away. Right now, we're truly looking at sustainability from every angle.

For years, we've been pushing what's possible in design, manufacturing, and new materials. We've been able to include recycled plastics in products like Chromecast and the new Stadia controller. And today, I'm happy to share that all of our Nest

products launching in 2019 include recycled plastics. Instead of these materials ending up in the ocean or in landfill, we're giving them a new life. We've designed and engineered the fabric on our Nest mini speaker, so it's made from a 100% recycled plastic bottles. A single half liter bottle produces enough textiles to cover more than 2 Nest minis and we didn't compromise on aesthetics or function. We created beautiful recycled fabrics and colors that blend into your home, while hitting the same rigorous technical and acoustical requirements.

We continue to focus on products that empower people to reduce their own environmental impact as well. Our Nest team has been at the forefront of these efforts since 2011 and as of this month, Nest Thermostats have helped consumers save more than 41 billion kilowatts hours of energy, enough to power all of Denver's electricity needs for six years.

Rick just filled you in on our new renewable energy investment. And as of last month, Google is offsetting a 100% of the carbon generated by our shipping partners for all customer orders. We have so much more to do, but by working with our suppliers, manufacturers on these initiatives, our goal is to clear the way for the entire industry and our planet to benefit. Another sustainability goal is simply reducing the amount of hardware you need to buy in the first place.

What if you didn't need to upgrade a bulky new game console every few years? With Stadia, we're actually consolidating devices, so the only hardware you need is a controller and a screen to play your games anywhere, anytime. To give people a great gaming experience, we designed the first cloud-based controller. Great design isn't just about how something looks. It's also about how it feels and subtle design differences can have a profound effect and we wanted the controller to be comfortable in the hands of all gamers. We found design inspiration in some unlikely places

[Video Presentation]

We worked with thousands of people playing hours and hours of games to test our controller against all of its limits. It needs to feel right for as many people as possible. Putting people at the center of our design is integral to our process and our principles, whether it's hardware or software, creating truly helpful products for people starts with empathy. One of our earliest projects we tackled within hardware team was designing a new kind of laptop that could deliver performance and versatility in a truly beautiful form. We wanted to physically embody the speed and simplicity that people love about Chrome OS.

The result was the original Pixelbook. The response was great. People really loved the award-winning design, the keyboard, and the speed. So, over the past couple of years, we've been working really hard to bring that kind of experience to even more people at a more affordable price. I actually believe that you can be more creative when designing within constraints.

So once again, we started with our users' needs, especially portability and battery life. We wanted to create a thin and light laptop that was really fast and also have it last all day. And of course, we wanted it to look and feel beautiful. We landed on Pixelbook Go. The design is so distinctive with an incredibly light magnesium that lets us create a very smooth matte finish in great colors. Pixelbook Go comes in just black and not pink, one of the iconic colors we introduced on Pixel 3.

And we created a new rippled wavy bottom that's easy to grip. Pixelbook Go is lighter than Pixelbook, but we still managed to add a battery that is 15% larger, making it easier to keep working all day. We also spent a lot of time making sure the keyboard is comfortable and quiet. We took all of our learnings from the original Pixelbook and really refined the design.

We ended up with keys that feel great to use and are even quieter than the original. And with Chrome OS, Pixelbook Go is always fast, secure, and all your devices stay in sync with each other. Everything about Pixelbook Go is designed to address real user needs for an affordable price. You can preorder it now in Just Black with Not Pink coming soon.

Next up, my colleague Rishi Chandra will tell you about the work we've been doing to make life at home a little easier. Thank you.

Rishi Chandra {BIO 17056644 <GO>}

Hey, everyone. I'm excited to give an update on Google Nest and our mission to create the Helpful Home. So last month, we launched Nest Hub Max, which is a great example of the power of ambient computing. See your photos come to life with a screen that automatically adjusts to your lighting conditions, pause your music and videos with a simple hand gesture, and it automatically adjusts the information and controls based on your proximity to the device.

At Nest, we want to put people first and build technology around their needs. Difference between just being smart and being truly helpful. So while the rest of the industry is focused on standalone devices, our focus is on building Whole Home solutions that bring together technology to provide real help for real homes and the most important place to get this right is privacy. It's your home, the most personal private space in your life.

So in May, we published a clear set of privacy commitments, which helps you understand how our technology works. Today, we want to share how these commitments extend beyond Google to our third-party ecosystem of partners. So we're announcing an update to our Works With Google Assistant program. We're working with partners to migrate their existing works with Nest integrations that people know and love, but doing it built on a foundation of privacy and security.

For example, we're acquiring partners to pass a security review before they can even request access to your Nest devices. You should have confidence in how Google and its partners are protecting your home data. And then, you can focus on, instead, the

great benefits of the Helpful Home. For example, let's talk about home Audio. It used to cost thousands of dollars and a professional installation if you want a seamless audio throughout your home.

Well, Google changed all that with the Whole Home audio solution that is simple, affordable, and sounds great. It started several years ago with the launch of Chromecast, making it easy to use your phone or your voice to play content on your favorite devices. And with Google Home Mini, home audio got even more affordable, with a great sounding speaker with multi-room support.

And with Nest Hub Max, you now have a Home Media Control Center right on your smart display and it all works seamlessly together with screen transfer, where you can naturally move content around your home. So, for example, I can start a playlist or watch a show on my Nest Hub Max in the kitchen. And when I'm done cooking, just say Hey Google, move this to the living room TV, and it will pick up right where I left off. It's really easy.

Now, for a lot of people, Google Home Mini was a perfect starter kit for your audio system. And today, we're introducing the next generation Nest Mini. It's even more capable with the same affordable price point and the same iconic design. So let's start with the design. Colors really help Mini blend naturally into your home and you now have a new color option called Sky. And as Ivy mentioned, all of our fabric is made from a 100% recycled plastic bottles.

Now, we also heard from you, you want a little more flexibility of where to place mini, so we added a simple wall mount. It really looks great anywhere in your home. Now, the original mini was designed to pack in great sound in a really small form. And with Nest Mini, you get even better quality sound, 2x stronger bass and even more clear and natural sound. And for those times when your home gets loud, like it does in mine, we added a third mic to hear you better in noisy environments.

Nest Mini also got a really cool new superpower. There is a dedicated machine learning chip with up to one TeraOPS of compute. So for the first time, core experiences of the Google Assistant can come from the data center and be moved instead to run locally on your device. Simply put, things are going to get a lot faster as it learns your family's more frequent commands. Finally, Nest Mini also powers an amazing home communication system; a home intercom, so you can talk room to room; a home alert system, telling you who is at the front door; a home phone, allowing you to call anyone in the world for free, using Google Duo.

I can even use my phone to call my Nest devices. It works great for those times I'm leaving work and I want to ask the family what they want for dinner. So that's the new Nest Mini, our next step in bringing seamless audio and communication to more homes around the world.

Okay, now let's talk about home awareness. One of our core products is Nest Aware, which combined with our Nest Cams provides intelligent alerts and camera history.

Now lots of our users have multiple cameras and we've heard from you that our Nest Aware pricing can get a little expensive and complicated. So today, we're announcing a new whole home pricing model.

For one monthly rate, you get Nest Aware support across all your Nest devices in your home. So whether you have two cameras, you have 10 cameras, you pay the same monthly rate. And you can choose between two different pricing plans depending on your needs. We even added more video history. The new Nest Aware will be rolling out early next year and it will be easy to switch over your existing plan.

Now, as part of the new Nest Aware subscription, we're also unlocking the power of speakers and displays to be part of your home awareness system, so devices like Nest Mini or Nest Hub can be your ears when you're on the road or on vacation. We use on-device AI, sound detection AI, to pick up critical sounds like barking dogs or smoking carbon monoxide alarms and we send alerts to your phone. So now in one go even those basic smoke alarms become smart smoke alarms. And when you get an alert, you have the option to hear the alert or listen live to confirm the alarm. Now, if it is an emergency, the Home app can see -- the Home app can directly connect you to the 911 call center closest to you, regardless of where in the world you are.

So in those critical moments, the last thing you want to do is scramble to find a local emergency dispatcher. Now, these notifications will be part of the new Home app, which actually includes a new feature called the Home Feed. It brings together all the notifications and snippets from your devices, organizes them and highlights the important stuff, so you can quickly see priority items or you get a general recap of the day. So that's the new Nest Aware; more affordable with more features and support for more devices.

Okay. Finally, let's talk about home connectivity. You can have the best home setup in the world, but it's nothing without great Wi-Fi coverage. That's why we launched Google Wi-Fi three years ago. And since launch, it has been the number one selling mesh Wi-Fi system on the market. And in 2019, it is the top-selling router of any kind. And it's a router that actually gets better over time with automatic updates to add parental controls, improved performance and enable Google's latest security features.

Well, today, we're also updating the hardware with Nest Wi-Fi. Now, the Nest Wi-Fi system is actually two devices, the router plugs into your modem and creates a powerful home network. The point expands your coverage. Now, working together, they create a single strong Wi-Fi connection throughout your entire home and our updated hardware and software deliveries up to 2x speed and up to 25% better coverage. So now the Nest Wi-Fi system only needs one router and one point to cover around 85% of homes in the US.

Now we're also solving a common probably you find with routers today. Most of them get hidden in a closet or cabinet, because truthfully they are pretty ugly which reduces their signal intention by 50%. Nest Wi-Fi is designed to be out in the open

where it performs at its best, with the range of colors that will naturally blend into your home. And of course, it's really simple to use. With the Google Home app, you can set up your Nest Wi-Fi network in minutes and once you're set up, it's easy to share your Wi-Fi password, manage your network, set a schedule for the kids or create a guest network. Nest Wi-Fi also provides a foundation for your Smart Home connectivity.

We're working with a growing list of partners to enable seamless set up in the Home app. And with support for BLE and thread, we can talk to smart home devices locally, so you don't have to buy a separate hub. Stay tuned for even more partner announcements over the next few months. Lastly, we added a Google Assistant smart speaker to the Nest Wi-Fi point, so it does everything the Nest Mini does; plays your music with great sound, provides answers to your questions and lets you control smart devices with just your voice.

So now you can broadcast a message to your kids that it's time for dinner. And if that doesn't work, try saying, Hey Google pause Wi-Fi for kids' devices. Pretty sure that will work. So that's the new Nest Wi-Fi; better coverage, smart home support and that Google Assistant. It will be available starting on November 4. With new affordable home solutions for audio, awareness, and connectivity, everyone now can start building their own Helpful Home. Thank you.

[Video Presentation]

Sabrina Ellis {BIO 17541752 <GO>}

Hi, I'm Sabrina from the Pixel team. Now let's talk about how Google's ambient computing vision comes to life when you're on the go. Pixel 4 introduces entirely new helpful experiences with more natural interactions. It's completely redesigned, with a new look, a new color and a beautiful new finish. And Pixel 4 includes camera features and sensors that you're not going to find on any other phone.

Let's start there. Five years ago, our Advanced Technologies team began Project Soli to investigate radar capabilities. Radar has been around for a long time and it's still one of the best ways to sense motion. It's precise, low power, and it's fast. There were lots of exciting possibilities. But here is what our first sensor looked like when we started working on Soli.

Radar sensors have always been way too big to fit in a phone. So we shrunk it down into a tiny chip, but that still wasn't small enough. So we have to shrink it down even more. Pixel 4 is the first smartphone with a radar sensor. It powers the Motion Sense capabilities for more human interactions with your phone. For instance, Pixel 4 has the fastest secure face unlock on a smartphone, because the process starts before you've even picked up your phone.

Motion Sense prepares the camera when you reach for your Pixel 4, so you don't need to tap the screen. It's so much faster and smoother. Motion Sense can power down your phone when you walk away and turn it back on when you approach your

phone. It also lets you control your Pixel with simple gestures; swipe to skip a song, silence a call, wave hello to Pikachu. Again, a wide range of helpful new features from gaming to personal wellness. Here's a quick look.

[Video Presentation]

Since the Soli sensor can detect the environment around Pixel 4, privacy had to be built in from the start. You can turn Motion Sense on or off at any time, and when it's on, all of the sensor's data is processed right on your Pixel. It's never saved or shared with other Google services. And Motion Sense isn't the only way we're making your phone interactions faster and more natural. The Google Assistant is now deeply integrated into Pixel 4's OS and across your apps. You can quickly open apps, search across your phone, share what's on your screen and a lot more.

The Assistant can simplify multi-tasking too with a clean new interface. Check this out. Just give Pixel 4 a quick squeeze. Show me Maggie Rogers on Twitter. What are her concert dates? Share this with Vivian. Reply, let's go see her. Open Ticketmaster.com. Search for Maggie Rogers' events. A key way we're making the Assistant this fast is with an on-device version of our language models that run in our data center. So they can run locally right on your Pixel 4.

This means the new Assistant uses a hybrid model. It can respond to many day to day requests on-device like starting a timer or connecting for request like, is my flight on time? You also have new ways to manage your data. Choose a time limit for how long you want your activity data to be saved in your Google account or just tell the Assistant to delete everything you said to it today or this week, and it will. You're in control and you can ask, get more details by asking, "Hey Google, how do you keep my data safe?"

We're taking the same care to protect your on-device data too. With Titan M and other security features, last year's Pixel 3 scored the highest for built-in security for a smartphone according to Gartner. We've built Titan M into Pixel 4 as well to protect your most sensitive on-device data, like your passwords, your OS data and now your face unlock model. Your phone has some of your most personal, private information, and we have a responsibility to keep it safe and secure.

Now, how many of you have tried a voice recorder app? I know I've tried a few thinking I'll be able to get organized by recording notes to myself, interesting lectures, important events, but then I end up with a bunch of untitled audio clips that I really don't know what to do with. So we created a new kind of audio recorder that taps into our speech recognition and AI. Let's see it in action.

We've had a Pixel 4 recording this show for the past few minutes. As you can see, with one tap, I can get recorder transcribing my words in real time as I'm saying them. Now, to show this is live, it is now 10:44 and it's pretty accurate. This means you can transcribe meetings, lectures, interviews or anything you want to save.

Eric, back stage, is going to save this recording and now I can go into the search bar and find whatever I'm looking for. I can search for sounds, words, phrases, let's see, all the times I've mentioned Pixel across my entire library of recordings. The places where the word Pixel are said are highlighted in yellow in the playback bar. So you can dive into the exact part of the recording you're looking for. It's pretty cool. And you'll notice this phone is actually in airplane mode. All this recorded functionality happened on device.

Now, I want to take a minute to talk about Pixel 4's OLED display. DisplayMate has awarded Pixel 4 XL their highest score, an A plus rating, together with the best smartphone display award. In five key areas like color accuracy and image contrast, DisplayMate classified Pixel 4 XL's display as visually indistinguishable from perfect. Pixel 4 is also our first smartphone with a 90 hertz refresh rate. And we've added some smarts. The refresh rate adjusts on its own depending on what you are doing. So you get a great visual experience while still preserving battery life.

Pixel 4 brings together so many helpful new technologies and capabilities and you'll get the best Android experience with Android 10 and you're the first in line to get the latest OS updates and features. We also want to make sure you get the best experience out of the box. So Pixel 4 comes with three months of Google One for new eligible members. You get lots of premium features including processions, for one on one virtual help. So if you have a question about your settings or want a few tips for the camera, we are there for you.

The new Pixel comes in three colors, Just Black, Clearly White and a limited edition called, Oh So Orange. It also comes in two sizes both with the same features and both available for pre-order, starting today. Shipping starts on October 24 and we're excited that people will be able to find Pixel in even more places. We're expanding our carrier partnerships. So Pixel 4 is now available through every major US carrier.

Now, we didn't forget about the camera. For the past three years, Pixel set the standard for smartphone cameras with incredible capabilities like HDR plus, Super Res Zoom, top shot, and of course Night Sight. With Pixel 4, we're raising that bar yet again, and it all starts with this little square, basically a miniaturized camera rig right on the back of your phone.

You can see the rear wide and telephoto cameras, a hyper spectral sensor, a mic for your videos and Instagram stories and a flash that we hope you'll use mostly as a flash light, but it's there just in case. But the hardware isn't what makes our cameras so much better, the special sauce that makes our Pixel camera unique is our computational photography.

And who better to talk about it than Professor Marc LaVoy from Google Research.

Marc Levoy {BIO 3440416 <GO>}

Thanks, Sabrina. It's great to be here. There is a saying among photographers that what's important to taking a great picture is in order; subject, lighting, lens and the

camera body. It's their way of saying that it doesn't matter which SLR body you use, unless you get the first three elements right. Well, here's a slightly different take on this list; subject, lighting, lens, software. So, by software, I mean computational photography. So what does that mean?

It means doing less with hardwired circuitry and more with code. I'd like to call it a software-defined camera. It typically means capturing and combining multiple pictures to make a single better picture. One version of this is HDR+. The technology we've used for taking photos on every Pixel phone. When you tap the shutter button, we capture burst of up to nine pictures. These pictures are deliberately underexposed to avoid blowing out highlights. We align them using software and average them which reduces noise in the shadows. This lets us brighten the shadows, giving you detail in both the highlights and the shadows.

In fact, there is a simple formula. Noise goes down as the square root of the number of images you average together. So if you use nine images, you get one-third as much noise. This isn't mad science, it's just simple physics. By the way, on the left is our raw output if you enable that in the app. There's something else about this list. It says the lens is important. Without quibbling about the order on the list, some subjects are farther away than you'd like. So it does help telephoto shots to have a telephoto lens.

So Pixel 4 has a roughly 2x telephoto lens plus our super res zoom technology. In other words, a hybrid of optical and digital zoom which we use on both the main and telephoto lenses, so you get sharp imagery throughout the zoom range. Here is an example. You probably we think this is a 1x photo. It's not, it is a zoom, taken from way back here. By the way, super res zoom is real multi-frame super resolution, meaning that pinch zooming before you take the shot, gives you a sharper photo than cropping afterwards. So don't crop like this, compose the shot you want by pinch zooming. Also, by the way, most popular SLR lenses do magnify scenes, not shrink them. So while wide angle can be fun, we think telephoto is more important.

So what new computational photography features are we launching with Pixel 4? Four of them. First, Live HDR+. Everyone here is familiar with HDR+'s signature look and its ability to capture extreme brights and darks in a way that looks crisp and natural. But even phones with good HDR solutions can't compute them in real time. So the viewfinder often looks different from the final image.

In this example, the window is blown out on the viewfinder which might tempt you into fiddling with the exposure. This year, we're using machine learning to approximate HDR+ in the viewfinder, so you get our signature look while you compose your shot. We call this feature live HDR+. So, the industry's most successful HDR solution is now real-time and WYSIWYG, what you see is what you get.

Now, if we have an intrinsically HDR camera, we should have HDR controls for it. So Pixel 4 has dual exposure controls. Here is an example. This is a nice HDR+ shot, but maybe you would like to try it as a silhouette. So you tap on the screen and lower the

brightness slider a bit. That mainly changes the capture exposure. Then you lower the shadows slider a lot. That mainly changes the tone mapping, and voila, you get a different artistic vision. Try doing that with any other cellphone. So separate sliders for brightness and shadows while you compose your shot. It's a different way of thinking about controlling exposure in a camera.

Second, white-balancing in photography is a hard problem. Mathematicians call it an ill-posed problem. Is this snow blue the way this SLR originally captured it or is it white snow illuminated by a blue sky. We know that snow is white. With enough training, so can the camera. We've been using learning-based white balancing in Night Sight since Pixel 3. In Pixel 4 we're using it in all photo modes. So you get truer colors, especially in tricky lighting. Here is a tough case, an ice cave. It's blue light but not a blue person and here's what it looks like with Pixel 4's white balancing.

Third, we've continued to improve portrait mode. With our dual Pixel or split Pixel technology, we've always been good at portraits and at macro shots. This year we're computing depth, again using machine learning, from both dual pixels and dual cameras which gives us accurate depth farther from the camera. This extends portrait mode to large objects and stand further back portraits. We also have a luscious new SLR like bokeh; that's the shape of the blur. Look at the lights on either side of her head. We're doing better on hair and dog fur which are hard and of course we still do great selfie portraits.

Fourth and last, we have continued to improve Night Sight in many ways and extended it to a use case that has always been sort of a holy grail for me. You could have taken this dusk shot using Pixel 3 last year. Using Pixel 4, you can take this night time picture from the same viewpoint.

In the year since we launched it, Night Sight has been called everything from fake to sorcery, well, it's neither. Think back to the mathematics that I explained at the beginning. Astrophotography is about taking longer exposures and more of them; up to 16 seconds times 15 exposures; that's four minutes. But it's a single shutter press and it's fully automatic. By the way, you can't do this with a single long exposure. In four minutes, the stars do move and trees wave in the wind. So you need robust alignment and merging of multiple pictures. And for a four minute exposure, we do recommend a tripod or you can prop your phone on a rock.

Is there machine learning? Yes, we use it for white balancing, as I mentioned. We also use semantic segmentation in all our photo modes and have for years to brighten faces in HDR+, a feature we call synthetic fill flash to separate foregrounds from backgrounds in portrait shots and to darken and de-noise skies in Night Sight.

Is there computational photography? There is lots of that too. Digital sensors are prone to hot pixels that are stuck at red, green or blue. The longer the exposure, the more hot pixels. Our exposures are pretty long. So we need some clever algorithms to remove those hot pixels. By the way, that's our Astrophotography field testing team and, yes, they sat still for a long time for this shot.

So where does this game stop? What can't we capture using Pixel 4? Well, we can capture the moon, which by the way, required some fiddling with those dual exposure controls I told you about, and we can capture a moonlit landscape. This is not daytime. It's the middle of the night, and the landscape is illuminated only by the moon; see the stars. But what we can't do, including on Pixel 4 today, is capture both at once in the same picture. The problem here is that the moon is blown out and the Marin Headlands at the bottom are just a silhouette. The dynamic range, the difference in brightness between a full moon and a moon light landscape is 19 at stops. That's 19 doubling about 0.5 million times brighter, way beyond the range of any consumer camera, even an SLR. So is this scene forever impossible with a cell phone? Remember what I said at the beginning about software defined camera, Pixel is committed to making its cameras better with software updates, so stay tuned on this one.

So to sum up, four new computational photography features; Live HDR+, with dual exposure controls; learning based white balancing; wider range portrait mode with an SLR Bokeh; and Night Sight with astrophotography. And remember, you can use Night Sight for many things besides stars; many things. So go out there and be creative with Pixel 4.

Now, it's my honor to introduce one of my favorite artist, who has spent her career creating some of the most memorable photographs over the last 50 years. 12 months ago, we gave her a Pixel and she has taken it all over the country to build a new collection of portraits. She also gives us suggestions and candid feedback, which we've taken to heart in the tuning of the Pixel 4 camera.

So please welcome my friend, Annie Leibovitz, along with our own Lily Lin.

Annie Leibovitz {BIO 2091061 <GO>}

Thank you, Marc.

Lily Lin {BIO 21241959 <GO>}

Hi, Annie. Thank you for joining us today.

Annie Leibovitz {BIO 2091061 <GO>}

Thank you, Marc. Thank you, Marc. Thank you, Marc. This is an extraordinary opportunity that Google gave me and I've always been interested in the camera phone and what it could do and what it's potential was and Google came to me and said, we'd like to support you in some sort of artistic endeavor and we thought of this project. And I mean it's obviously what's interesting about a camera phone, I mean it is -- is you can carry in your pocket, for example. Go ahead, I'm sorry.

Lily Lin {BIO 21241959 <GO>}

No, no, it's great. I know that you've been using the camera for over a year now to shoot a collection of photographs some of which we are seeing the behind the scenes here. Can you tell us more about the project?

Annie Leibovitz {BIO 2091061 <GO>}

Well, we started really with the Pixel 3 and I was very suspicious and very careful with it and it really became an exercise in light and composition and content. And then, when the Pixel 4 came along, I was kind of very impressed about how I relaxed with it and just glided with it, and used it and really just enjoyed taking pictures. I've really, towards the end of -- I mean, we're going to be doing more work, but towards the end of the work that we were doing, I felt like I was just beginning to sort of get it and I just let the camera do the work, quite honestly, and really enjoyed myself.

But the project, the people...

Lily Lin {BIO 21241959 <GO>}

Yeah, yeah, some of which we have today, Noor and Chase and Idris.

Annie Leibovitz {BIO 2091061 <GO>}

This is Noor and Chase and Idris. I mean, the people -- I mean, the people made that made the project, I mean made -- we really turned to people who care and people who matter and people who are doing things that give us hope and across the board, and every single person that we photographed is doing something that they care about what they're doing and they represent great parts of us who are getting on with it.

Lily Lin {BIO 21241959 <GO>}

Right, change makers, I think, is what I've heard you call them, true change makers around the country. So you've been traveling -- been traveling across the country shooting these amazing subjects.

Annie Leibovitz {BIO 2091061 <GO>}

When Google first came to me with this, they sort of totally seduced me by saying, would you like to drive across the country and then and that turned into, of course, going back to people. So I don't know if it is -- if you see, what I did was, I decided to take two photographs to create a portrait and because it's hard to say what you want to say about a person especially these extraordinary people in one picture, and so I made it a diptych, and took two photographs. For example, it was Sarah Zorn from the Citadel. There is a photograph of her almost on graduation day in her uniform, but next to her is a photograph of the boots she wore for four years every single day.

Lily Lin {BIO 21241959 <GO>}

Well, I -- so I have to ask, I'm so curious because you have access to the world's best camera equipment. So how is it different with this project just having what you have in your pocket now? What was that experience like?

Annie Leibovitz {BIO 2091061 <GO>}

Well, I've been using, like everyone else, camera phones for a while and the whole idea was can you use it to go out and do -- work as a photographer. And I was dying for this opportunity -- to be given this opportunity by Google to sort of develop the camera phone for a photographer and how to use it. And as I said before, it was a little bit of a rough start and then I just relaxed and I really totally enjoyed myself. One of the last shoots with Meg, the soccer player, it really felt like we were just floating. I mean, she was really a beautiful -- anyway, she was just a beautiful muse and I took these photographs that I wasn't really thinking about the camera or thinking -- just really composing and the light was beautiful and she had that red shock of hair and it just feels great.

Lily Lin {BIO 21241959 <GO>}

That's great. Well, so before we go, since I have you, I have to ask, what pro tips do you have for all of us here who want to take beautiful images like this with the phone in your pocket?

Annie Leibovitz {BIO 2091061 <GO>}

Oh, it's all inside you. I mean, you just go out and you do. It is all there. I think what's great about the camera phone, I mean, my children use this phone, use this camera and I mean, we all are using this camera and it's a brand new language and if you want to do something more specific, then you may fall into another category and you're a photographer, but it's just really great that this is available for everyone to use.

Lily Lin {BIO 21241959 <GO>}

Yeah, the democratization of photography is what I've heard you call it, so...

Annie Leibovitz {BIO 2091061 <GO>}

I think it's great.

Lily Lin {BIO 21241959 <GO>}

So, thank you so much. And thank you. I wish we had more time, but I know you and as well as Nora, Chase, Idris are going to be sticking around. So thank you for that. Thanks for joining us on stage, and guys, Annie Leibovitz.

Annie Leibovitz {BIO 2091061 <GO>}

Okay, thank you.

Rick Osterloh {BIO 15100996 <GO>}

Thank you so much, Annie. It's an amazing project. We're all huge fans. That was awesome. Well, as you've seen today, our vision for ambient computing is to create a single consistent experience across your home, your work and on the go. It's available anywhere you want it, whenever you need it. With the introduction of our new Pixel phone, Pixel Buds, Pixelbook Go, Nest Mini, Nest Wi-Fi, we're taking a big step towards this vision with much more to come.

Now we couldn't get to all the product experiences today. So if you're here with us in New York, there'll be a lot more product details to see upstairs in person. And for those on the live stream, please go to the Google Store online, see a lot more.

Thanks so much for joining us today and we'll see you again soon. Thank you.

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