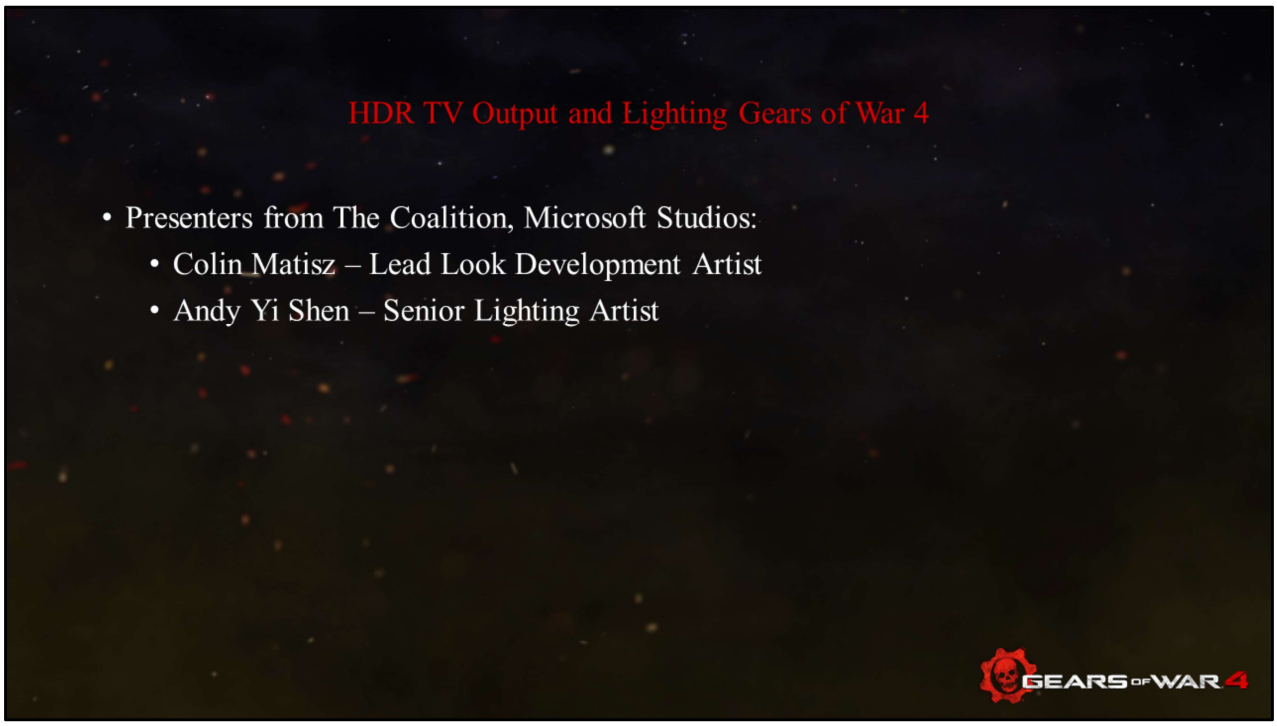
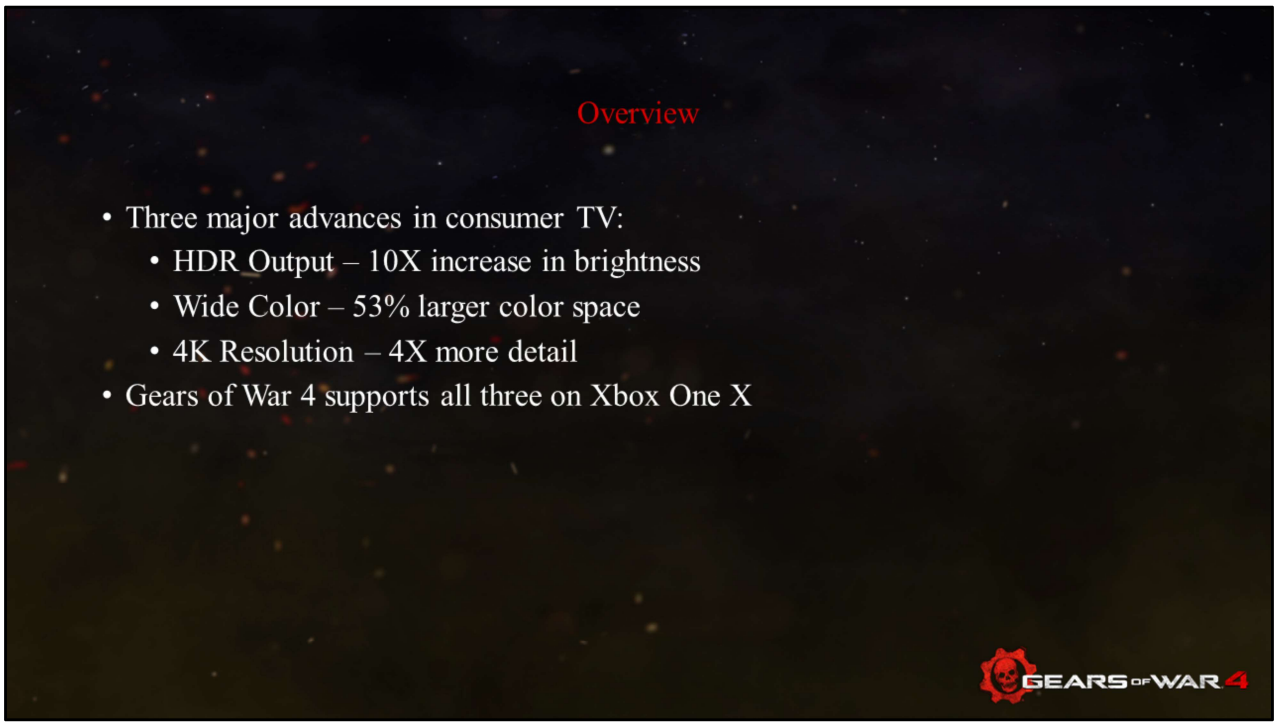

GEARS OF WAR 4
HDR TV Output and Lighting Gears of War 4
30 JULY – 3 AUGUST Los Angeles
SIGGRAPH2017

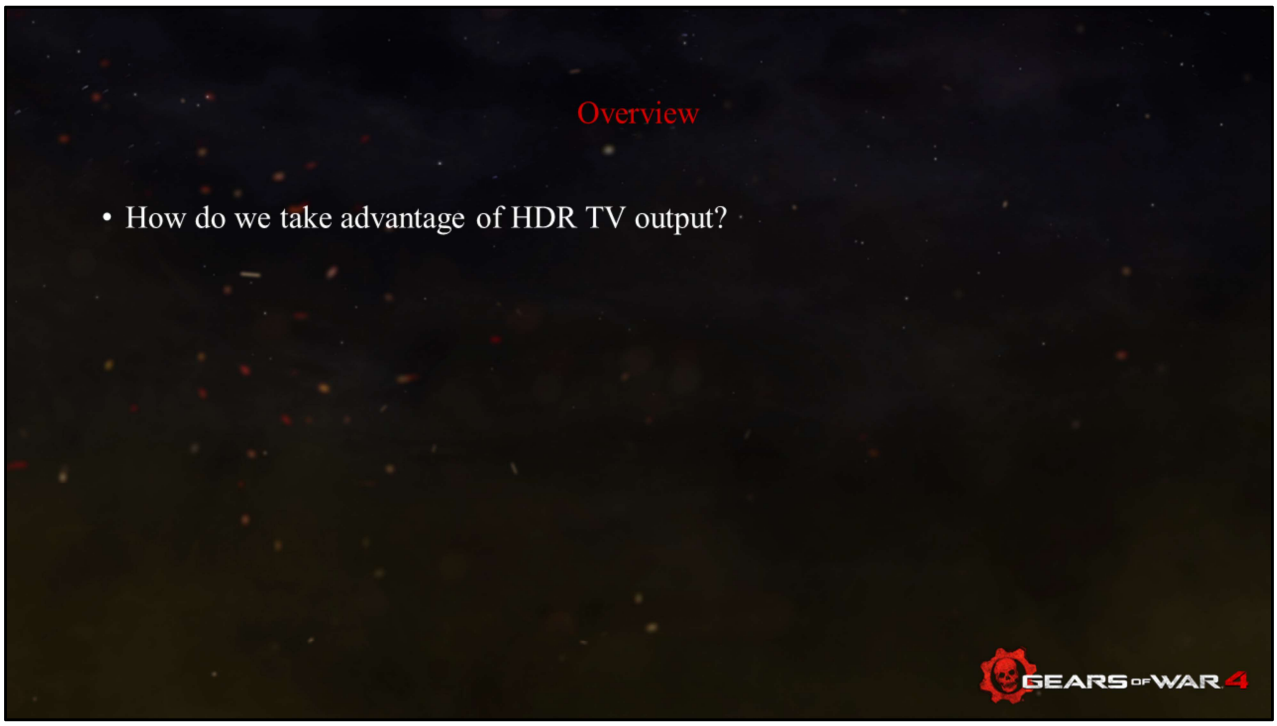


- I'm Colin Matisz, the Lead of Look Development at The Coalition, and my colleague Andy Shen will be co-presenting

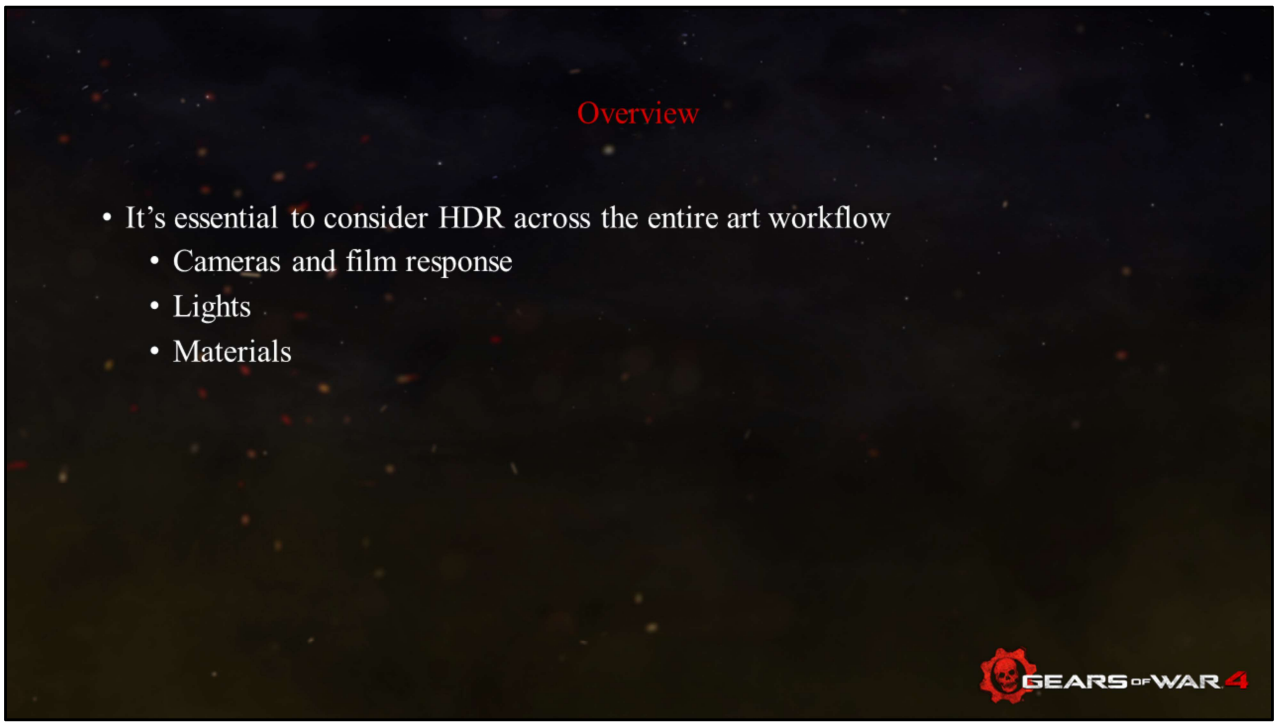
- Mid-way through production on Gears of War 4, we found out that we'd be supporting a new version of the Xbox One, later renamed the Xbox One S, that would have HDR TV output
- So naturally we asked, what IS HDR TV output?



- Well, it's part of three major advances happening in consumer television: *
    - HDR, or High Dynamic Range output, for much brighter brights and deeper darks - we're talking a ten-fold increase in peak brightness over conventional TV *
    - Wide Color Space for color that pushes the limits of what we can perceive *
    - And 4K Resolution for four times the detail of HD *
- Gears of War 4 had to take advantage of all three of these things, including 4K on our super new console the Xbox One X

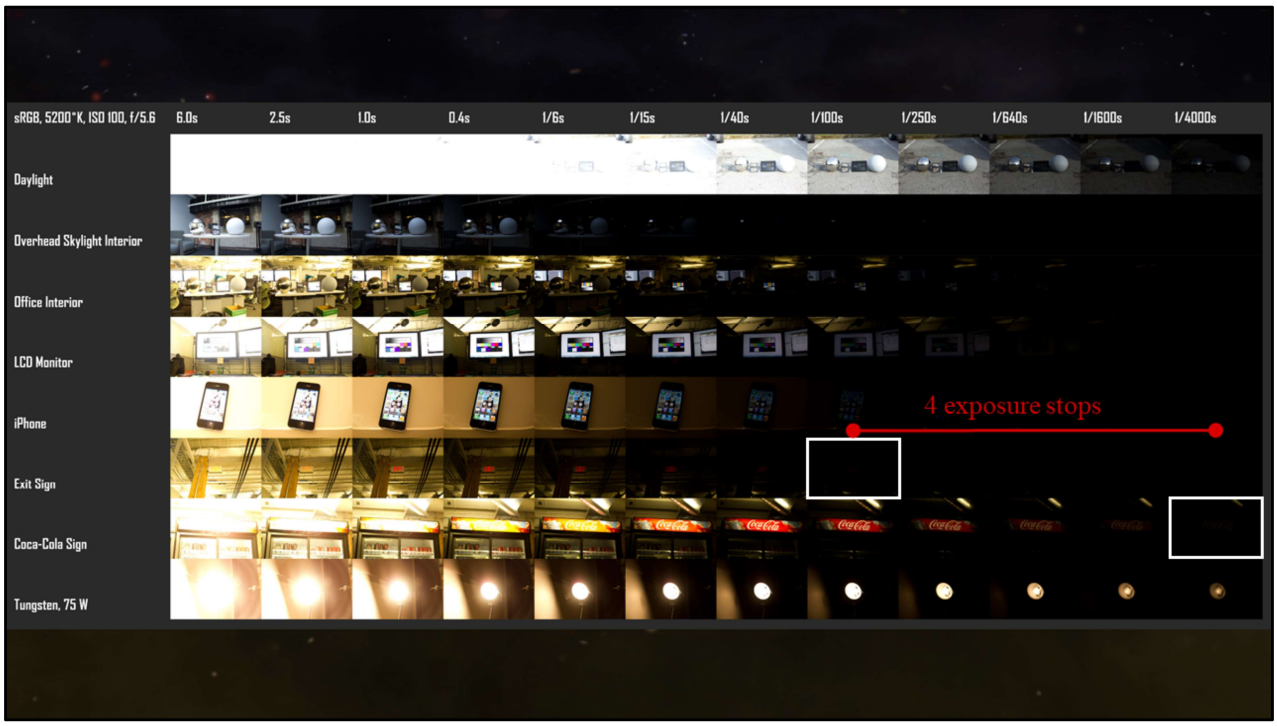


- The focus of this presentation is on how we solved the HDR TV output part of the puzzle
- So with these TV's capable of showing such an incredible range of brightness, what do we need to do to take advantage of that?



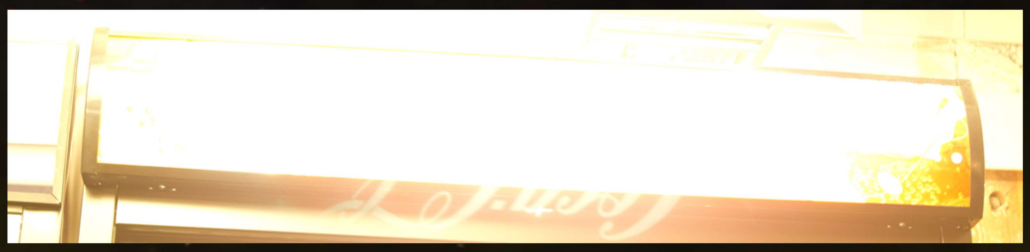
- Well it turns out, that if you follow a really careful HDR art workflow, you're already on the path of success
- This means that all of your cameras *, lights * and materials * work perfectly together
- I'm going to go over what I recommend as an HDR content workflow, and point out some interesting things I discovered

- Before getting in the game engine, it’s essential to take lots of HDR multi-exposure reference photography to really understand how real-world cameras and light behave



- For these photos I locked my camera's color space, white balance, ISO and aperture – I only varied shutter speed
- Each column represents a stop of exposure – you can easily see the relative color and brightness of each light source
- Note how the Coca Cola sign * is four stops brighter than the exit sign *, for example
- You can also see how camera properties react to light, such as bloom, lens flares, lens dust and vignette

0 exposure



0 exposure

- Here we see the exit and Coca-Cola signs more closely
- Note when you can’t see them glow anymore, and how many exposure stops apart this is

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-3 exposure

-3 exposure

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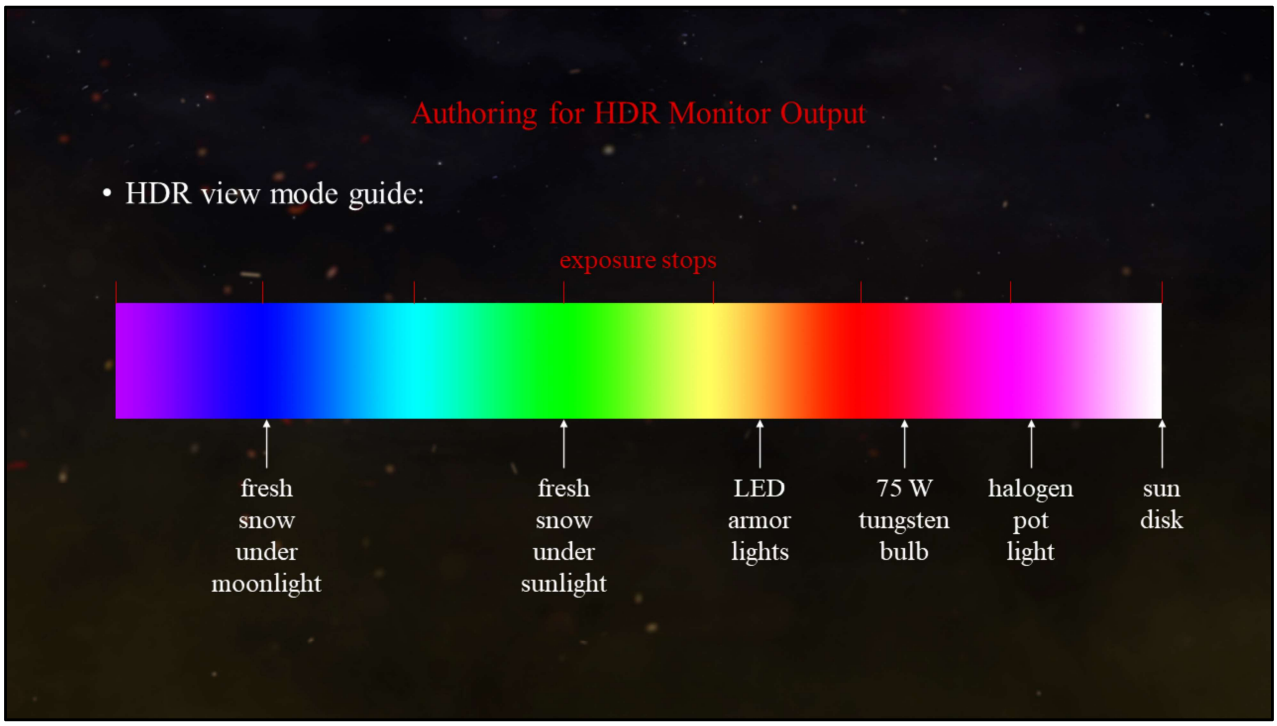
- I created a lighting test scene in our game engine *, and standardized all camera settings based on the multi-exposure photography
- The camera exposure, white balance, bloom, lens flares, film response or tonemapper, and many more parameters are tuned and locked *
- Our game engine, Unreal Engine 4, lets us define light intensity in lumens and color temperature in Kelvin, so we created a '75 W tungsten-filament' light source and defined all lights relative to it based on our HDR reference

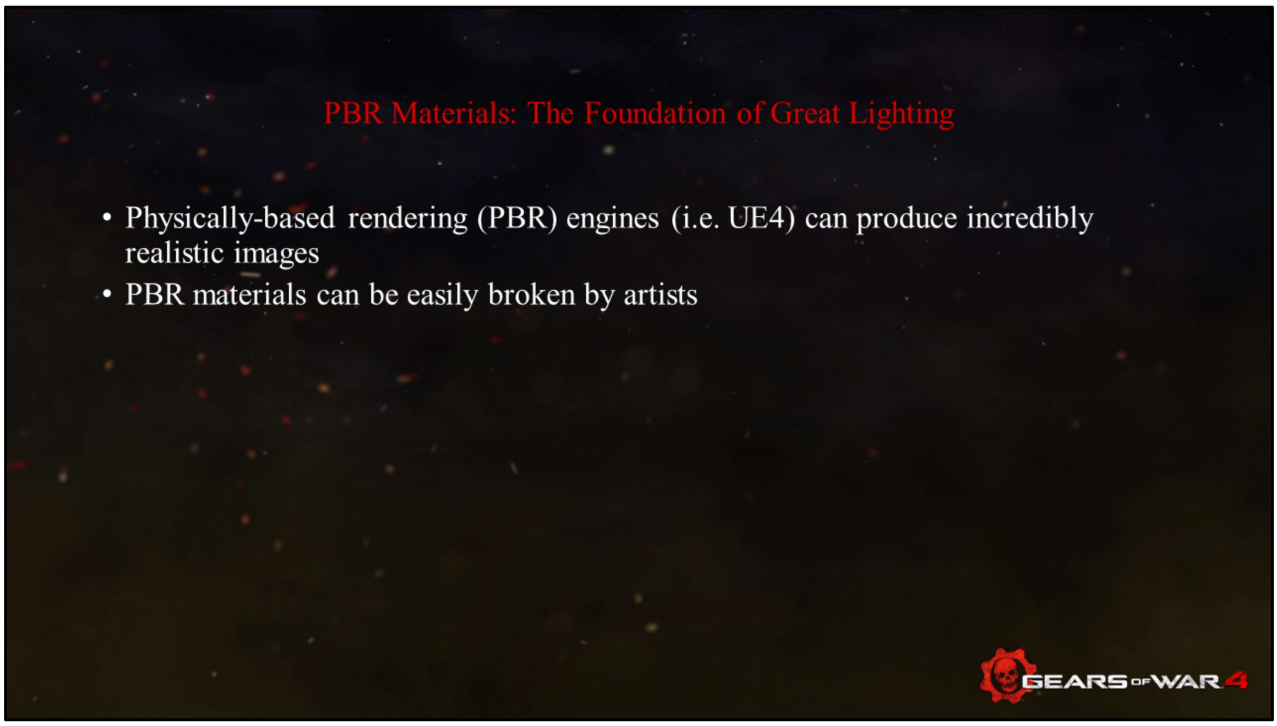
- Note the intensities of the light sources and sky
- The 75 W bulb is in the middle of the scene – all other light sources were tuned relative to that by varying the exposure of the in-game camera

- I developed an editor HDR view mode that represents exposure stops with false-color bands

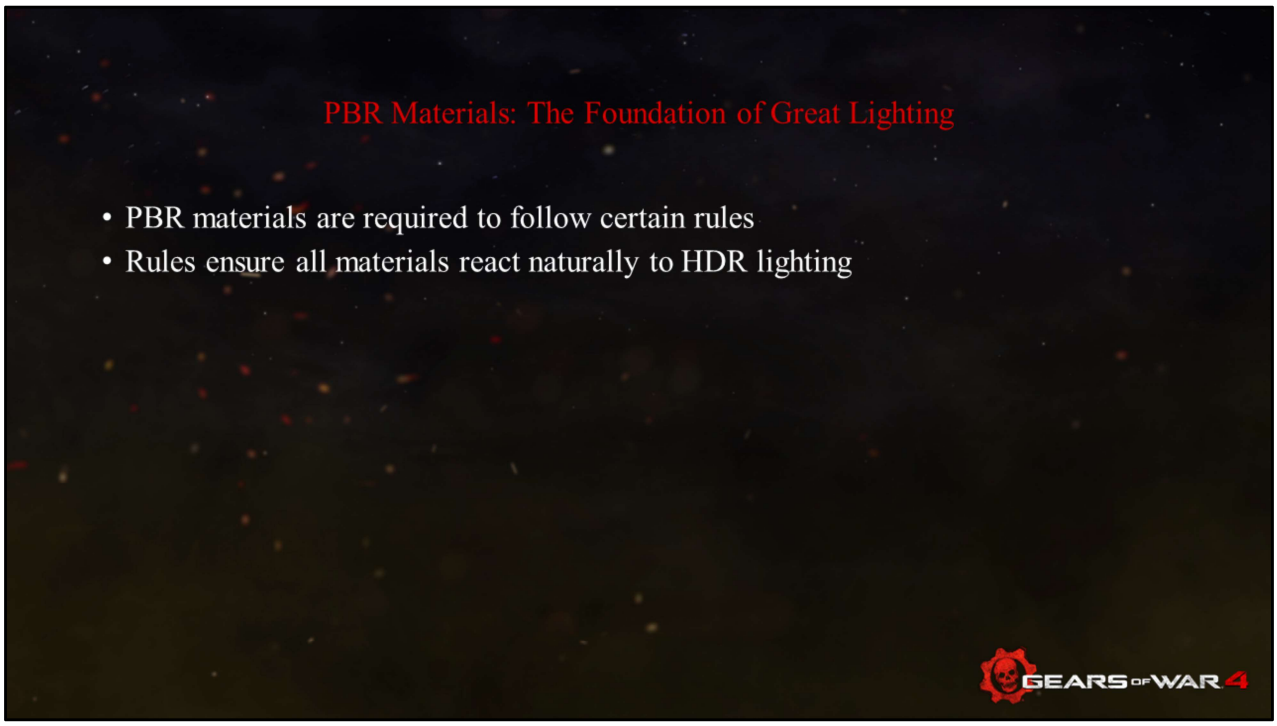
- This helps us see bright luminosity values without having to vary the in-game camera's exposure or build the game and output to an HDR display
- Note the spectrum of colors we use to represent the exposure stops



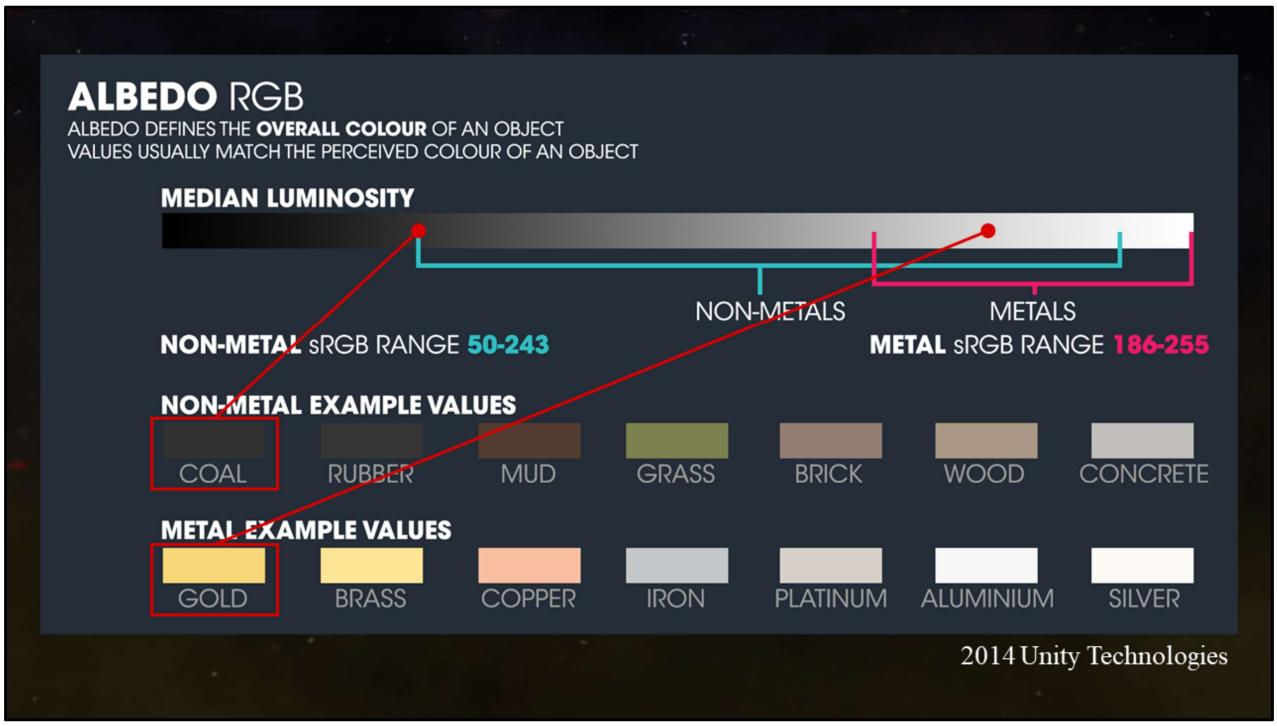
- Here's where some of our lighting values fall onto it *
- The artists can now figure out where their lights fit in to this spectrum



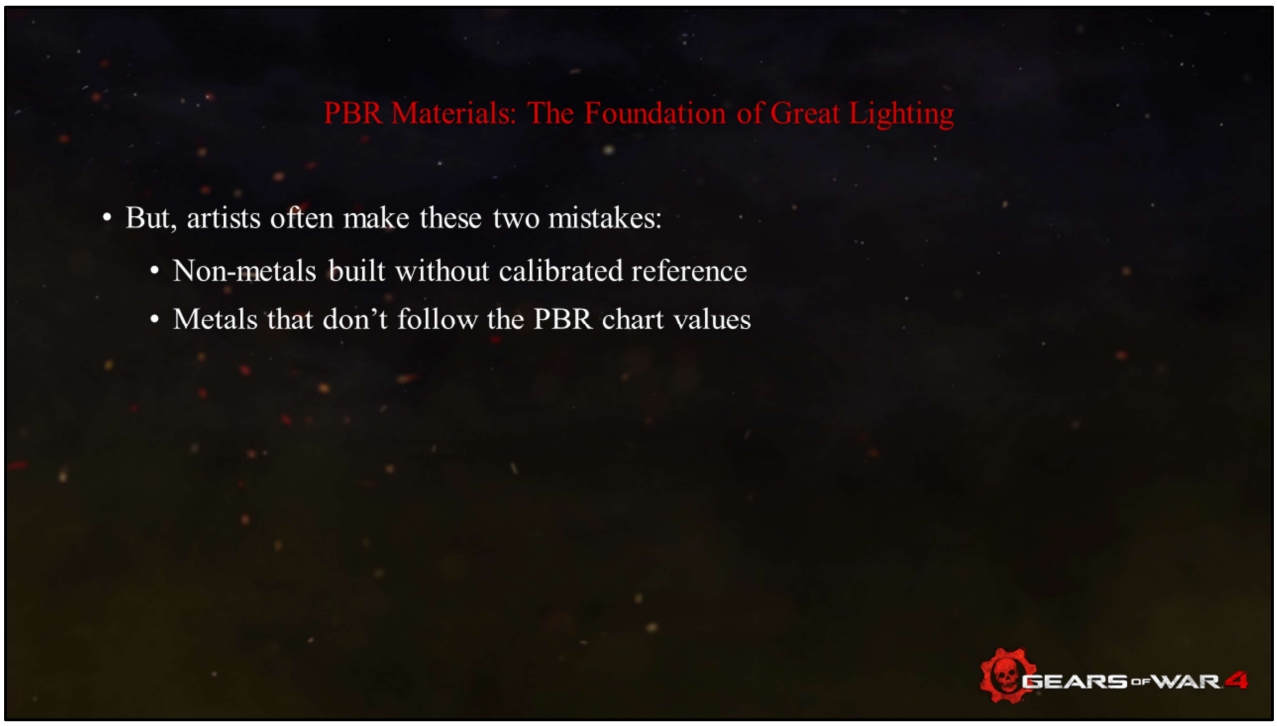
- We have these fantastic new PBR rendering engines such as Unreal Engine 4, that have the potential of producing images that you feel you could reach out and touch *
- But even with properly calibrated cameras and lights, it's all for naught if your artists break the rules surrounding physically based material creation



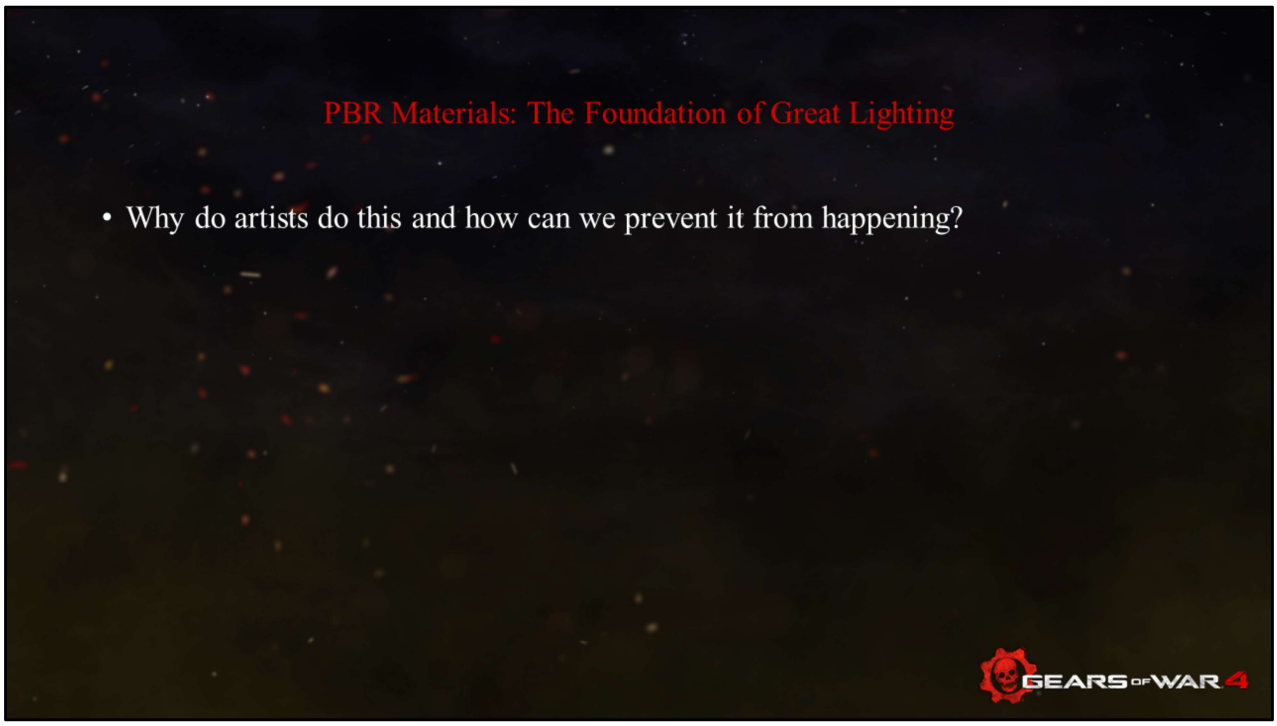
- Real-time engines provide guidelines that clearly state rules for material authoring, based on scientific measuring of real surfaces *
- Follow these rules, and all your surfaces will react beautifully and consistently to HDR light



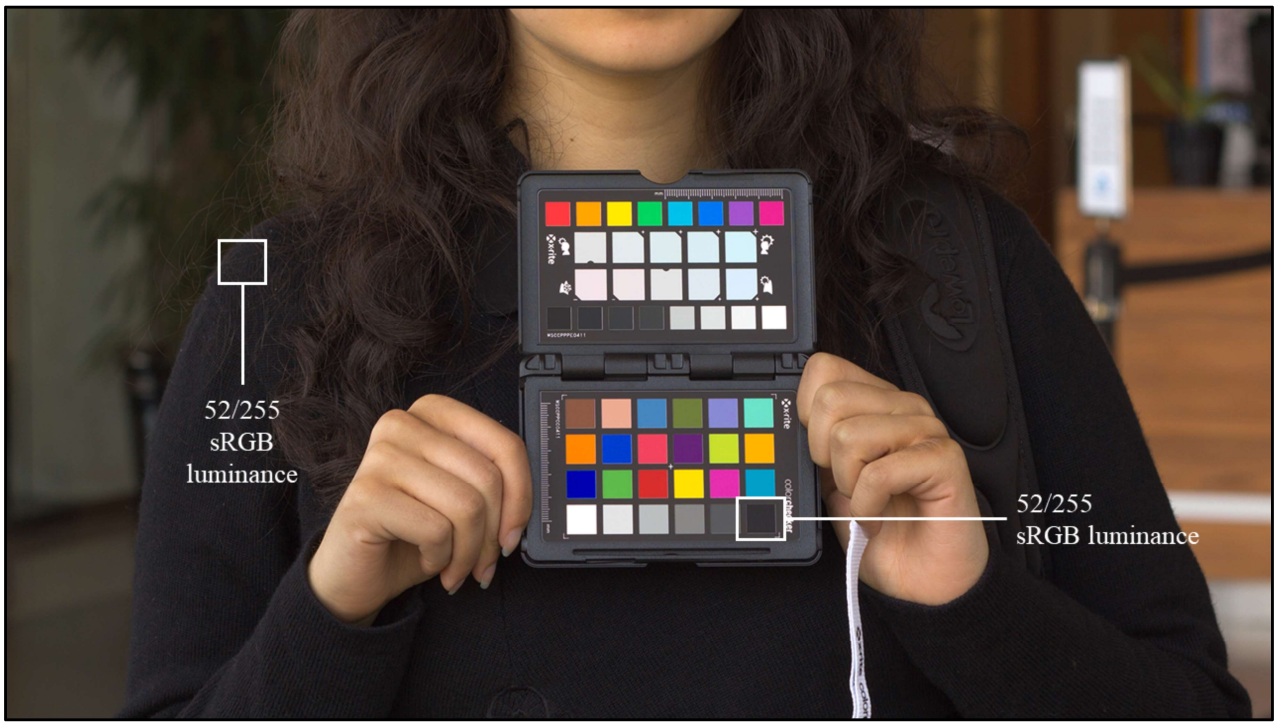
- Here's a chart made by Unity that shows what color and brightness values should be used for non-metals and metals
- These values work across many engines that use the so-called 'metallic' workflow, including UE4, Unity, Marmoset and Substance Painter, for example
- Note how bright the non-metals are, including the darkest non-metal coal * – much brighter than black
- Also note how bright the metals are * – none are darker than 186 out of 255, in sRGB



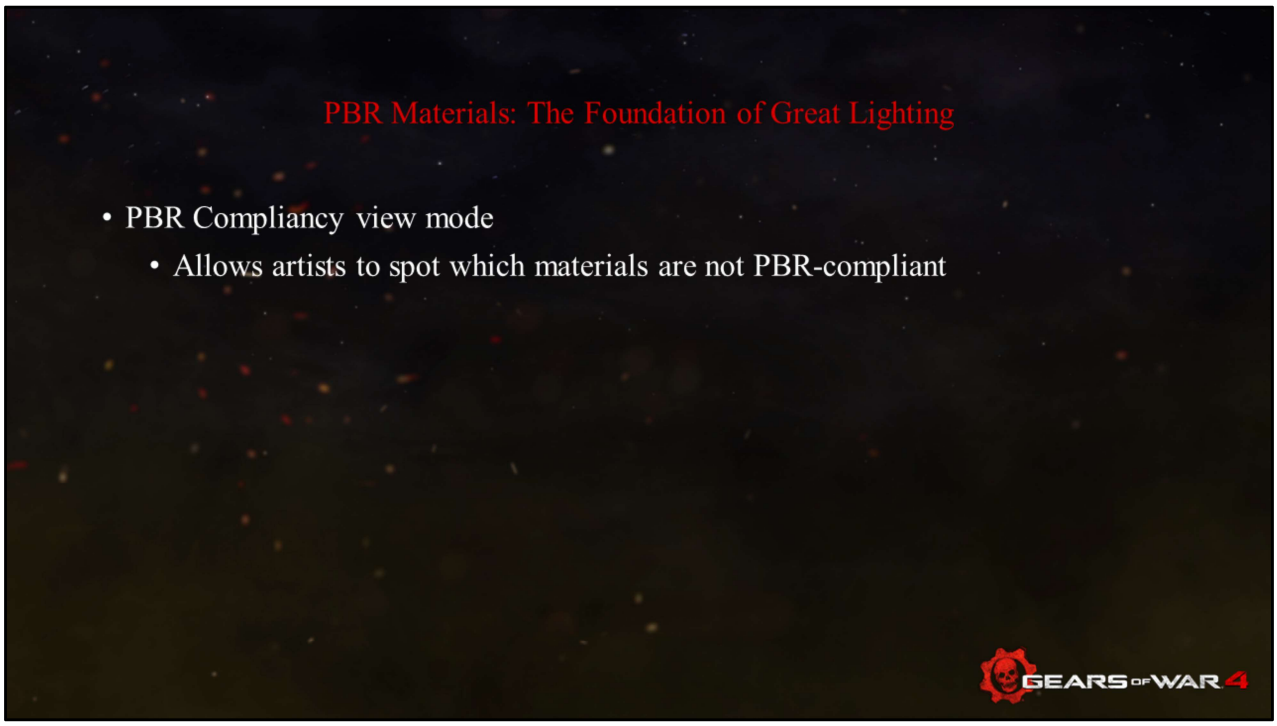
- But, artists commonly do two things that break PBR lighting *
- They tune non-metal surfaces without calibrating to real world reference *
- And they create pure metals without following the rules for our new PBR realtime rendering engines



- So why do they do this, and how can it be fixed?



- For non-metals, as long as artists use a colorchecker in their reference photography, they'll find that all diffuse surfaces are not too bright, and not too dark
- Most of the materials you think are black, are actually brighter in sRGB space *
- On Gears of War 4, we made a lot of fantasy materials, but it's still important to ask which real materials they resemble most, and calibrate diffuse colors accordingly



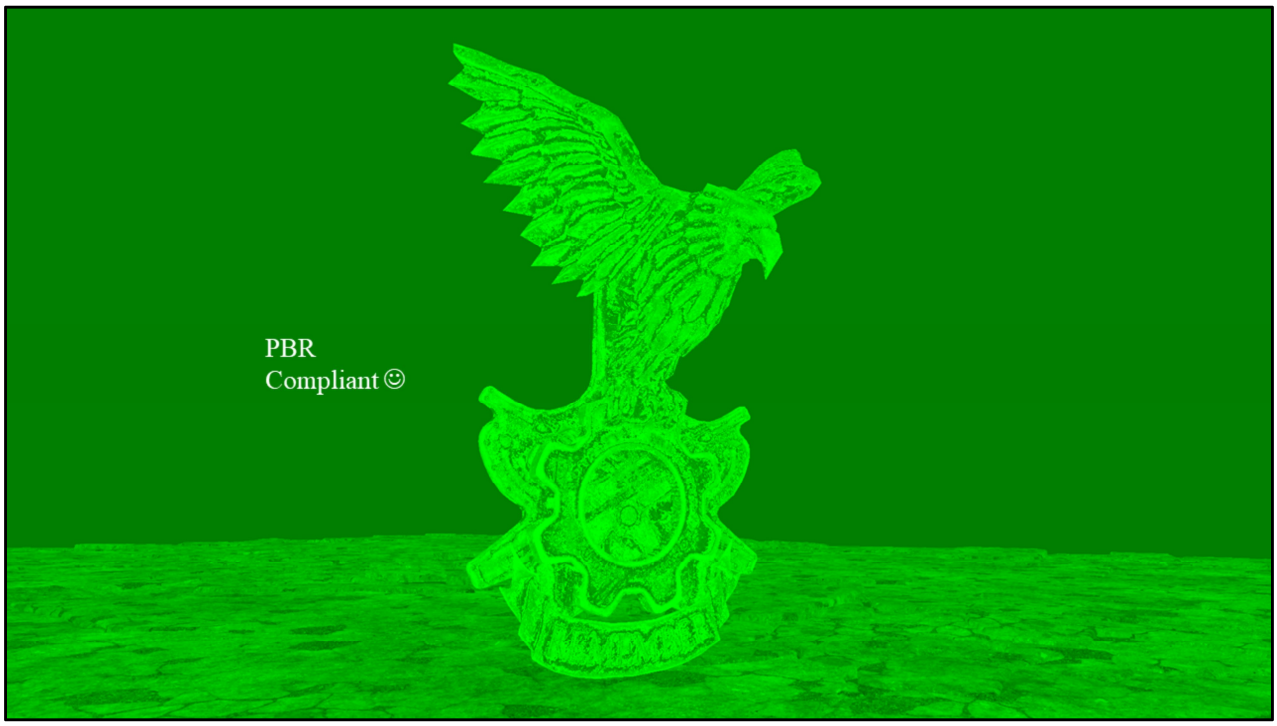
- I wrote a PBR Compliancy view mode based on the rules of physically based material inputs for metals and non-metals *
- This allows artists to easily spot in the game editor which materials are not PBR-compliant, such as metals with dark base colors

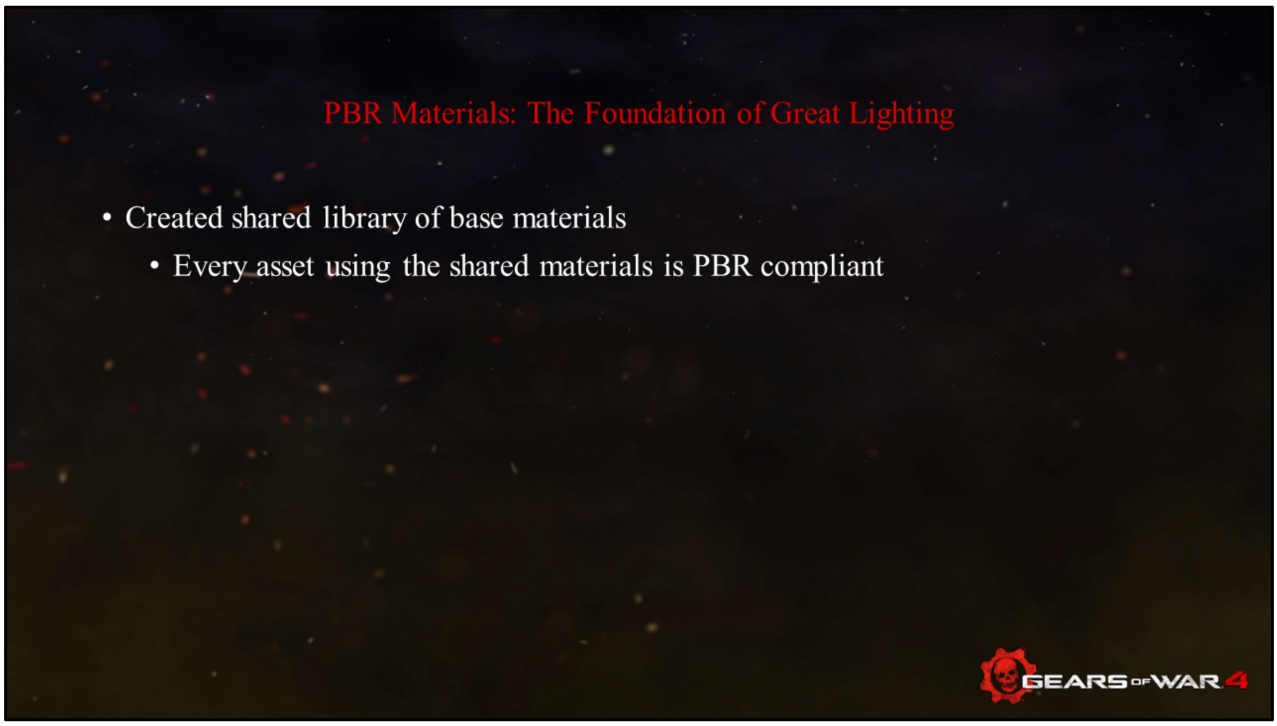
- Here’s a copper metal statue that’s been tuned too dark, according to those rule charts for base color values, for PBR

- In the PBR Compliancy view mode, it appears red

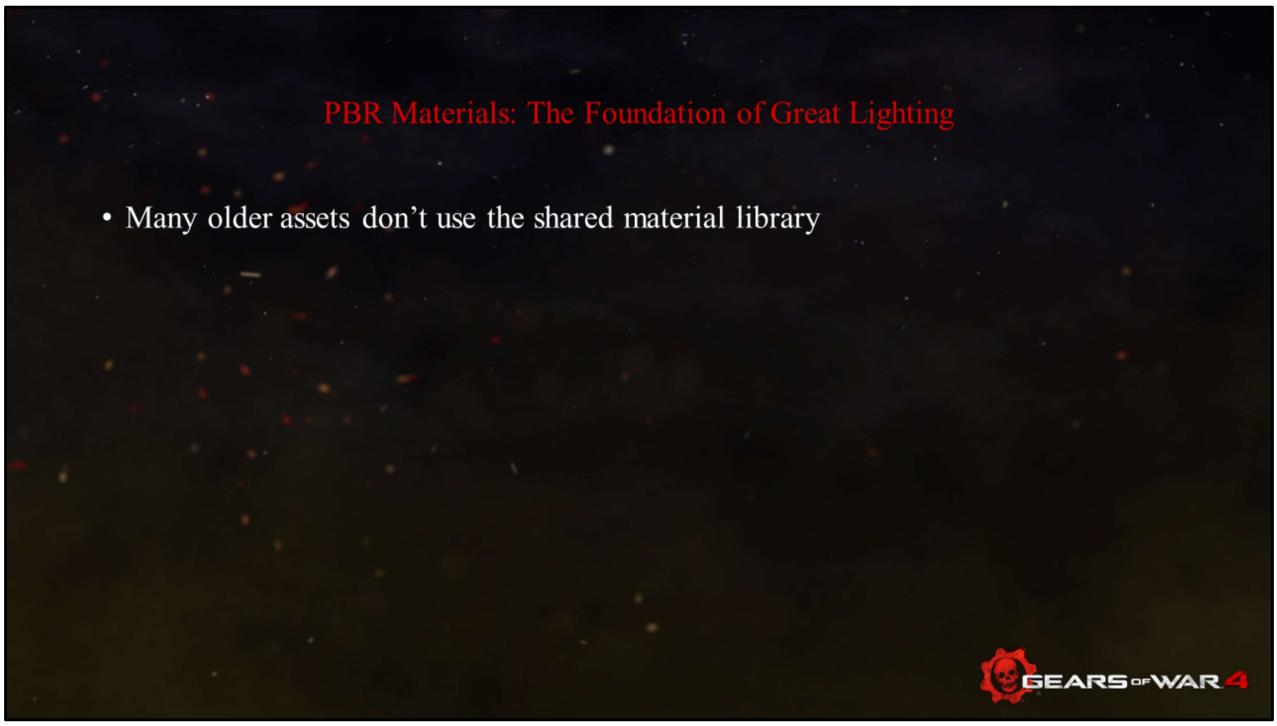
- The artist then brightens the metal base color… *

- …to exactly align with the PBR chart value of copper
- Now it’s PBR compliant in the view mode, and it lights wonderfully


PBR
Compliant ☺



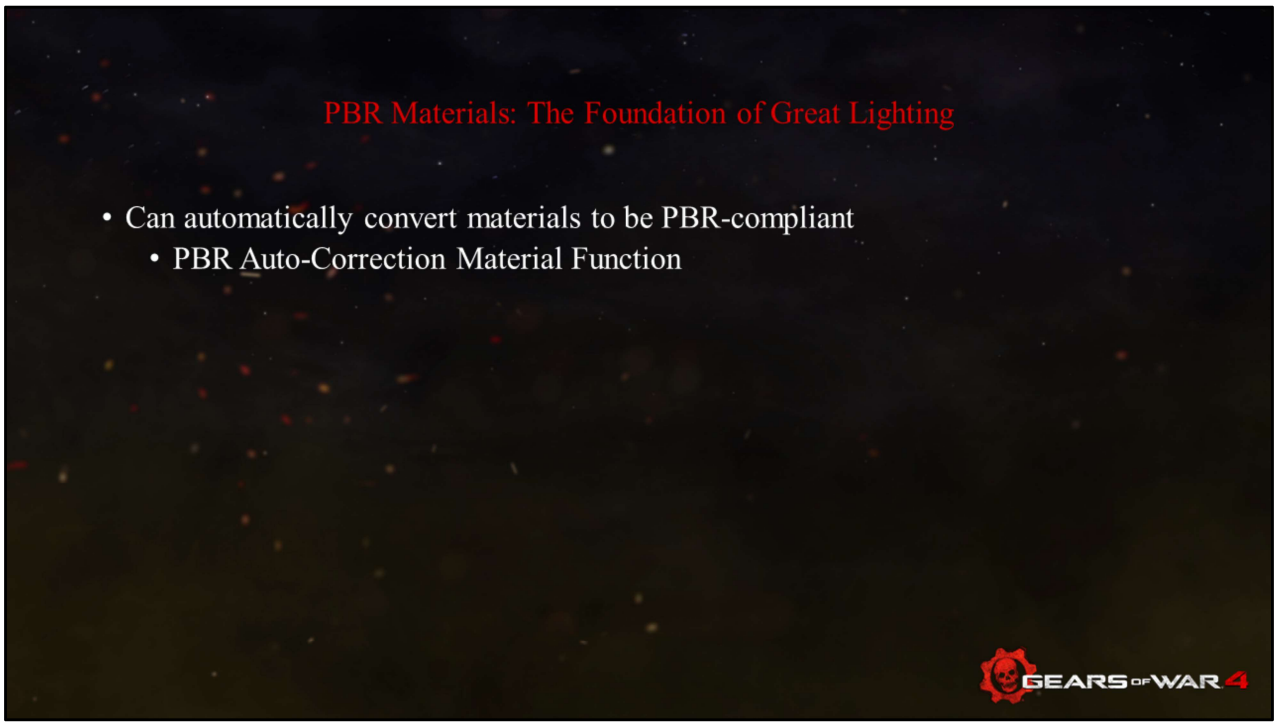
- Our CG Supervisor, Colin Penty, led the development of a material-masking system that allows us to share base materials *
- We used the PBR compliancy view mode to tune each of these shared materials, so now materials react to light great from every artist, even external partners



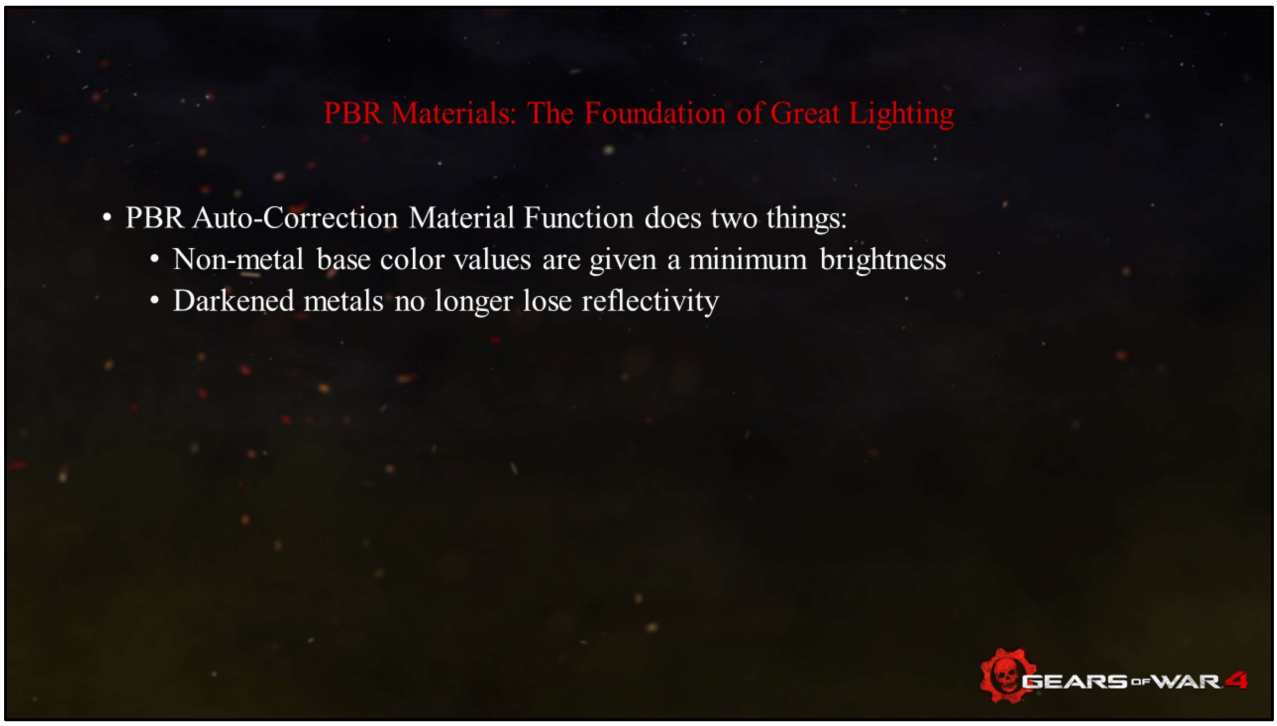
- But, we have hundreds of older assets that don't reference the shared material library
- It can be very time consuming to hand-correct their metal, non-metal and mixed surfaces, which are often mashed together on the same texture page

- Here we have an older asset that doesn’t use the shared material library

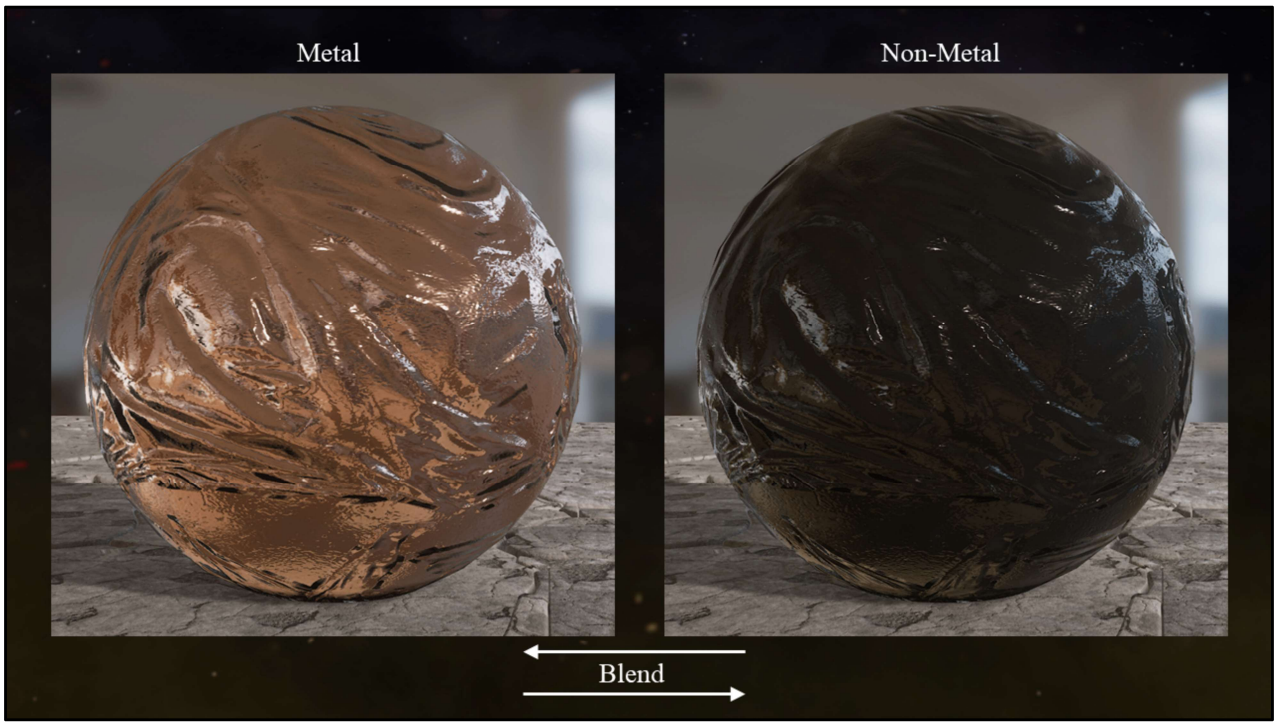
- You can see in the PBR Compliancy view mode here, that the non-compliant parts are scattered amongst the complaint parts, making them difficult to manually fix



- So I wrote a shader function that automatically converts broken materials to be PBR-compliant *
- The PBR Auto-Correction Material Function

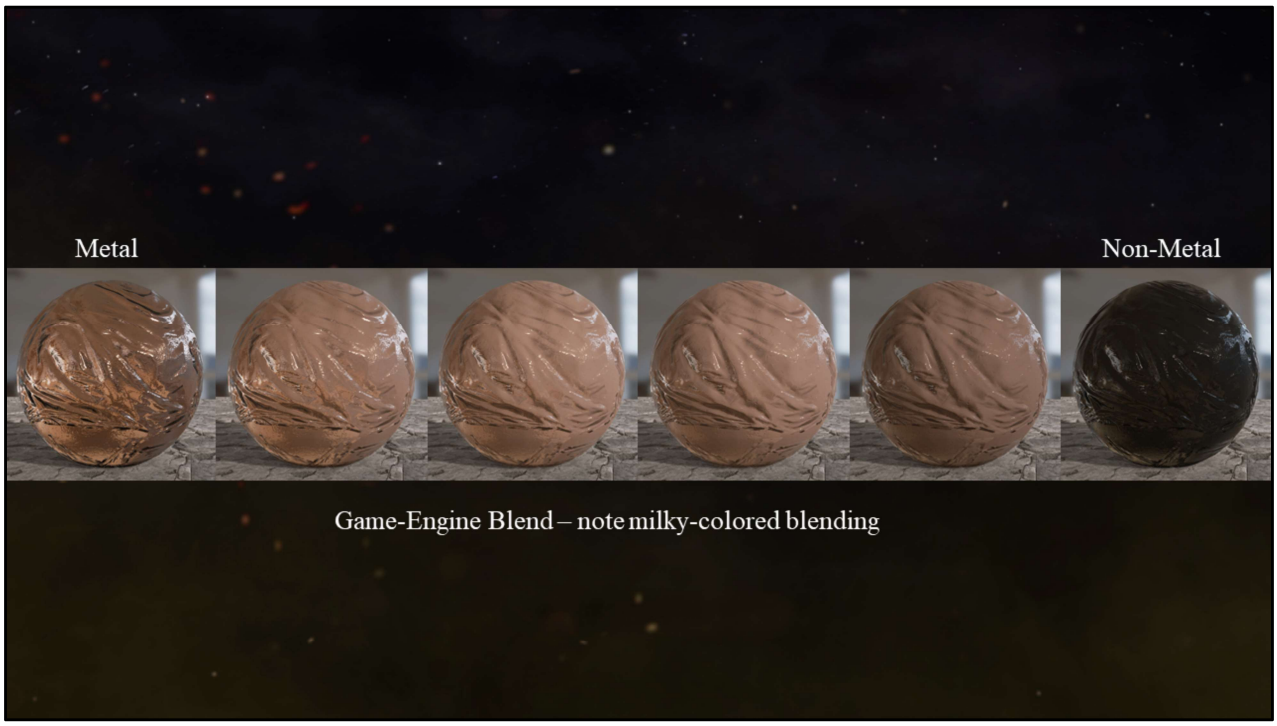


This function does two main things to fix the art *
Non-metal base color values are given a minimum brightness to avoid unnaturally dark diffuse surfaces *
And artist defined dark pure metals now no longer lose reflectivity – we clamp the metal base color to a PBR-compliant minimum brightness



- This function also addresses another major reason why artists tune metals to be too dark
- Often artists want to blend dark non-metals and metals together, such as rust over steel or anodized weapon parts *
- Here we're going to blend the pure copper sphere on the left with the pure charcoal-colored sphere on the right, to produced an anodized surface

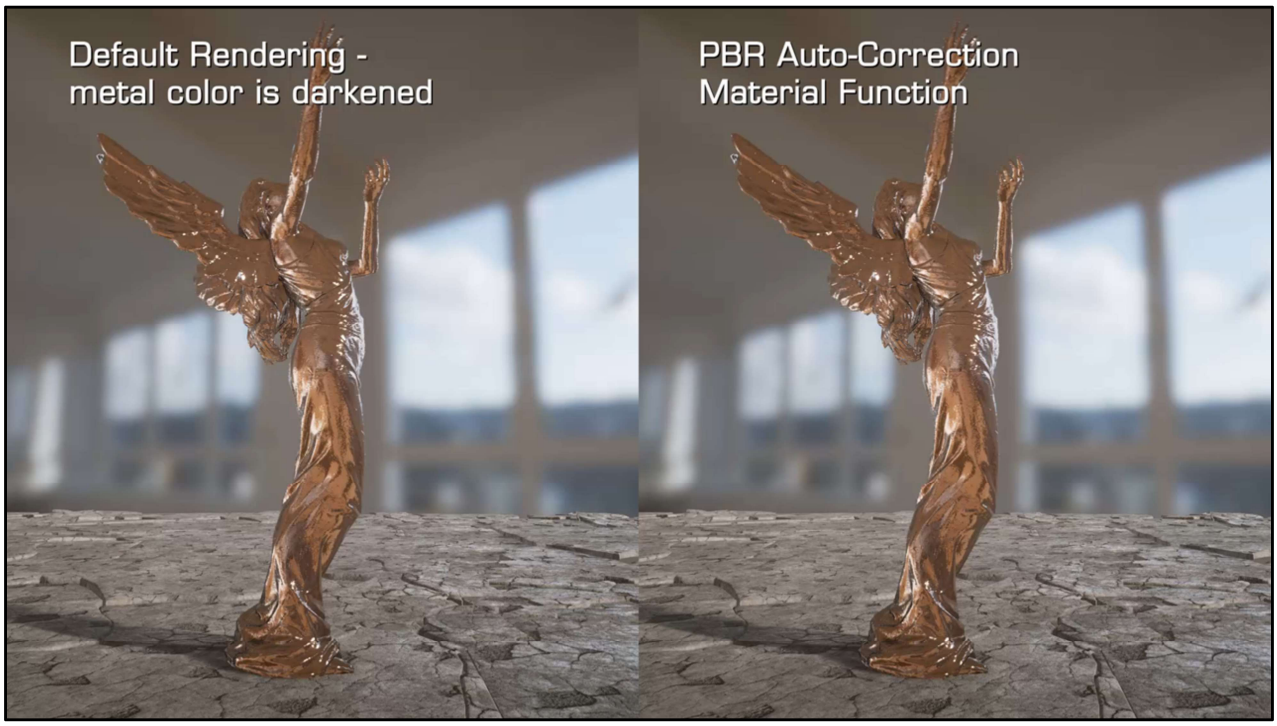
- This is the expected blend, which produces a nice series of anodized looks with realistic reflections



- But this is what happens in most deferred rendering engines when an artist does the blend and tries to stay PBR compliant
- The blended region takes on a sort of milky appearance, due to the engine only using one color to drive both the metal and non-metal properties

- So this leads to artists avoiding the blend, and opting to darken the metal color until reflectivity and diffuse is pretty much killed off, which you see on the far right spheres

- Here in this comparison with the expected blend, you can really see just how much reflectivity and diffuse is lost when artists do this

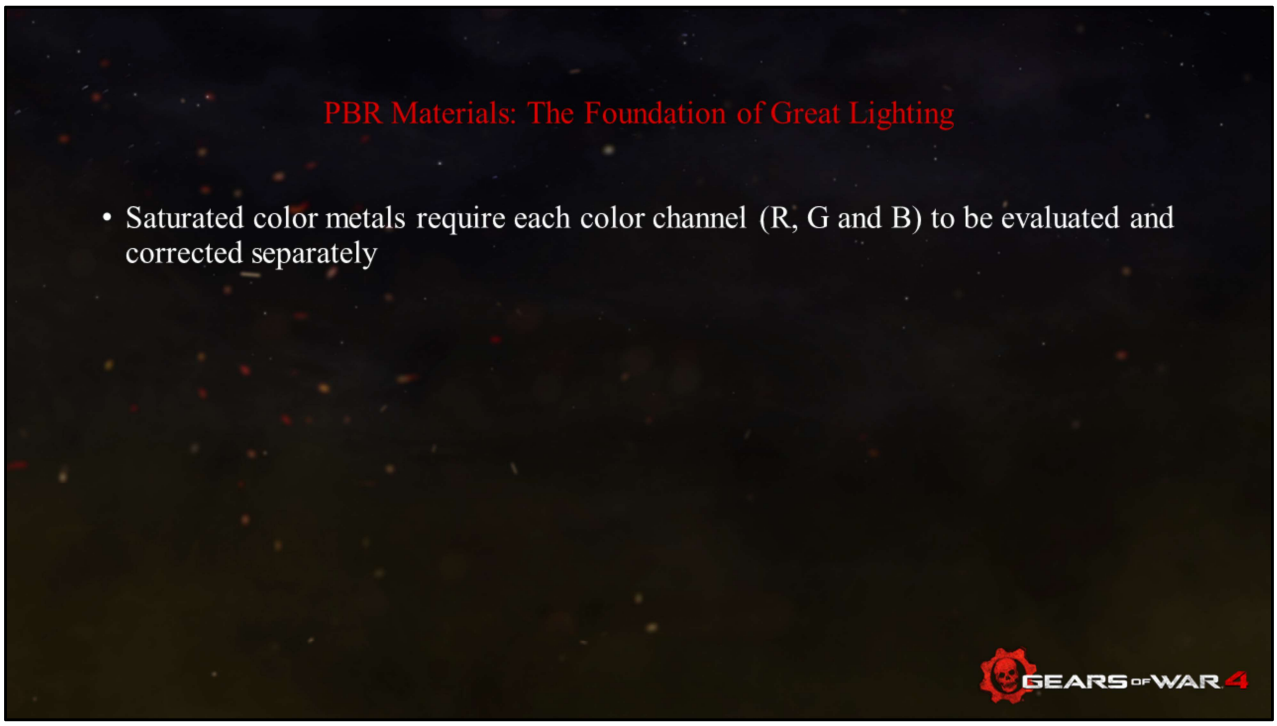


- With the default rendering on the left, note how the reflectivity completely disappears as the metal becomes increasingly darker and non-PBR compliant
- This directly affects HDR lighting in a big way, effectively killing highlights on surfaces
- On the right the PBR Auto-Correction Material Function has been activated, and now both the diffuse and specular lighting are correct
- This is done by dither blending in a dark non-metal over top of a PBR compliant metal. The dither blend is smoothed out by our temporal anti-aliasing.

- Here’s our PBR-broken arcade cabinet again

- Enable the function, and all materials are automatically fixed

Parts that had previously suffered from lack of reflectivity or minimum diffuse, are now reacting properly to the HDR light in the scene



Strongly colored metals can be auto-corrected in the same manner, but they require each color channel (R, G and B) to be evaluated separately

- Let’s take a look at this very blue statue, as it is rendered by default
- Something’s not looking believable about it
- Now let’s look at the statue, isolating one color channel at a time

- Here's the statue's red channel – note that there are zero reflections or diffuse lighting
- This tells us that it's behaving like a pure metal with a base color that's too dark

- It’s the same story in the green channel

- Only in the blue channel, does that statue resemble a PBR correct metal

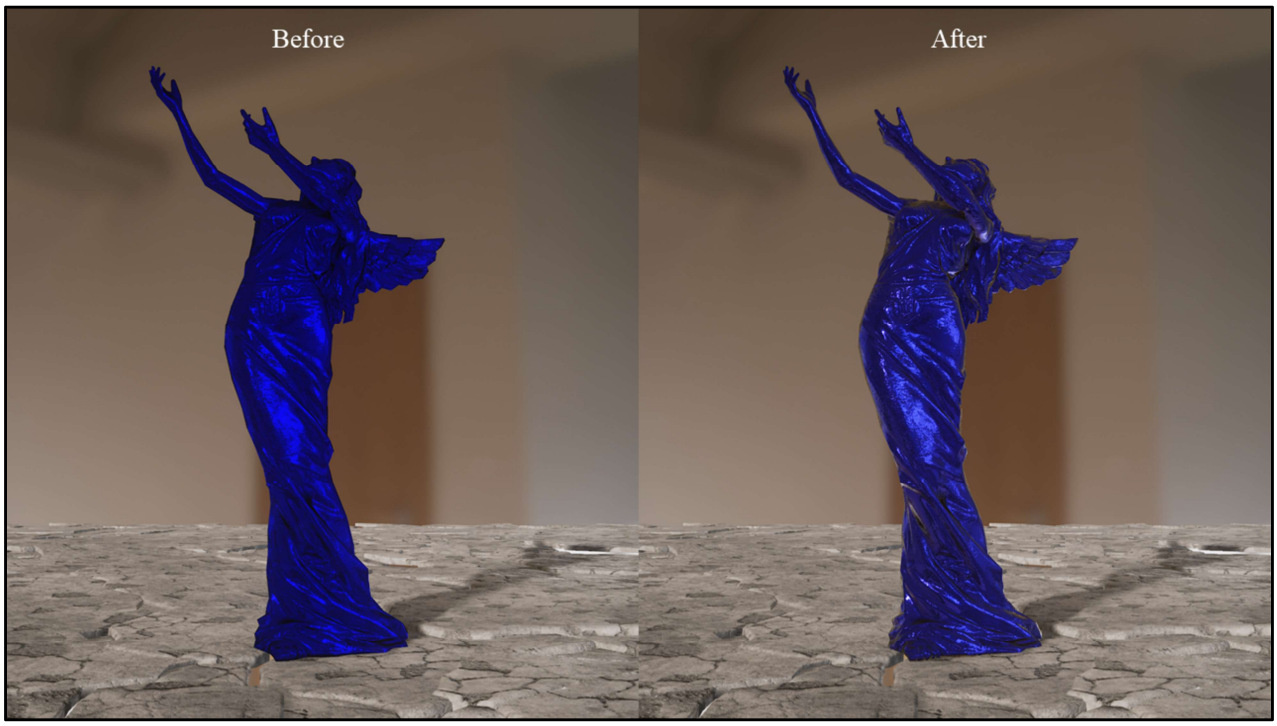
- So we conclude that this statue not PBR compliant

But we have the technology to fix it

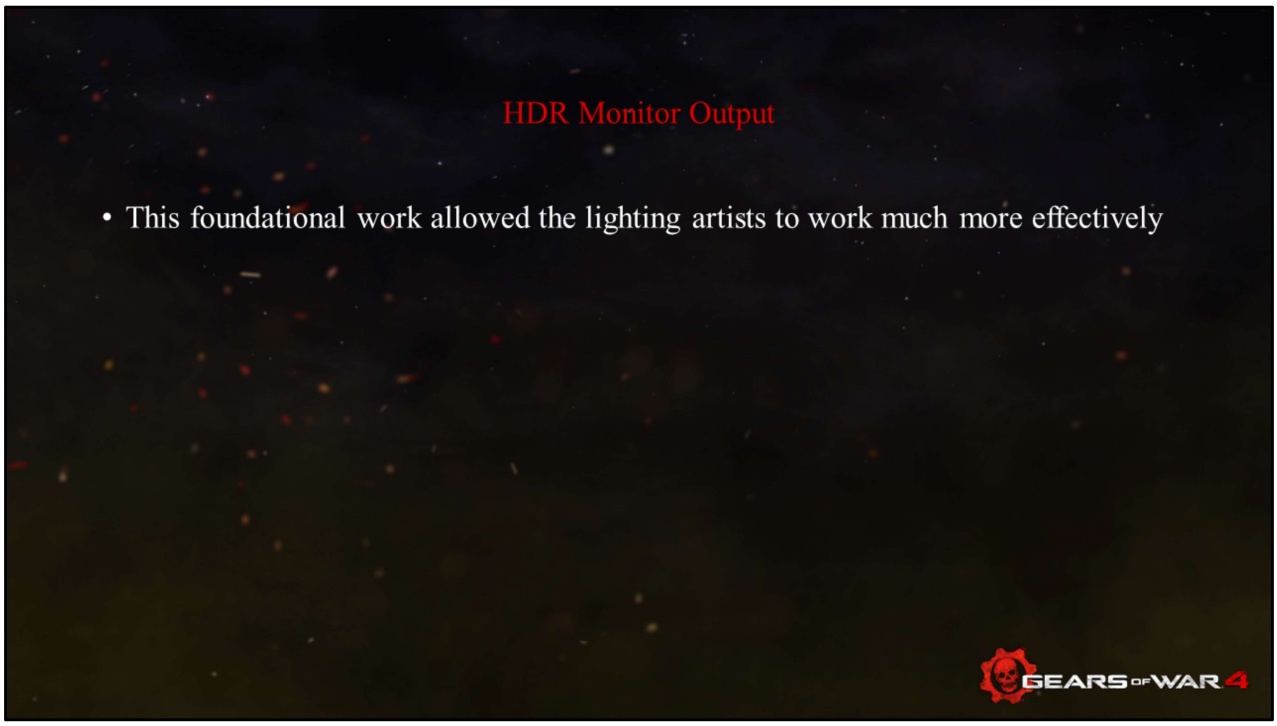
- Looking at the red channel, the Auto-Correction Material Function has properly blended in non-metal diffuse and specular lighting

- As with the green channel

Blue channel remains a PBR compliant metal



Now this blue statue looks believable, reacting great to the HDR light in the scene



- With properly set camera, lighting and materials values, the lighting artists could work much more effectively
- Andy Shen will now walk you through this

- ANDY:
- Hi, I am Andy Shen, senior lighting artist at The Coalition.
- On Gears of War 4, HDR lighting played a major part on conveying the mood and tone of the story
- As a visual demonstration, I will be using areas where I worked on the lighting for the game to show the type of artistic challenges we faced, and our approaches in achieving high level lighting goals.

- Dam B: Here we here a variety of HDR light sources interplay with each other, by incorporating the workflow and guideline Colin has just covered, you can see the flood light filtering through rain and fog, volumetric light scattering from the moon, dynamic flickering fluorescence, and bioluminescent glow from the pods, all lighting values and colors tuned to work beautifully together in a cohesive manner. This greatly enhances the immersion of the player experience.

- PBR & HDR:
- Let’s have a closer look, to enable the lighting artists to focus on the craftsmanship aspects and creative process, we must first understand and apply the science of light and material response to build a strong foundation as a canvas for the artists.
- Having the ability to visualize HDR light intensities, and PBR material compliance, allows the artists to concentrate on style, direction, and composition of lighting in a much more effective way.

- Breakdown:
- A well composed lighting is essential to the atmosphere of the scene. it goes a long way to build upon strong references and concept art when setting visual benchmarks. As lighting artist work from broad strokes down to smaller details, all the visual elements begin to come together as depth of the scene is being brought out. it really showcases the power of lighting in taking a scene from rough to polish.

- Daylight: In a scene dominated by natural light sources and indirect bounce lights, it is critical to achieve optimal HDR tonal range and exposure, by referencing real world lighting values, tuning against color histogram to ensure details are being well preserved across the entire lighting spectrum.

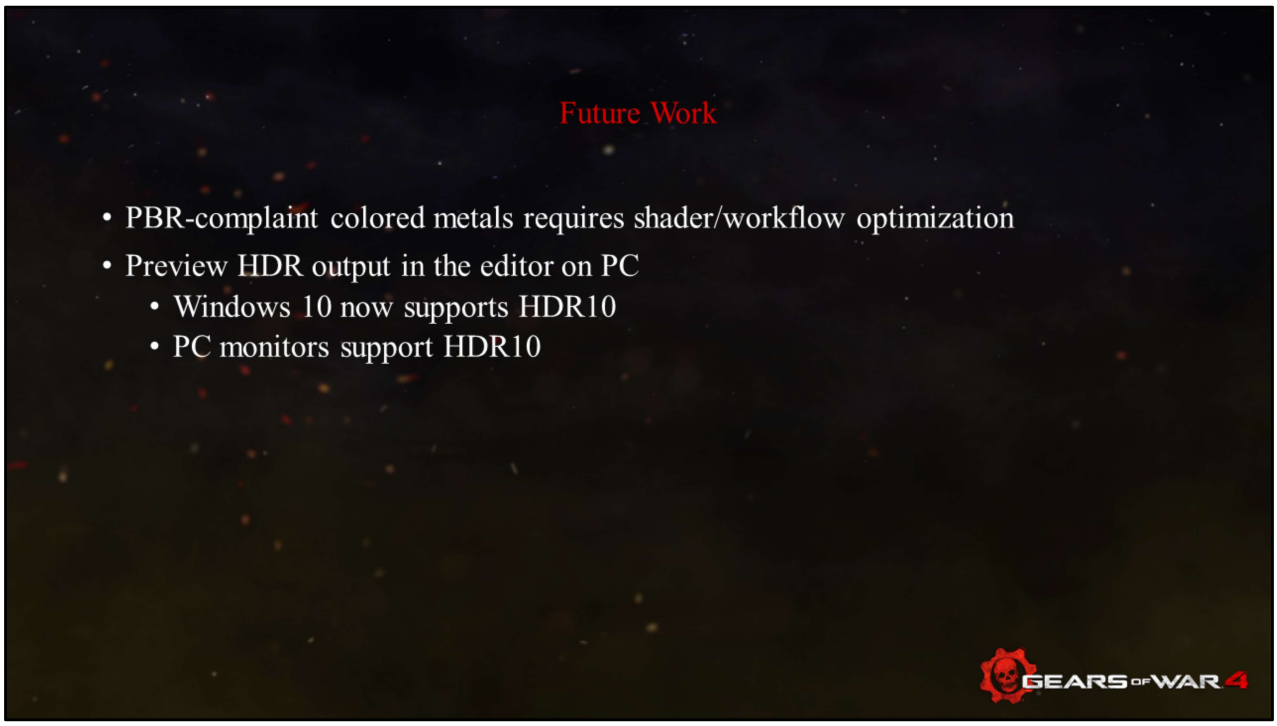
- Dam A: Good lighting design in video game not only enhances the look and feel of the space, it also impacts how functional the level plays. Our goal on Gears of War 4 is to achieve a highly crafted, cinematic feel in our gameplay level lighting. On top of using lighting to craft a sense of wonder around each corner, you can also see the way I have focused the lighting composition along the intended path, to naturally guide the players attention, ensuring cover locations and key gameplay areas are distinctive, this provide a smooth gameplay experience that is both functional and visually pleasing.

Cine Lighting

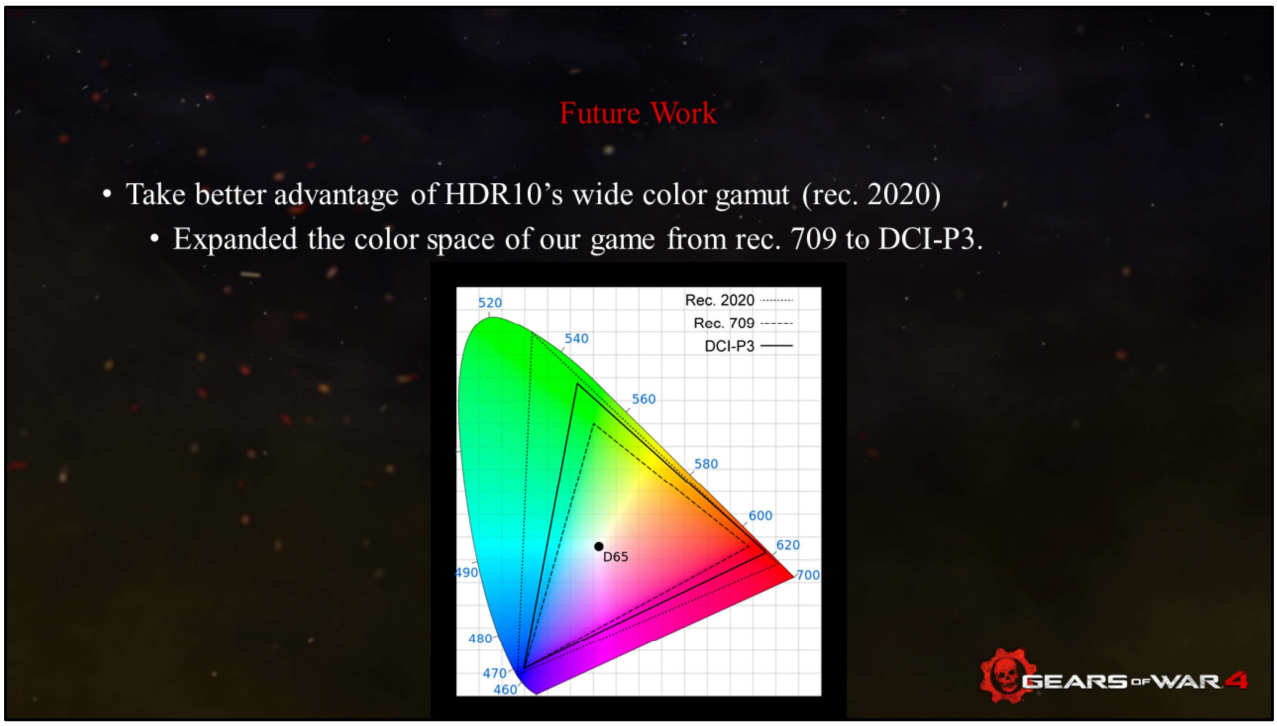
Same amount of attention to detail also applies to character cinematic lighting, here I build upon the aforementioned principles to get rich separation of characters from background, utilizing lighting as a power tool in conveying intense moments in the story.

The ability to combine both the technical knowledge and artistic craftsmanship of HDR lighting, has proven to be key factors in achieving high level of believability in our art work.

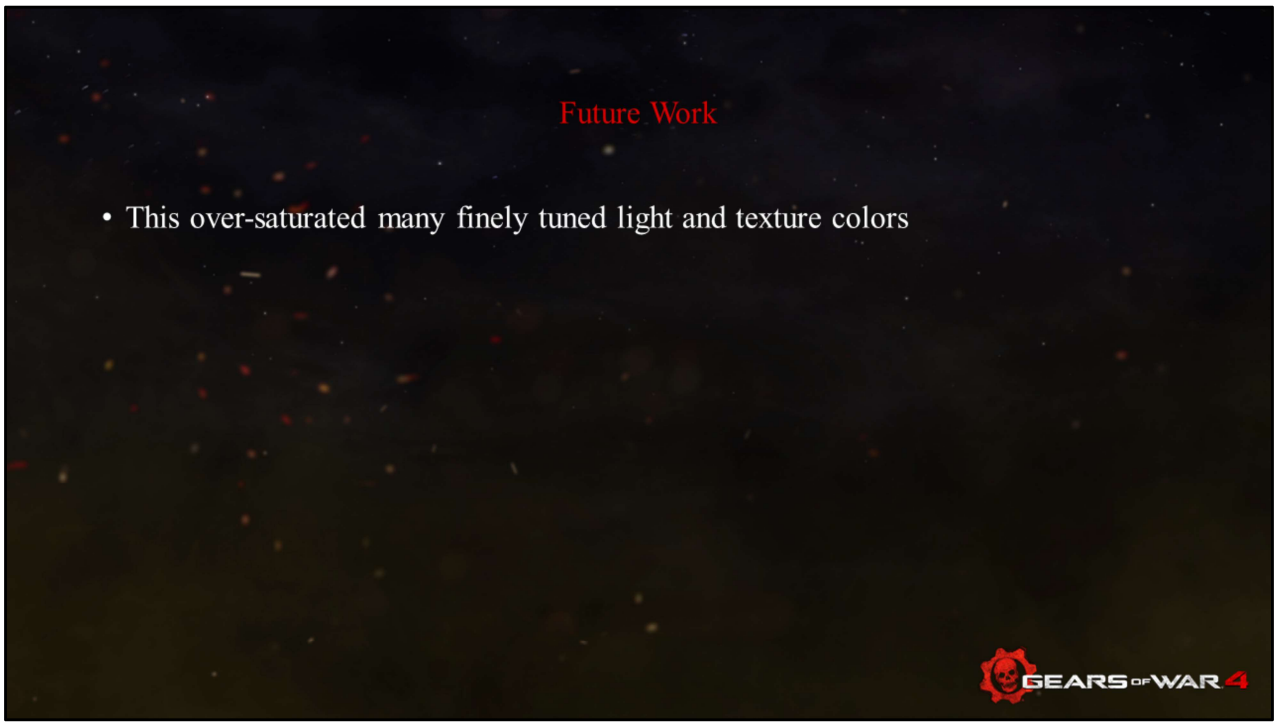
- With all these techniques followed, our work looked consistent and natural when displayed on a HDR TV *
- The Xbox One S and X output to the standard HDR10 format, supported by most manufacturers
- Perhaps in the future, this giant screen here will properly display HDR, and you'll be able to experience our visuals first hand, right here in this room



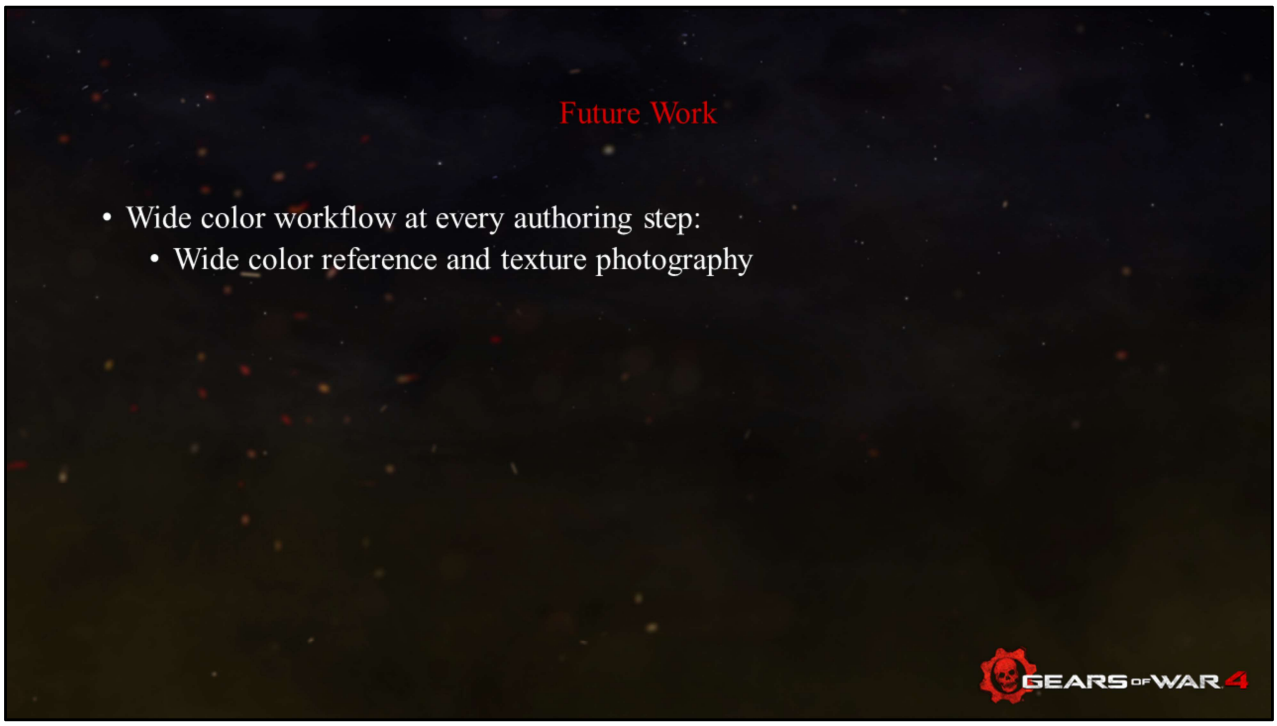
PBR-complaint colored metals require a more expensive shader function – so for future work we're looking for ways to optimize our scenes to allow us to use it more *
We're also looking into the ability to preview HDR in the editor on PC, rather than being forced to build the game to console *
The good news in that Windows 10 now supports HDR10 output just like the Xbox One S & X *
And there are new PC monitors that support HDR10



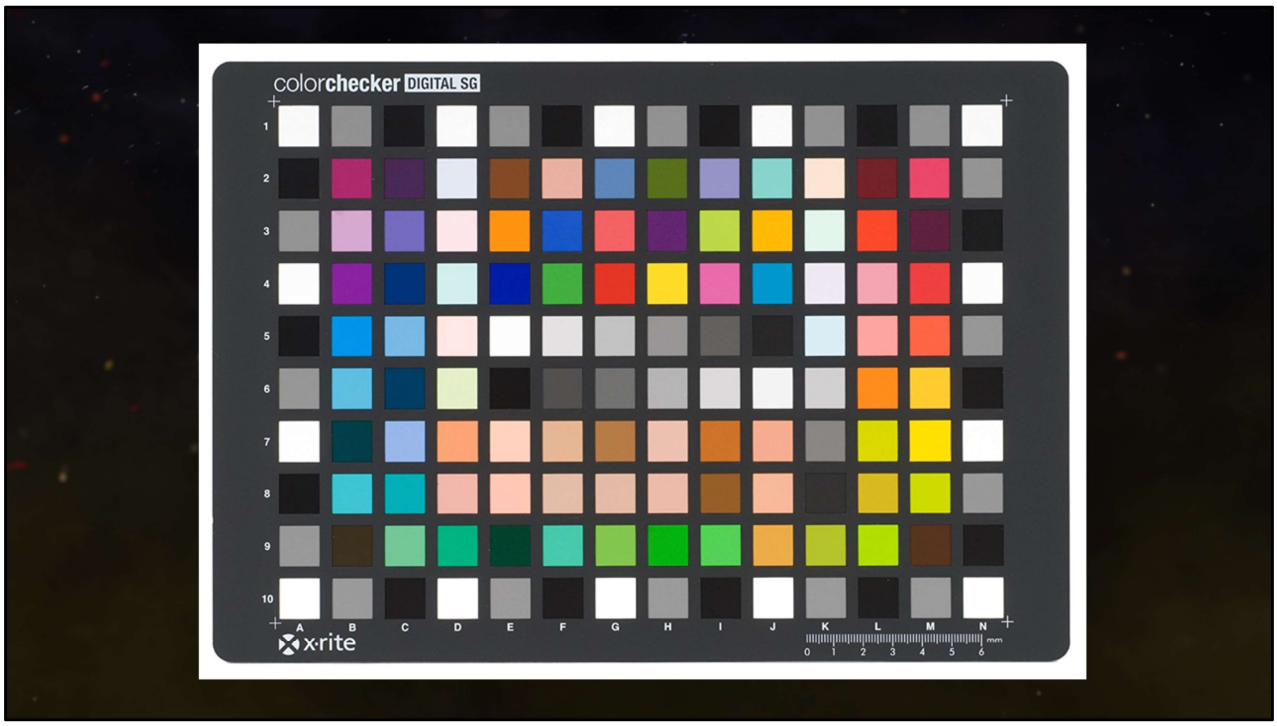
- Wide color is an exciting new frontier that we've only scratched the surface of
- We want to take better advantage of HDR10's wide color gamut *
- On Gears 4 we expanded the color space of our game from the standard format of rec. 709 to the common film gamut DCI-P3 through a simple remapping



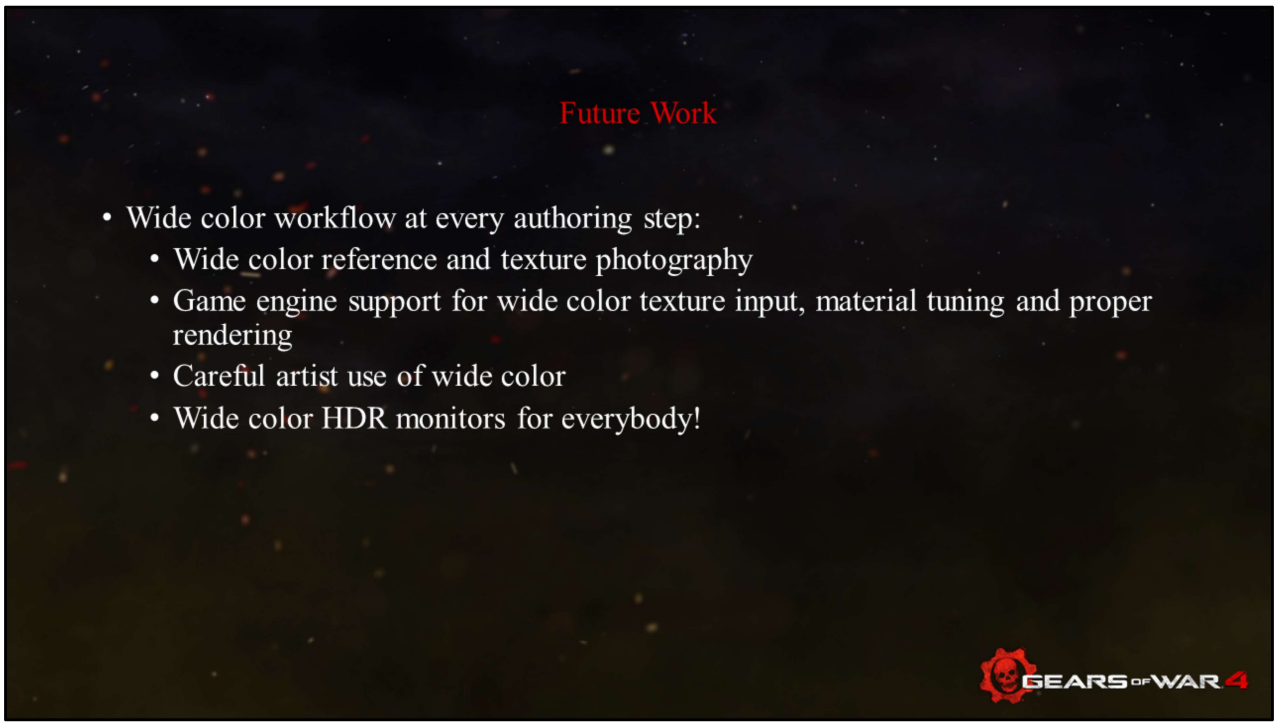
- This unfortunately made many colors in our game more saturated than what artists originally intended on non-HDR TV



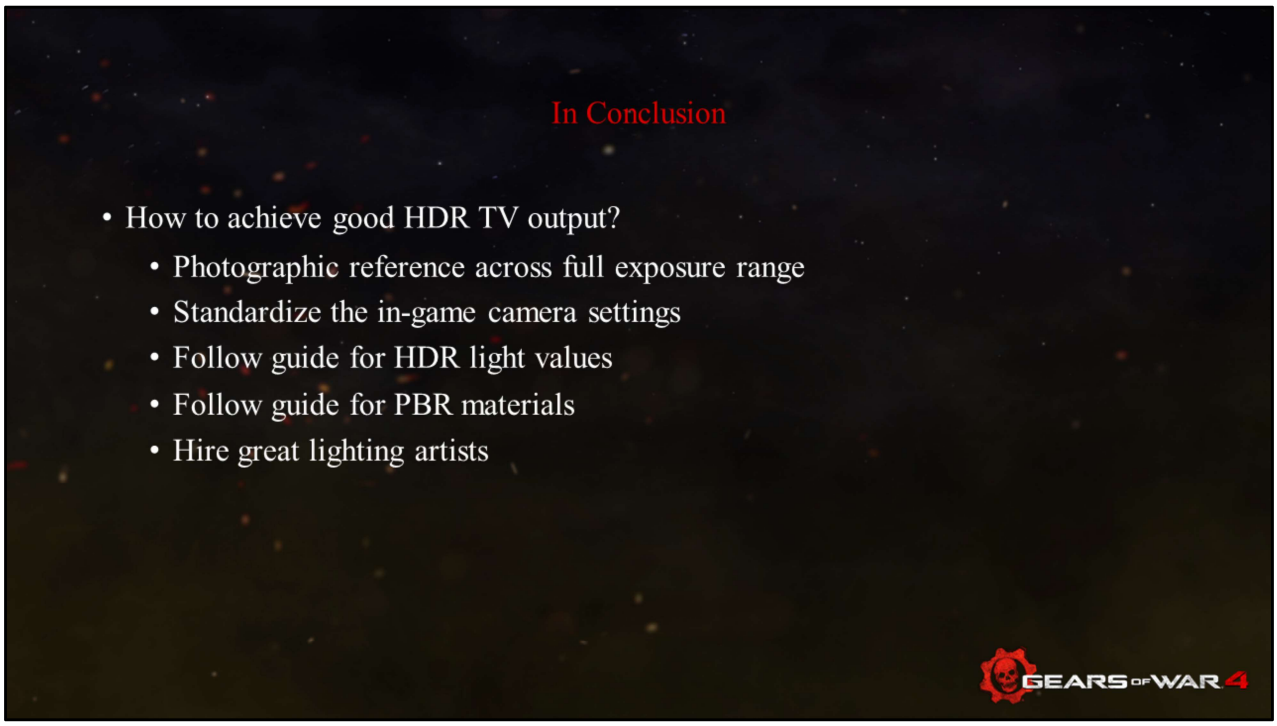
- I prefer to implement a wide color workflow at every authoring step *
- Starting with wide color reference and texture photography, by processing RAW photos into wide color space



- This is the X-rite ColorChecker Digital SG, which has a much larger gamut than the original colorchecker and will become a staple of wide color workflows, I'm sure



- We'll need to get game engine support for wide color texture input alongside standard sRGB textures, wide color material tuning and proper rendering in HDR *
- And train artists to only use wide color where it makes sense (such as for skies or weapon fx) *
- And finally, we need to buy HDR wide color monitors for the team



In summary, I recommend you do these things to ensure great HDR TV output from your game *

- Use photographic reference to understand what cameras and lights do across the full exposure range *
- Standardize the in-game camera settings *
- Get the artists to follow the guide to HDR light values *
- As well as the guide to PBR material creation *
- And hire great lighting artists

Thanks to everyone who worked on Gears or War 4 and contributed to solving the challenges of HDR TV output and lighting!

Thanks for listening to us

FULL TIME POSITIONS

http://thecoalitionstudio.com/#Join-Us

Contact: Andrew Glover, andrewgl@microsoft.com

- Lead Character Artist
- Gameplay Engineer
- Rendering Engineer

Contract POSITIONS

Contact: Jack Coleman, jcoleman@aquent.com

- Concept Artist
- Cinematic Lighting Artist
- Gameplay Animator
- Graphic Designer
- Layout Artist - Cinematic
- Lighting Artist
- Level Artist (Intermediate & Junior)
- Level Designer
- QA tester
- Technical Director - VFX
- Tools Software Engineer
- VFX Artist
- UI Engineer