TOMB TECH
THE VISUAL EFFECTS TECHNOLOGY OF RISE OF THE TOMB RAIDER
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An exclusive Crystal Dynamics feature interview with Technical Art Director Mike Oliver & Game Director Brian Horton

Article by Brandon Klassen
Redwood City, California. It’s a hot, beautiful summer day at Crystal Dynamics, the studio who successfully rebooted the Tomb Raider franchise in 2013 after working with the 2006 follow-up to Core Design’s games with Tomb Raider: Legend. Now, they’re hard at work on the reboot’s sequels: Rise of the Tomb Raider. Technical Art Director Mike Oliver speaks to me from the studio, and I also have the opportunity to catch up with Brian Horton, Rise’s Game Director, at E3 in Los Angeles, where Crystal debuts gameplay footage.

Led by Mike Oliver, the visual effects team at Crystal consists of three full-time members and one contract artist: Scott Kennedy, Brad Shingledoekes, Leo Braz da Cunha, and Ross de Young. Can you tell us a bit about the team?

Brian Horton: Mike Oliver is our technical art director, and his primary job is to make sure the vision that we have as art directors is seen through the technology department to get the best result. Mike’s job, in addition to making sure our effects are great in the game, is to push the boundary of technical achievement throughout all of the art that we create in Rise of the Tomb Raider.

Scott Kennedy is actually now our lead effects artist, now that Mike is a Technical Art Director. Scott’s dealing with all the particles and all the explosions—anything you see in the game that tends to be particle-based goes through Scott Kennedy. And we also have Mike Abahazy—he’s also a technical art lead—and his job is to make sure that the game not only looks great but runs at frame. So he’s dealing a lot with optimisations and things that we have to do in order to afford these more advanced techniques—how do we get other things optimised down in such a way that we can balance the frame rate and get a good frame rate and a good resolution.

So the visual effects team is comprised of technical people that work directly with programmers and artists that make amazing effects, to ultimately create something that is both aesthetically pleasing but also technically feasible.

What are the areas that the VFX team is responsible for?

Mike Oliver: The visual effects team is mainly responsible for creating the atmosphere, mood, and dynamic excitement within the Tomb Raider franchise. The majority of our work falls within particle simulation but also touches many other disciplines. We are routinely involved in modeling, custom rigging, research, updated texture assets, or revamping combat effects. Each effects artist is also paired with a specific game team and level development. This allows us to have in-depth knowledge of the levels being produced, the goals of the space, what custom effects need to be created, and address any concerns or difficult tasks early on. Finally, we allocate any remaining time to priority items that are brought to our attention by production or other game teams.

Rise of the Tomb Raider uses “Foundation Engine, ” which is your in-house proprietary engine—and a lot of upgrades have been made for the game. Can you describe that process?

Brian Horton: We’re very proud of the enhancements done from, even Definitive Edition, which was on Xbox One and PlayStation 4, where we took Tomb Raider (2013) and tried to advance our technology as much as we could within that same game.

We have a very robust toolkit. Horizon is our world-building tool, and that allows level artists and level designers to iterate very quickly by building assets in Maya, importing them into Horizon, and moving them around to create worlds. We also have a system called ActionGraph and AnimGraph—and that’s what Mike primarily uses—where we can create custom materials and shaders and events that are very much design-driven or artist-driven, and that allows the programmers to spend more time on tools to help us, so, it even creates, the vision we want to create without having to wait for them to make an exhaustive, custom piece of technology.

Mike Oliver: Our proprietary engine is always undergoing iteration throughout production, not just between projects. From Tomb Raider (2013) until this point we have had substantial improvements culminating in a full HDR pipeline, deferred lighting with localized global illumination, PBR compliant materials, volumetric lighting, color grading, screen space ambient occlusion and integrated particle lighting.

The character pipeline has also been improved to allow for a mix and match workflow we nicknamed the ‘paper doll’ system. It allows body parts and gear of similar characters to
be swapped amongst each other easily, creating for greater variation with less memory overhead. Included with this comes a suite of new materials, such as subsurface scattering and facial and body blend shapes.

Finally, our level editor was completely re-written from the ground up, including a new object workflow and visual scripting language. We are fortunate to have such dedicated engineering and technical artist teams.

How does the new lighting system work?

Brian Horton: We’ve completely rewritten our lighting engine. We took our deferred engine, which was very powerful—we could put a lot of dynamic lights in the game—and we now can create more true, correct forward lights that allow translucence to be lit. For instance, all our physics particles are now dynamically lit in the game, where they never used to be. We have what we call image-based lighting, where we bake out the whole room as a series of images, and we’re able to reflect back the light. So if I have a red wall, the light will hit that red wall and bounce back, and you feel a real natural sense of radiosity, or light scatter as light hits a surface and bounces back. We also have a fully physically correct material system, which means that metal will feel like a metal, skin will feel like skin, plastics, all of these things are rendered to be simulated as correct. So no matter what time of day it is, whether it’s night time or day time or whatever time of day you have;traditionally, cinematic scenes were pre-rendered from real life. So this is a big change that we had in our technology. It’s making our game feel that much more believable, and because it’s all dynamically lit, we can still iterate very, very rapidly. We don’t have to worry about baking out complex light maps or anything pre-calculated, it’s just all happening in real-time.

How do you implement dynamic light sources, such as torches, flashlights and fire?

Mike Oliver: Dynamic lighting for particles has been drastically simplified since Tomb Raider (2013) due to our new object system. Visual effect artists can now create an object that contains both an effect template and a light. With some simple scripting, we are able to expose controls such as intensity, colour and distance. This allows both artists and designers to achieve any lighting result they are after without in-depth knowledge of scripting or the lighting system.

You mentioned the Definitive Edition, which gave Crystal the chance to upgrade Tomb Raider (2013) for next generation consoles. Neow. Rise is the first fully next generation Tomb Raider game, and gives you the opposite challenge—the game has to perform on the Xbox 360 as well. How do you balance designing a game you have to plan for in development, or does that scaling happen during the porting process?

Brian Horton: If you may or may not know, Neowes has been a long-time partner of Crystal Dynamics. They’ve been with us for a long time, all the way back to the Legacy of Kain days, and they’re technical wizards. They’re able to do advanced technology but also have been able to find ways to work with their team to down-res assets and try to maintain as much of the visual fidelity as they possibly can. So they’re very tech-centric, they know our rendering technology very, very, very well, and they’ve been able to do some amazing tricks to get the 360-game looking as comparable as they possibly can.

One of the interesting trends in video game trailers has been the “in-engine footage” title card. Whereas video games used to rely on pre-rendered cinematics, they now more often use their engines to drive cinematics. In the Tomb Raider reboot, the engine’s architecture allowed seamless movement between cutscenes and gameplay as well as seamless movement between different areas of the game, which I think is very much an under-appreciated detail that contributes immeasurably to immersion.

Mike Oliver: Absolutely, this is a common workflow in modern games. Traditionally, cinematic scenes were pre-rendered to allow for higher quality assets, animation, lighting and visual effects. The downside was the investment of time required to complete these cinematics and the difficulties associated with revising them. The Xbox One really allows us to generate in-game cinematics nearly to the quality of pre-rendered movies. This has incredible time-saving benefits because any change made in-game is automatically updated within the cinematics. This gives us the ability to produce and iterate on far more cinematics than traditionally possible, while maintaining consistency of the visual look across the entire game.

Brian Horton: The seamlessness of Tomb Raider (2013) was important to us. There were load screens obviously if you died, or things like that, but we tried, whenever possible, to keep the player completely immersed in this world. We didn’t want to take them out of the world. And the streaming world, the streaming environment, is a big part of that. The ability to transition from one place to the next, and you feel like it’s just a part of a real, living ecosystem, is a key component to the recipe that we believe makes for a compelling Tomb Raider game. So we’ve continued in that tradition for Rise. It’s a seamless game—if you never die, you can go from the very opposite. A number of Rise’s visual effects seen in the gameplay footage debuted at E3. Lara’s breath is visible in a cold environment, and snow covers her hair and outfit. The realistic light hitting Lara is just one of the improvements to Crystal’s Foundation Engine.

Above: Key art for Rise of the Tomb Raider’s presence at E3 showcasing its technical wizardry.

Opposite: A number of Rise’s visual effects seen in the gameplay footage debuted at E3. Lara’s breath is visible in a cold environment, and snow covers her hair and outfit. The realistic light hitting Lara is just one of the improvements to Crystal’s Foundation Engine.

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Opposite: Two of the environments seen in Rise of the Tomb Raider’s E3 gameplay footage—the entrance to a cave, where Lara engages a bear in a deadly struggle for survival, and overlooking one of Rise’s expansive hub areas. Thanks to Rise’s new lighting and effects systems, these environments are more colorful, more alive, more dynamic and more interactive than the environments of the reboot.

Rise of the Tomb Raider is said to have hub spaces that are three times larger and also denser than those in the reboot. Did this provide any challenges to the VFX team? Mike Oliver: The impact of large spaces on the visual-effects team was less of an issue than with other disciplines. Because of the Xbox One we were allotted more memory and had more CPU/GPU cycles to use. In Tomb Raider (2013) we made great strides to set up effect templates that were conscientious of performance and easy enough for designers and artists alike to use. The largest issue we faced was actually populating the world with effects and maintaining existing content due to the constant iteration of the levels.

The atmosphere of the environments in Tomb Raider (2013) were very effectively designed, with a lot of subtle details that really brought each area to life. How are you approaching designing these atmospheric effects for Rise? Mike Oliver: When developing the mood and atmosphere within a unit we tend to work very closely with the level teams and concept artists. We try to match any key art and then propagate that feeling through the remaining areas of the level. This is accomplished using our existing effect templates and any unique effects specific to that level. Very often these levels also undergo time of day and weather shifts as the player progresses through the game. With our new particle lighting model, this is usually a seamless transition that requires little adjustment. We then add or remove effects as needed to help compliment the new goals of the space.

Finally, once the levels reach an acceptable quality bar they are fine-tuned with a suite of post-processing effects such as color grading (LUTs), motion blur, volumetric lighting, lens flares, etc.

Brian Horton: We believe atmosphere and motion are what bring the world to life. I often talk about the effects as the glue of any environment we make. So if you look at a world that can be beautifully rendered, it doesn’t feel right, it doesn’t feel like a Tomb Raider space, until we really get the effects in there. So I look at the effects artists as, they’re the final cherry on top, they help give us a sense of place, immersion and connectedness. If the wind is blowing, we can tell the wind is blowing because of the particulates of snow that come off the edge of a cliff face. Or obviously the particulates of snow that go through the air. The hope always is to make it feel that the world and character interaction is correct.

Another thing we spent a lot of time on was that snow trench and the idea of Lara trudging through snow. That was a beginning to the very end—you never experience a loading screen.

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Another thing we spent a lot of time on was that snow trench and the idea of Lara trudging through snow. That was a
big tech investment that we feel not only pays off aesthetically, but it pays off from a gameplay perspective, because you can start to see enemies making tracks in the snow, and that can make Lara pause if she comes across tracks. Those are human tracks, or those are animal tracks. Mike worked directly with the programmers to create a deformable snow that was believable. So these are the things that are important to create that sense of atmosphere and connectedness of characters and environments, so it feels like one cohesive picture.

Tomb Raider (2013) had fantastic environmental effects, which are also a major part of bringing the world to life. What tools are you using to handle environmental effects—such as rain and snow—for Rise?

Mike Oliver: Environmental effects is one of the areas where we have invested heavily as an effects department. One of the new features available in Rise is our weather system. This system allows designers and artists alike to create weather on the fly. It gives them the ability to set simple criteria in our visual scripting language, such as the type of precipitation and its intensity level. Inside the effects system, we use these values to dynamically adjust the various effect attributes, allowing us to achieve anything from a light serene snow fall to a raging snow storm.

To complement the weather system, we also have tessellated ground which helps Lara integrate further into the environments she visits. She can trudge through waist high snow leaving deep trenches or barely noticeable toe marks in the sand. Finally, for several key moments we also utilize Side Effects Houdini to create dynamic shots that wouldn’t normally be possible with our in-game effects. We then composite them in real-time into our game engine, further helping sell the believability of Lara’s environment and their dangers.

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Above & Opposite: Much of the initial concept art released for Rise of the Tomb Raider depicted Lara trudging through snowy environments. The importance of Lara’s interaction with snowy terrain was a focus of technical R&D for Rise.

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The large effects, such as the avalanche sequence seen at E3, are an exhilarating gameplay experience, but must be incredibly time-consuming to create.

Brian Horton: We have multiple pillars throughout Tomb Raider that we used, and we talk about them in three ways. There’s a traversal pillar, there’s a combat pillar and a puzzle pillar. But ultimately, all of them tend to have a layer of experience to them—something that is visceral, something that you can feel. The OMS levels are those big crazy levels, those punctuation points, like the avalanche. These take many, many man hours—teams dedicate months and months to bring a sequence like that to life. And while they’re expensive to create from a minutes perspective—it takes a lot of time to generate a short amount of minutes—we believe
they’re vitally important to our overall formula, to make sure the player, when they’re in an open exploration space, they’re feeling immersed, but then to give them that pacing spike, to give them that moment that feels larger than life—“I can’t believe I survived that”—is really what helps round out the overall pacing and gameplay.

Mike worked directly with our programmers to make sure our large effects, like the avalanche, could be something that was film-quality in real-time. That was a major R&D project that we wanted to go through, where we’re able to use some very sophisticated technology to create film-like assets in real-time that are compositied directly into the gameplay. So that avalanche is something that could easily be rendered in a movie, but we’re able to see that fully in real-time.

Fire and explosions were particularly impressive in the reboot and featured heavily in sequences that really drove the player with an exciting sense of danger. How have you made improvements to fire for Rise?

Mike Oliver: Fire is always a difficult thing to achieve in a real-time environment. It has a very organic look and motion that, if not executed correctly, can ruin the player’s immersion. We experimented with many different types of fire when developing Tomb Raider (2013), such as material based ‘procedural’ fire, individual sprites, animated geometry, and flipbooks. We ended up going with flipbooks because it provided the most believable sense of motion and visuals. This decision did not come without pitfalls, however. Texture atlases quickly caused memory issues as well as low resolution animations and repeating patterns. Nothing a little glow and creative placement couldn’t fix, however.

With Rise we continued this technique but were able to increase the number and resolution of texture atlases, allowing for much more variation and quality.

Water simulation was another key visual effect element in the reboot. While the game didn’t feature underwater sequences that fans have come to love in the franchise, Lara spent a lot of time wading through water-filled areas. Have there been improvements made in the water simulations for Rise?

Mike Oliver: The water in Rise has undergone substantial visual and performance improvements. We are now able to use the reactive ripple water in all areas of the game, whereas in Tomb Raider (2013) we were limited to small hallways. Additionally, we utilize fluid dynamics simulations inside Side Effects Houdini to generate flow maps, foam maps and displacement maps, allowing for truly dynamic and dangerous water.
Throughout her adventures, Lara’s skin and clothes will get wet, dirty and bloodied, but to mention the wounds she’ll suffer. Noah Hughes has mentioned that Lara will also have snow stick to her hair, which will then melt indoors. How do the VFX systems technically interact with the player’s actions to create progressive changes in Lara’s condition?

Mike Oliver: Lara’s contextual changes when in various environmental conditions are driven using the weather system. Visual scripting ‘hooks’ are exposed on Lara and when she detects that her environment is cold, she will begin to shiver and display cold breath, or warm her hands by a fire. If she stays too long in the rain, parameters within her materials will change over time, resulting in a wet look. Her ‘damaged’ visual states are also controlled in a similar manner. We check to see how much health Lara has remaining and as she moves closer to death, we dynamically adjust her materials to reveal more blood as well as other post effects such as vignettes, desaturation, and screen splatter.

One aspect of the reboot’s visual effects actually turned out to be controversial. Lens effects—rain drops, blood splatters and hexagonal flares—appeared in various situations and partially obstructed the player’s view. Some loved the effects, while others felt they were unrealistic or found them distracting in terms of immersion.

Mike Oliver: Lens flares and screen gunk is always a bit of a controversy. The concept behind their creation was to help bring additional emotional response and believability to the player experience. In Rise they are still prevalent. Some have been reduced or removed, while other new types have been added.

Brian Horton: I definitely think we’ve refined the idea of lens dirt and lens water splats and things like that. We still use them, because we believe it’s part of our aesthetic—to create that immersive, survival, documentary feel—but we’ve also subdued the amount that we see them and they dissolve off the camera lens faster. We’ve created a technology now, which many other games have, where there is lens dirt but it only really shows up when the light is directly in front of the lens. So that means that you’re not seeing it on all the time. Or before, we just put particles on screen, and they would show up no matter where the lighting direction was. So I think it’s a much more sophisticated expression of lens effects, but it is still there, and for those that might have issue with it, I believe we’ve struck a really good balance of it, feeling immersive without being in your face and being too obtrusive.

Another visual “overlay” we saw at E3 was film grain. Brian Horton: We want to make sure that there is a grit to the screen and a texture. We’ve deliberately added film grain, and it is something we tune as we go all the way through production to find the right levels. It’s one of those little last bits that we add to bring a little bit more texture to the image and give us that feeling of a real piece of stock film.

Is there a point in the development do you find that you can look at the VFX objectively and overall feel for the success of the effects within the context of the rest of the game? Have you reached that point yet?

Mike Oliver: I believe that it is difficult for an artist to look objectively upon their work. We strive very hard to improve ourselves and our craft and often we overlook how wonderful something is in order to find areas of improvement. But when I pull myself away from scrutinizing pixels and take the time to enjoy the fruits of our labors I can really see that our work is starting to shine as a whole. Beta for us is really the turning point in our production. It’s the point where we stop the broad strokes and fine-tune the little details that sell the experience.

What are some of the details you’ve been able to put into your work on Rise that you’re particularly proud of?

Mike Oliver: There has been a large amount of things I’m proud of on Rise. This was my first production at Crystal where I wasn’t focused solely on visual effects. I had an amazing opportunity to work with a great deal of talented people on the best ever visual improvements. Areas such as our weather system, dynamic terrain, the Houdini initiative and dynamic ‘next gen’ visual improvements. Areas such as our weather system, dynamic terrain, the Houdini initiative and dynamic water to name a few. Of course, FX is still my passion, and I pull myself away from scrutinizing pixels and take the time to enjoy the fruits of our labors I can really see that our work is starting to shine as a whole. Beta for us is really the turning point in our production. It’s the point where we stop the broad strokes and fine-tune the little details that sell the experience.

Any closing thoughts about the gaming experience that fans can look forward to with Rise of the Tomb Raider?

Brian Horton: We had a tremendous amount of people that completed Tomb Raider (2013)—I think it was 65% of the people that played the game completed it all the way to the end. That might not sound like a lot, but actually is quite a bit, when you think about the amount of games that people play for a certain amount and then stop. So we believe that that sense of pacing, sculpting our three pillars—whether it be an immersive, emotional moment like being in the Den of the last games and you have this dark place you have to escape, then you have to survive in a wilderness and hunt an animal, and then you have an intense sequence where you have to escape a burning building—all those things sort of weather and weave together to create an overall sense of highs and lows.
We continue to think about that pacing. It’s extremely important to us that people feel that just when they’re about sick of something, or they feel that they’ve had enough of it, they get something else. And that’s the great thing about making a Tomb Raider game—we have a lot of different styles of play. On top of that, we give you more player choice in Rise of the Tomb Raider on how to approach combat. With Rise of the Tomb Raider, we believe we have the most ambitious and interesting Tomb Raider game we’ve ever made.

Mike and Brian, thank you so much for your time, and for sharing some of the behind-the-scenes secrets of Rise of the Tomb Raider with us!

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