Sam Nicholson, ASC on *Our Flag Means Death*

Rhys Darby as Stede Bonnet and Taika Waititi as Edward Teach (Blackbeard) in *Our Flag Means Death.* Photo by Aaron Epstein / HBO Max

Sam Nicholson, ASC discusses his work as virtual production supervisor on Our Flag Means Death, *starring Taika Waititi as Blackbeard). The story is loosely based on the true adventures of Stede Bonnet (Rhys Darby), who bailed out of pampered aristocracy to become a pirate. David Jenkins, the series creator, said, "Very early on, I was talking to Taika about it, and he said, 'don't do any research.' It was nice to...then invent things..." Sam Nicholson is Founder and CEO of Stargate Studios.*

No one really likes working on green screen.

A long time ago, we launched the concept of a virtual backlot on green screen—using digitized city backgrounds so that series television could seem to appear to have been filmed on location while principal photography was still being done in Los Angeles. For Ugly Betty, it was New York. For Pan Am, it was Idlewild Airport, now JFK Airport, in the 1970s. And for 24, it was Washington, DC, which is very difficult to film. The more difficult the location, the better, because you go in with a very small team and few people ever knew you were there.

But no one really likes working on green screen. It's like sensory deprivation for actors, directors and cinematographers.

What's the resolution of reality?

Then, along comes the intersection of LED technology combined with powerful Nvidia graphics cards and all the Blackmagic Design hardware that allows you to economically capture 12K RAW motion picture images, color grade on set and feed vast amounts of data to a 20K screen, in 8K chunks, using Blackmagic 8K DeckLinks. And all of a sudden, the question of why 8K becomes, "Well, why not 20K, 30K, or 50K?" If you're going

to virtualize reality with a camera and capture data, then the pixel count is crucial. So when people ask, "Why do you need 12k," I say, "Well, what's the resolution of reality?" It is at least 12K, probably more.

Our Flag Means Death

For *Our Flag Means Death*, we determined that we wanted a contiguous wall, 165 feet long by 30 feet high, surrounding a pirate ship, covered by multiple cameras because it's a comedy. Taika Waititi likes to shoot long takes with multiple cameras. He didn't want to be restricted by a frustum—a single view where it looks really good in one angle, but it doesn't look good anywhere else. I understand the necessity for a frustum or multiple frustums if you're in the 3D universe, but we had a very short prep schedule of only six weeks, and we're talking about ocean backgrounds at 20K in about five-minute loops. So for anyone who's done water work, with multiple scenarios that would last an entire season, the economics of it all suggested that there just wasn't time to even think about the CG route.

We were on a boat to shoot the backgrounds with five Blackmagic URSA Mini Pro 12K cameras. The images had to be stable, which proved to be a major challenge because we weren't on a barge. We were on a small boat, rocking around a lot. That doesn't work well on a big video wall when you're trying to stitch five cameras together. We used Unreal Engine to drive, stitch, modify, and control the lighting. And we used Blackmagic hardware on set to distribute what was five times 12K, so 60K of data. We chose the Blackmagic 12Ks because the BRAW files are incredibly efficient and very high quality. Even so, we were shooting about 30 terabytes a day.

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URSA Mini Pro 12K cameras recording to SSD Drives

After a call to my friends at SanDisk and Western Digital, we decided to go with 100% SSD memory on the cameras. We put a 4 Terabyte SanDisk SSD Extreme on top of every 12K camera. You shoot all day on the boat, get in at 10 pm, get back to the hotel at 11:00, and now you've got from 11:00 PM until 4:00 AM to download 30 terabytes of data from the cameras' SSDs to 200 Terabyte SSD RAID arrays.

Hope that half the crew is not seasick

You back-up the data, format the SSD drives to get ready for the next day and hope that half the crew is not seasick, which definitely happened. That was the one thing I didn't anticipate—what percentage of people would be hanging over the side. That's definitely not in any cinematographer's handbook. Transderm Scopolamine patches should be in the handbook. I've done a lot of boating, so I don't have a problem with being seasick, but some of the crew did and used those patches behind the ear.

But we went through inclement weather so rough that we had to turn back a couple of times, with heavy rain and all the things that you get in the real world, but that translated into some really amazing footage and it was all real.

Over two weeks in Puerto Rico, we shot landscapes, shorelines, seascapes. We shot on boats, did aerials and used drones. We built a library for the entire season of the show with many options. Clearly, you have to over-shoot. That's really what you want to do if you're going to build a virtual library for a series—it is better to get a lot of footage and be future-proofed so that it's not only good for that season, but you might be using it five years from now.

What are the creative goals?

The defining factor off the top is, "What are the creative goals?" Then, you need to think forward and say, "What's my schedule and budget?" And, "How do we come up with a plan, whether it's CG, photographic, a hybrid, or whatever? How do we blend these tools at a price that the production can afford, that meets the schedule, and that we can be on set with a dependable system?" And so you need to have enough time to test, and see those images up on that 165-foot wall, and really be 100% confident when you step on set for that first day of principal photography, that there will not be a single minute of downtime. I'm glad to say that in 12 weeks of shooting, we never had any downtime at all. No one ever had to wait on the ocean back-grounds.

Like an orchestra

Everyone has to be on the same page. The studio has to be on the same page, the director, the DP, and critically, the production designer, Rob Vincent. We talked very early on and started doing computer layouts of the virtual space to ensure that the screen was big enough, and when would we shoot off it? And when would you see the floor? How high could you put the camera? What kind of wide lens? What kind of moves could you do? I think all those things need to be rehearsed in virtual space before you begin because the last thing you want to do is drop a 165-foot by 30-foot high wall in and have it in the wrong place. That is not an option. The set for Our Flag Means Death was in the biggest stage we could get at Warner Bros. in LA.

Very early on, after a lot of discussions with Rob, we decided to split the ships into three parts and put them all on wheels so that

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they could be rolled in and out, and they could become different ships: the French warship, the English warship, and of course the Revenge. When you get virtual production right it's like an orchestra that is hitting all the right notes. That's really exciting.

On location in Puerto Rico

We did San Juan first. The east end is much calmer, so we did a lot of work there. When they run aground, the backgrounds of the beaches and forest were in Puerto Rico as well. And a lot of good visual effects work went in there to blend it all. We had our team in Malta working on traditional visual effects and DNEG did most of the heavy lifting.

Stabilizing 5 cameras on a small boat

The reason we didn't have a big barge rather than a bouncy powerboat as the camera platform at sea was mainly economics. We wanted to be able to travel rapidly between locations and get tight to the beach and go over shallow areas. So we had a medium-sized fishing boat, about 35 feet long. To stabilize five Blackmagic URSA 12 cameras, we had a Black Unicorn 3-axis stabilized head. We also digitally stabilized everything again in post afterwards.

To sync all five cameras together, we used Denecke time code generators. We synced time code feeding each camera's time code input. These cameras weren't genlocked. Matching time code is crucially important.

Lenses

We used 12mm Laowas, 25mm ZEISS Batis, and, of course, lots of SIGMAs that were great because they are affordable, very sharp and neutral.

Photographic vs CG backgrounds

I'm very proud of how we addressed "Our Flag Means Death" because we made all the right decisions about whether it should be photographic or CG and how we built the set. How do we give Taika an unlimited resolution background against which he can shoot anywhere he wants? You can tell when you look at the show that it feels very natural. I think everybody kind of gets obsessed with, "Oh, it has to be a CG background." But we worked very hard to ingest very high-resolution photographic data, captured at infinity (so there are no parallax issues) into Unreal Engine engine and allow it to play all these virtual moves, and manipulate them, and do off axis projection and so on. Coming at virtual production from a cinematography starting point is something that I think we're really good at because we've been doing it for a long time and we have all the right hardware and the right connections.

Real-time playback

Interestingly, in virtual production, everything has to be based on real-time playback. What you can you do in real time is the underlying, capital, bold-typeface question that you must keep in mind because no matter how good your world is, or how high res or beautiful its detail and texture, if it doesn't play at 24 frames per second on that screen, you're out of luck.

Principal photography on the stage

For principal photography in the stage, the main unit had ALEXA LF cameras. They didn't have genlock either, so we just went high frequency on the whole screen at 120 Hertz. Very early on, we explained that you're not going to be able to shoot high speed. Don't expect to go 48 frames per second. And so, we never had any frequency problems, and we tested everything for frequency at our facility and the curve of the wall and the color shift of the angles. We did extensive testing for three or four months before the show started.

Pixel math

To figure out the resolution math, we have five URSA Mini Pro 12K. That's 5 x 12K = 60K. But the LED wall is not 20K. Remember that we are overshooting the backgrounds, so we might lose about 20K in the overlaps of the cameras. The first image that we

put together is going to be 40K. That has to look really good at 40K. But we're going to down-res it to 20K for the wall.

When we do the math on a 165-foot wide screen, it's going to be 20K horizontal. And then you ask how many 8K feeds will it take to create a 20K screen? With a 16:9 ratio, if you take an 8K single panel and you put four of them in a quadrant, four of them will create a 16K image. But the screen was longer than that. The screen was 20K. So we had to add two more 8K instances on one side of it. So you really are driving six synchronized 8K screens.

The background consists of about 2,500 panels, so that's about 800 panels per screen. Sweetwater did the installation on the wall and it was beautifully done, worked flawlessly. They assembled the background; but we know how to drive it. We know how to create the content so it plays back perfectly. We understand production, what kind of controls we're going to have on set. One of the problems with just hiring somebody who can build a big LED wall is they don't necessarily understand production.

DaVinci Resolve

Everything was fed and synchronized through six DaVinci Resolve Studios (post production software application) in real time. Not only do the cameras have to sync to the screen, they also

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have to sync to your DaVinci Resolves that are feeding them in real time. You have to be prepared on set for the DP to say, "Can you make the depth of field a little bit more shallow?" We have to do that on six simultaneous DaVincis.

So you do a master shot. Say it's a three minute take. Then you want to do pickups. The image has to update. You have to edit on set and jump into the timeline, say a minute and a half downstream, and all the machines have to do that. And when they get to the closeup, they may say, "Can we make the horizon rise and fall faster?" Or add clouds. We're doing visual effects through Fusion and the DaVinci Resolve live on set, editing and updating six DaVinci Resolves at once. It's a considerable challenge, but that's what you have to do to respond to creative requests on set.

Plan B and be pleasant.

You learn, having lived through a lot of productions, to always have a plan B. Your Plan A is going to have snags in it eventually. If nothing else, someone kicks out the power and all of a sudden your machines go down. It's happened. Both the scary but also the satisfying thing about virtual production is that it is live performance. Any mistake that you might make is going to be up on 165 foot wall in front of the crew. There's no place to hide.

It takes a unique production-tested group of people that can go in and be creative, be pleasant, not let the pressure show and make it into a really nice experience. Because Taika likes a really relaxed set. Music's playing, everybody's having a good time. They're doing comedy. They're doing great. And the last thing you want to do is the technical rocket scientists over on the side saying, "No, you can't do this." It has to be fluid and creative and fun. When people come over and say, "Wow, it feels like we're really on a ship. And can we do this? And can we try that?" Then you have a tool that is actually doing what it's intended to do as a production tool and not as science experiment. That tone that was set by HBO as well. We have a long history with HBO.

Productions have challenges either about budget or technical or timing. This was not so much of a budget challenge, as it was a technical and schedule challenge because Taika's schedule is extremely tight. The concern on the executive level was really about not wasting a single minute of his time. At one point, he was

finishing another picture during the week. So we had to shoot on the weekends for 12 weeks. So, he's working seven days a week.

Meanwhile, back on the boat in Puerto Rico

The dependability of your hardware is your lifeline, both in Puerto Rico and on set. Everything has to be production-proven and backed up, and you have to have an alternate plan and you have to have extras and spares and all that stuff that you need. And we're a very small crew of only four or five people.

For example, to change aperture, the AC doesn't climb up and change each lens. We wrote some very interesting software to control the cameras and the lenses. We're controlling the lenses and the functions of the camera through the Blackmagic Design ATEM Mini Extreme switcher. We can see all the cameras. You absolutely want to see that they are all recording. If you can't see them and you can't check them, that's a problem. You can switch from one camera to the other. The ATEM was in a plastic bag with a power inverter because it's an AC system and you're on a boat and there is no AC. There's no generator. You're inverting from 12 volts to 120 inside a bag that's getting sprayed with about a 40 mile an hour wind hanging on to the side of a boat, bungie cording the thing onto the sticks. It's the real world. It's not in a lab. When the tools can live through a shoot like that, you say, "Okay, that's good." You have to have this very dependable, flexible hardware that is realistically affordable. Blackmagic hardware has amazing bang for the buck.

The array for the big wall in the studio had to be an extreme high pixel count. And one of the things that sold me on the Blackmagic 12K camera was being able to put 4 Terabyte SSDs on top and record all day long through the USB-C port.

You're on a relatively small boat, up in the crows nest swinging around, trying to hang onto the cameras with sea spray and everything coming over you and the sun is going down and some of your crew members are immobilized, seasick. And you're thinking like, do I really want to just swap a 160 gigabyte card at that point? There's no way. Any single thing that allows you to streamline the data pipeline and still get that kind of resolution in a dependable and affordable package is what we need. And the Blackmagic RAW is very efficient.

I have to say that for anybody who has shot with multiple cameras, who's got the checkbook for $500,000 in cameras on a small boat with salt water spray everywhere. I would love to do that. But is there any producer ready to risk that kind of money? We all have limited budgets. I love to shoot with the expensive cameras; they are brilliant. But when I'm putting five or nine of them together shooting for virtual production, you really need to have a lot of cameras to pull it off and they have to be dependable, affordable. The data has to be great. And when it's all said and done, you have to have a beautiful image at the end of the day. And the URSA Mini Pro 12Ks did that for us beautifully on "Our Flag Means Death."

The plates had to be shot from about 20 to 30 feet high. That's how high a pirate ship is. So we put the cameras on a flying bridge of our fast fishing boat. But the thing that you forget about it is even though the camera may be steady, you are getting hurled around. It's a pretty wild ride up there while you're, by the way, trying to change lenses.