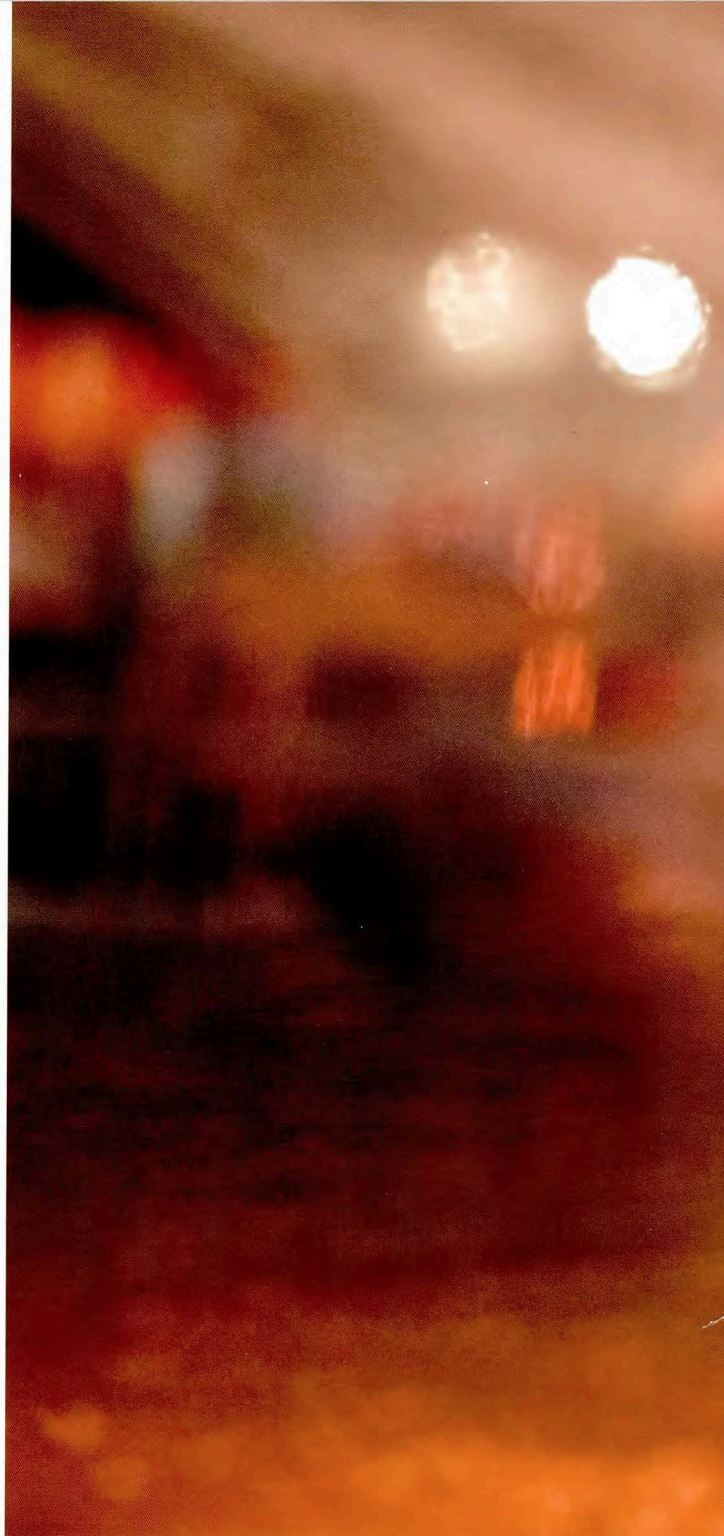


RoboDog

BY JODY DUNCAN

Oliver Daly was making his living as a freelance animator, primarily for the healthcare industry, when he suddenly had a vision of a robotic dog confronting dirt-biking adolescents in the desert. Intrigued, he began traveling the 70-plus miles from Los Angeles to the Inland Empire to attend motocross events, meeting the participants and listening to their stories. "I was amazed to discover this incredible community and youth culture that revolved around riding dirt bikes in these vast spaces," said Daly. "I thought it would be a beautiful way to do a science fiction story, to set it in this real world that was also very fast, very neon, with these bikes flying through the air."



While immersing himself in the motocross world, Daly also wrote down story ideas as they came to him, and created one iteration after another of the Artificial Intelligence dog — ultimately named A.X.L. for ‘Attack, Exploration and Logistics.’ “As I put things together,” Daly said, “I started to see that the best way to get this movie made was with a proof-of-concept short. So we raised money on Kickstarter, and I shot three days out in the desert in the Inland Empire.” The seven-minute short, *Miles*, told the story of the relationship between a young, awkward dirt-biker (Robby Rasmussen) and a robotic dog that has been built as a secret military weapon.

With neither time nor money in abundant supply for the short, Daly narrowed visual effects shots down to only 22, created by freelance artists around the globe. “I worked remotely with visual effects lead Kay Poprawe and modeler Sven Klimm in Germany,” said Daly, “as well as dust effects lead Ahmed Saady Mansy in Iraq, and head of animation Delano Althais in the U.S. They all worked in their spare time, and finished the shots in six months.” Territory Studio also came onto the project, generating shots of the robot dog’s POV.

The short led to a greenlight for the feature-length *A.X.L.*, a Lakeshore Entertainment, Phantom Four Films and Global Road Entertainment production starring Alex Neustaedter as Miles. To expand his original concept to full-feature length, Daly began a yearlong process of writing and refining a screenplay. “I’d had one story in mind initially,” Daly recalled, “but in the process of making the short, that story came into much sharper focus. I saw what worked and what didn’t, what was filmable and what wasn’t, and all of that informed the feature. I also fleshed out A.X.L.’s character, giving him more of a range of emotions and moods. He could be very threatening, but also vulnerable and funny.”

The more three-dimensional A.X.L. characterization had significant impact on the dog robot’s design, first conceived by Daly and Fausto Martini for the short. Boasting a long history of creature and robotic effects, Legacy Effects came on board the feature production, refining the design in digital sculpts and then creating a practical A.X.L. puppet that would be used on set. “I knew that to make this movie for the budget we’d need to do about half the A.X.L. shots practically,” said Daly, “leaving our visual effects budget reserved for shots that couldn’t be done practically.”

Legacy Effects supervisor John Rosengrant assured Daly and the film’s producers that a practical A.X.L. was viable. “We told them about the experience we’d had on *Real Steel*, which had very successfully combined practical and CG,” Rosengrant said. “Then we met

with Oliver to work on the A.X.L. design. Fortunately, Oliver is well-versed in CG, so he knew the language of ZBrush and Maya, of creating characters in the 3D world. I paired him up with our designer, Scott Patton, and they started with Fausto Martini’s model, and then made changes to make it a little more dog-like, and a little less mechanical. We looked at German Shepherds and Mastiffs as reference, but also brought in features of a military machine. Scott did that model in ZBrush, working and reworking it with Oliver.” To determine A.X.L.’s final size, the designers built the ZBrush model around a scan of Dorian Kingi, the suit performer who would be inside the robot dog puppet.

Once Daly, Rosengrant and Patton had an approved design, Legacy Effects rapid-prototyped A.X.L.’s parts, molded them, and cast them in durable, lightweight urethane — the same flexible material the team had developed for its Iron Man suits. “After we molded it,” said Rosengrant, “we reassembled all the master molds, cleaned up the whole thing, and did a test paint job on it, with Oliver’s guidance. In the end, the blacks and silvers created patterns that were similar to a dog’s markings.”

Though it had no moving parts, the prototype served to give Daly and his crews a sense of what A.X.L.’s physical presence on the set would be, how big it would be in relationship to the actors, and how its paint job and textures would look in various lighting situations. The prototype was even used as an exhibit at early publicity events for the movie. “Most importantly, though,” Rosengrant commented, “this thing was our bible as to how to get all of the pieces of A.X.L. back together. When you take something like that apart, you need to make sure it goes back together properly, with all the right lines and everything — and there’s no model kit instructions to tell you how to assemble it.”

Assembly was no small matter, as the A.X.L. puppet would have upwards of 150 individual pieces, mandated by the character’s many points of articulation. Legacy Effects’ key artist Mike Manzel and key technician Seth Hays led the build and mechanization of the puppet. “To build the final A.X.L.,” explained Manzel, “we started with the grown pieces, and then replaced some of those with fabricated ones made of metal or aluminum. A huge part of the job was making all those hard-shell parts work together. If you look at Transformers, they have hard plates that seamlessly move over one another, and they can do that because they are in the CG world. We had to figure out how these plates could move in the *real* world. We tried a lot of different things, putting magnets and springs and elastic on the back of them — there was a lot of testing and crashing. We could





Filmmaker Oliver Daly delved into the subculture of motocross racing in his feature film about an awkward youth forming a relationship with a top-secret piece of military hardware—a robotic dog named A.X.L., for ‘Attack, Exploration and Logistics.’ Under the supervision of John Rosengrant, Legacy Effects built a full-size practical puppet that enabled the filmmakers to capture 50 percent of the A.X.L. shots in camera. Method Studios took the lead in animating A.X.L. for action sequences that couldn’t be shot practically—such as an early scene in which A.X.L. and Miles (Alex Neustaedter), on a dirt bike, race through a motocross obstacle course.

have spent more time up front, figuring out all of that in the computer, but there is something to be said for working it out on the floor, with your hands on the physical thing.”

Seth Hays built a spring-loaded mechanism into the neck and spine of the puppet, which served to make the head more or less neutrally buoyant, and thus relieved strain on Mike Manzel, who would rod-operate the head from above the puppet, lying on a pettibone. “It was a diving board, basically,” said Manzel, “attached to a long-armed forklift, so it moved me way out and suspended me above the dog. I would be completely out of frame, with the exception of one rod that went up to me.”

“It was a very direct way of getting a performance out of the head,” commented John Rosengrant. “Mike was right there, looking at the actors in the scene and reacting to what they were doing. It would have been an expensive thing to do all of that radio control. We’re getting some radio-controlled servos now that are super strong, but at the time, there wasn’t anything that could have fluidly moved that head, within the budget we had. Having Mike directly connected to the head by way of the rod was a great way to go.”

“There was a subtlety that Mike was able to bring to

the character by operating the head directly,” added Seth Hays. “It’s a robot, yes, but it also has to be this boy’s best friend—and Mike was able to create that connection in a way you wouldn’t get with radio control.”

The final A.X.L. head could move up, down, extreme left and right, and tilt left and right. While Manzel puppeteered the gross movement of the head, Hays operated the jaw and ears via radio control. “The ears gave him a lot of emotion,” said Hays, “just by moving up and down, or turning. The jaw was basically open and close.”

John Rosengrant radio-controlled the puppet’s eyes and also communicated with Oliver Daly to oversee the overall puppet performance. “I was always observing the scene,” Rosengrant said, “whether through a monitor or live.” Rosengrant also controlled the color of the puppet’s eyes, which changed depending upon A.X.L.’s mood—red for attack mode, and blue when he was calm or playful. There were also LED lights all along the puppet’s body, illuminating the robot’s inner workings, particularly in the movie’s night scenes.

Overall body language was provided by performer Dorian Kingi inside the puppet. “Dorian was on all fours inside this thing,” said Rosengrant, “his arms inside the dog’s arms, and his legs hanging out the back. His torso was supported by a sling inside, which helped to hold him up. It was very quick—he could get into it in



Miles introduces A.X.L. to his friend Sara (Becky G). Cutting Edge joined Method Studios in delivering the film's visual effects, which – in addition to animating the digital A.X.L. – consisted of removing rods connected to the practical puppet, adding subtle facial expressions, and extending or re-creating live-action settings. Production visual effects supervisor James McQuaide ensured that every location was heavily covered with lidar surveys and lighting reference to aid visual effects in creating smooth transitions from the practical to the animated A.X.L.

less than ten minutes. Once inside, Dorian could shift his weight or move the thing bodily forward – and that subtle shifting of weight or moving a paw forward really made the front end of it come alive. It was very organic, simple and direct motion.” A series of springs and bungees along the back of the puppet connected to a parallelogram arm, taking most of the weight of the puppet off Kingi – a key concern since the performer could be inside for as long as two hours at a time.

In some cases, crews shot the puppet without Kingi. “Sometimes it was just easier not to have Dorian in there,” Rosengrant commented. “If A.X.L. had to lay down, for example, Dorian would come out of it and we’d put a form in there to take up the hollow space.”

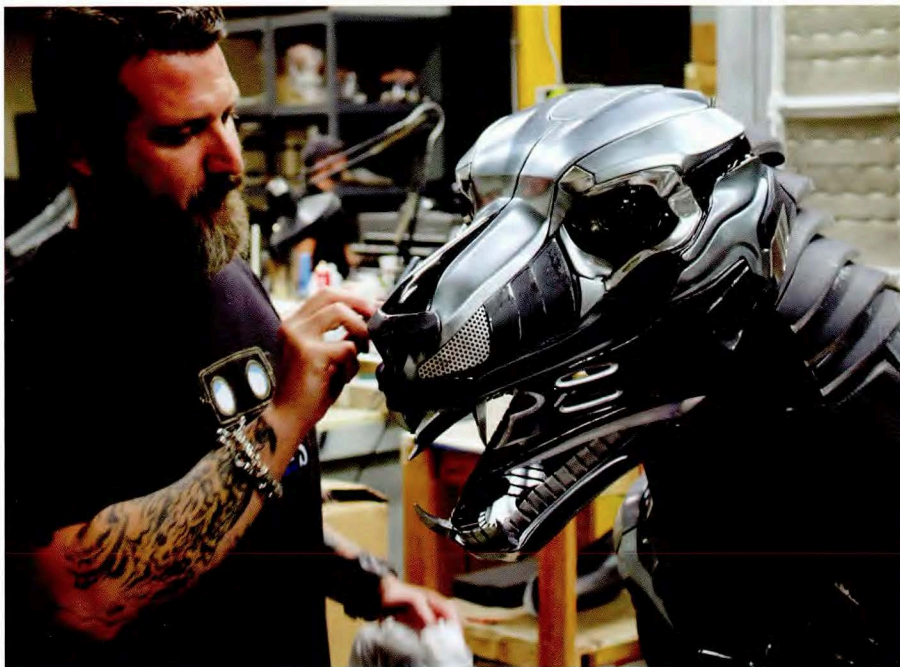
Coordination between Kingi and the three outside puppeteers was worked out in a series of rehearsals at Legacy Effects and at nearby locations. “It really was a dance between the four of us,” said Seth Hays, “all of us working together to create the performance. After the first week, we were pretty much in sync.”

“We’d all worked together so often on other projects, we were used to that collaboration,” Mike Manzel added. “Puppeteering is a matter of reading the moment and putting life into your character. There is improv that happens all the time, and you have to be on your toes to act against the other characters in the scene.”

After a three- to four-month build, the A.X.L. puppet was put through a trial run at a southern California rock quarry. Though the puppet performed without a hitch, shots from that test revealed that A.X.L. came across as a bit too friendly, without the requisite aggressive edge of a military machine. “The budget was really tight,” noted John Rosengrant, “so we couldn’t do a whole rebuild of this thing. I suggested to Oliver that we design some applique pieces that could go on top of what was already there; and to his credit, Oliver designed up some pieces in a very clever way. He sculpted these pieces in 3D, himself, and then we took those and made them watertight and made sure they fit onto the head exactly. They made the head look more aggressive, and I think it was a good call. A.X.L. looked great, and he could still deliver softness when he needed to, just through his performance.”

Legacy Effects’ A.X.L. puppet was used virtually every day of the show’s 40-day shoot in Santa Clarita, Simi Valley and Camarillo, and ultimately provided more than half of the movie’s A.X.L. shots, particularly those featuring close interactions with Miles and other human characters. “There is a lot of interaction between the characters and A.X.L.,” said Rosengrant, “which was very important to this story. You can’t have a boy and his dog story if there’s no dog there! It would have made

Once Oliver Daly approved Legacy Effects’ A.X.L. design, the team rapidly prototyped parts, molded them, and cast them in durable, lightweight urethane – the same flexible material Legacy had developed for its Iron Man suits. Technicians then reassembled master molds for the purpose of creating a test paint job, with significant input from Daly. The paint scheme featured black and silver areas reminiscent of a real dog’s markings. Legacy Effects painter Jamie Grove touches up the A.X.L. puppet. / More than 150 individual parts were required to accommodate the puppet’s many points of articulation.



the actors' jobs really tough to play against nothing. Alex Neustaedter was terrific in that he really embraced it and enjoyed working with the robot, and there was a genuine camaraderie that built up between A.X.L. and him. We were able to create a spontaneous performance between us and Alex because as we were puppeteering, we were all reacting to what Alex was doing; and he was reacting to our reaction.

"Oliver also loved working with our A.X.L., and his enthusiasm for it was infectious. He wasn't going, 'Okay, bring in the animatronic — if we *have* to.' He really loved it. You can tell when a practical effect is an afterthought and when it is truly part of the process; and Oliver was a big fan and supporter of ours through the whole thing."

"The practical dog was really the soul of the production," affirmed Oliver Daly. "To see A.X.L. develop from the design into 3D-printed parts into the final amazing creature — that kept me and everybody else excited about the project. I remember taking the crew over to Legacy, and even before they had everything working and moving, there was a feeling we got from the A.X.L. puppet that wouldn't have been there if we'd just been dealing with a rough placeholder of some kind. I don't know that we all would have been on the same page, or if we all would have had the same groundedness. That was true for everybody — wardrobe and the camera department. Everybody used that puppet as a jumping off point. And of course, it was a huge factor in the kind of intimacy we got between A.X.L. and the characters."

As successful as the puppet was, everyone had known from the outset that A.X.L. would be a computer animated character in a large number of shots; and so, visual effects supervisor James McQuaide made it his first order of business to determine just how many such CG shots could be delivered for the film's modest budget. "We had to stay within that budget," said McQuaide, "but we also wanted to deliver some ambition to the screen. There were three or four major set pieces that we knew would have a lot of the CG dog in them. Any time the dog had to move in a serious way, we had to go into CG world."

Among McQuaide's primary tasks on set was to facilitate transitions from the practical to the computer animated A.X.L., thus ensuring a cohesive performance on screen. "We had to think about how those transitions from the practical to the CG would happen," said Oliver Daly, "and so, we covered our bases and shot empty plates of everything, in case we had a complicated hand-off. When we were dealing with the puppet on set, we always made sure that the rods weren't passing over the actors' faces or anything that would make them more difficult to remove. And if the A.X.L. animatronic wasn't



in the frame in a particular shot, we ensured that we had space for him and that we were getting the right reactions from the actors.”

Crews walked a Legacy-built A.X.L. head on a stick through every scene for lighting and scale reference, and did lidar surveys of every location to provide visual effects with material necessary to re-create settings, as needed. “Because of the modest budget,” said James McQuaide, “we had to do a very good job of all of this data wrangling. We had to have a precise representation of what had happened on location — because that was the only reference that the visual effects vendors were going to have to execute their shots.”

McQuaide set up A.X.L. animation and other visual effects work in Australia, working with Method Studios (formerly Iloura) and Cutting Edge, with Method taking the lead, animating key scenes such as the first meeting between Miles and A.X.L., a frolic through an obstacle course, a party in the desert, the escape from a military base, and the characters’ final parting. Cutting Edge delivered A.X.L. animation for a scene in which A.X.L. greets Miles’ friend, Sara (Becky G), and scenes set at Craine Systems, the maker of the A.I. military machine.

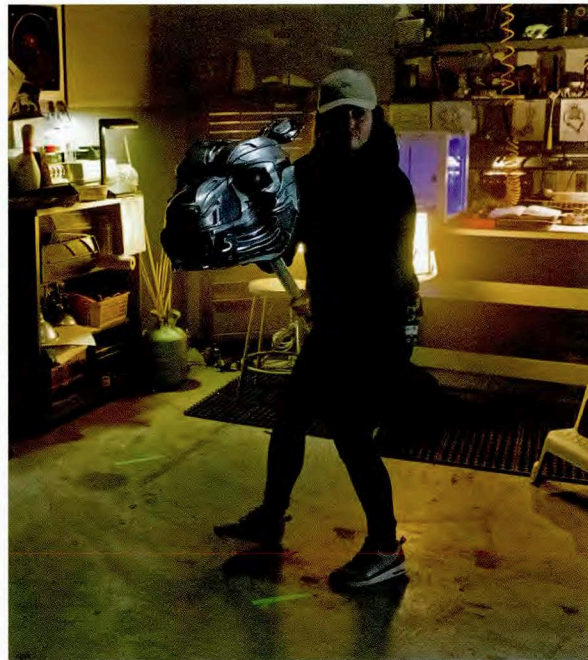
Both Method and Cutting Edge extrapolated from the

puppet performance to create their final A.X.L. animation. “Our computer animated A.X.L. had to look like the same character as the puppet,” said McQuaide. “We were in the CG world and could have done anything; but we had to adhere to the limitations they’d had with the practical, and then segue into a freer performance — but in a way that wasn’t jarring. So we’d do a shot that wasn’t too far off from the practical, and then the shot after that might be a little freer. Over a series of shots we’d get away from the practical so that there wasn’t a sudden leap from the practical to the CG A.X.L.”

Animators also had to find the sweet spot between robotic and dog like movement in the A.X.L. animation. “A lot of what we were trying to do in CG was to create the idea of a large silver dog,” said McQuaide, “with dog qualities and behaviors. It jumps up and down like a dog, and there’s a scene where it chews on an exhaust pipe as if it is a bone. Oliver’s aesthetic was to push it to something that had the heart and soul of a dog, even though it was this big metallic thing. We looked into the state of robotic animals, and it is remarkable what is available even now. So A.X.L. isn’t that fantastical, and because of that we felt confident in giving it characteristics of a dog.

“The trick was to get beyond its vaguely scary appearance, which we did by making it somewhat clumsy.

To inform A.X.L. animation at Cutting Edge, visual effects supervisor Rangi Sutton oversaw motion capture sessions with a greyhound dog, whose lithe form clearly revealed underlying skeletal structures and musculature. The resulting mocap data was then mapped into the CG A.X.L. and proved invaluable in animating canine actions such as running and jumping. / On the set, Legacy Effects key artist Mike Manzel — who led the A.X.L. puppet build with key technician Seth Hays — operated the head from above, lying on a pettibone that was out of frame, leaving only a single rod to be removed by visual effects.



A.X.L.'s overall body language was provided by performer Dorian Kingi inside the puppet, his arms fitted into the dog's two front legs, and his legs hanging out the open back. The performer's torso was supported by an interior sling. A series of springs and bungees along the back, connected to a parallelogram arm, took most of the weight of the puppet off of Kingi, who infused life into the character simply by shifting his weight or reaching forward with a paw. / An A.X.L. head-on-a-stick was walked through every scene to provide the visual effects department with reference for scale and lighting.

Oliver's idea was that it would be like a puppy, with all the energy of a puppy but also the lack of coordination. Over the course of the picture, he becomes more coordinated and less of a puppy — and the animation had to reflect that. By the end, he's a much more mature and stable character than he is when we first meet him."

To build its CG A.X.L. model, Method started with digital files from Legacy Effects. "That was helpful," said Method visual effects supervisor Joshua Simmonds, "but the Legacy CAD model required quite a bit of rebuilding in order to make it production-ready. At the same time, we had to maintain the look of the scan model and puppet in our A.X.L., especially around the head and shoulders."

The rigging of the model was designed to facilitate the animation of A.X.L.'s dog-like behaviors, with joints that corresponded, more or less, to those of a real dog. "A lot of the joints looked really cool in the static puppet," said Simmonds, "but once it was running at full stride, we had to make sure that the hips and shoulders and legs all moved a bit more loosely, and more like what you would see in a dog. So there were quite a number of design issues that we worked out at our end.

"This project was something of a dream come true for our riggers because there were so many fine little

details. Just to move the leg forward or to lift the shoulder required a lot of internal workings, pistons and servos. I think the riggers took about three times as long as we'd budgeted for because they became somewhat lost in their world!"

In early scenes, Method Studios' animation emphasized A.X.L.'s robotic qualities, and was comprised of machine-like, jerking movements. "Oliver and James didn't want the audience to connect with A.X.L. too early," commented Simmonds, "because, in the beginning, he is still a fierce military robot. But as the movie goes on, and A.X.L. forms a close bond with Miles and his teenage friends, he becomes more and more dog-like — and even puppy-like in some scenes. When we got to those later behaviors, we referenced real dogs for the animation. The important thing was that A.X.L.'s transition from robot to dog happen incrementally through the movie. That was a clear direction from both Oliver and James — they wanted to see A.X.L.'s personality unfold as the movie progressed, and they encouraged us to really go for dog-like behaviors later in the movie."

A.X.L.'s textures, too, evolve as the story progresses, reflecting the tumbles, falls and damage inflicted on him in the course of the story. "There were variations of A.X.L. depending on how dirty or damaged he was," said Simmonds, "and we had to set up our asset to

accommodate those kinds of textural changes. For example, in the early sequence where Miles and A.X.L. first encounter each other, A.X.L. chases after Miles on his dirt bike, and then takes a tumble down a hill. He had to wind up with a lot of dust on him after that tumble; but we were also intercutting with the live-action puppet, and so we had to match the level of dust they'd had on that." Method also had to match the dust kicked up by Miles' dirt bike in the scene. "It was good to have that reference, but, in some respects, that made it more difficult for us. Miles' dirt bike and A.X.L. were in the same shot, so we had to do a very good one-to-one match between the dust being kicked up by the dirt bike and the dust kicked up when A.X.L. takes his tumble. We did all the dust as Houdini simulations." A.X.L.'s tumble down the hill was also one of the more difficult animations due to the need to create appropriately out-of-control, 'floppy' limbs on a CG robot. "Turning a giant metal robot into a rag doll was fraught with challenges. We had to make sure the rig was loose enough to accommodate the action — but not so loose that A.X.L. looked like a bobble-head doll."

Later, as fast friends, A.X.L. and Miles engage in a frolic, maneuvering through the obstacle course of a motocross track — Miles on his bike, A.X.L. on his robotic limbs. "This was the most fun sequence in the film for us," said Simmonds, "because the animators had the opportunity to create an almost Fred-and-Ginger dance routine with the two characters running through this obstacle course. They are somewhat in sync, and so we had to match what the stunt rider had done on the dirt bike to some degree. There were shots where they were both leaping over something in sync, but there were other shots where they were crossing over and under each other. They'd done a pretty decent job blocking all of this out in postvis, but we refined and tightened up the choreography."

The lighting on A.X.L., rather than the character's animation, was the main issue in a nighttime party scene set in the desert, especially since some of it had been shot with a small Canon Rebel camera to suggest the partygoers were filming the rave. A.X.L. often appears in the background of the 'selfie' footage, sometimes as nothing more than a silhouette. Throughout, the scene is illuminated by firelight. "We had to put in all the appropriate cues to get a nice sense of modeling of A.X.L. through that scene," Simmonds said, "making good use of rim lights and the reflective qualities of his chrome."

In the film's third act, Miles helps A.X.L. to escape the Craine Systems facility, where he has fallen under the control of Andric (Dominic Rains). Running from the laboratory, the two fall down a cliff and wind up in the

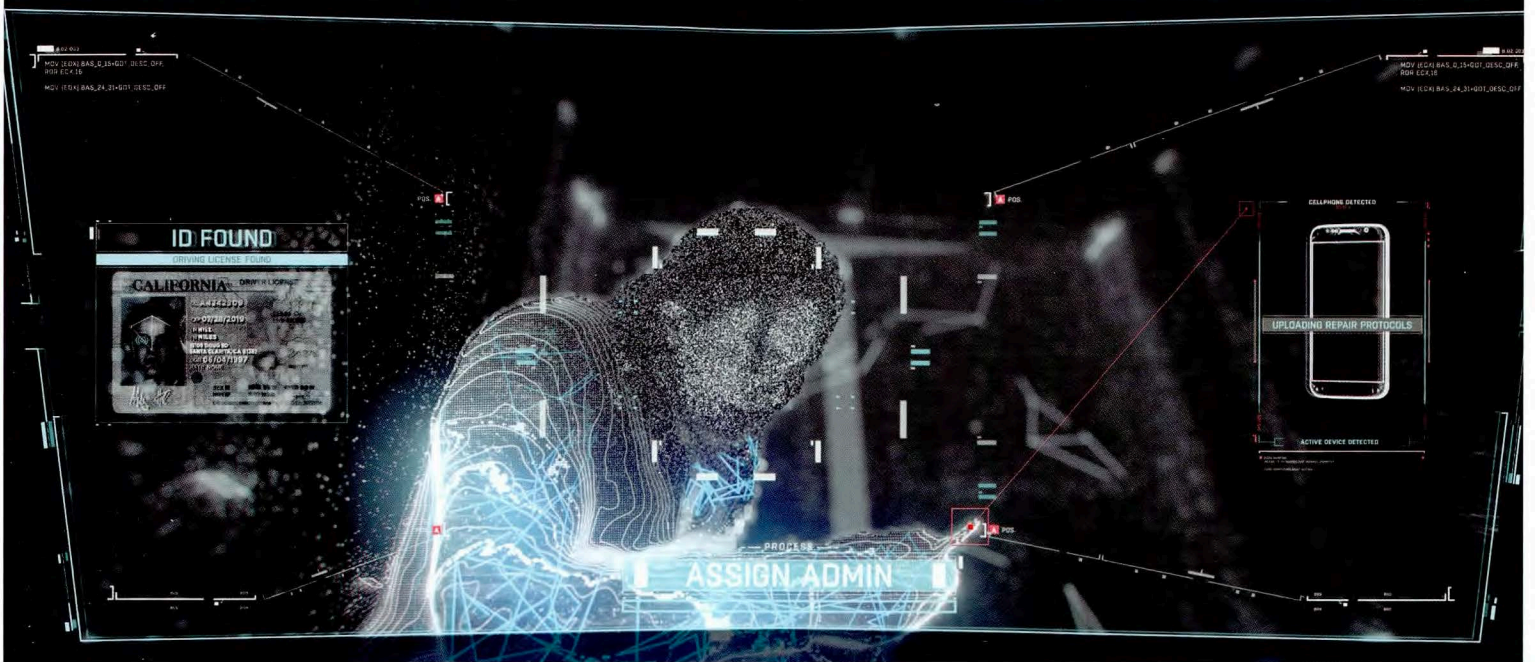
desert below, both suffering injuries. They are then set upon by tiny drones, which are engaged to debilitate A.X.L. with small electric charges. "That was a fairly interesting animation exercise," stated Simmonds. "A.X.L. is crossing the desert, running with a high degree of intensity; and then suddenly he is stopped by these electric charges. The trick was to integrate that action and the electrical charges into the scene without its becoming comical, which it could have easily done."

At movie's end, Miles and A.X.L. part ways in a tender scene that featured many closeups employing the A.X.L. puppet. Method enhanced the puppet's facial expressions, especially around the eyes, but still underplayed A.X.L.'s performance. "We only had a handful of controls available to us around the eyes," Simmonds noted, "but we tried to use them in a subtle way, and in the end it came across fairly well." Method executed similar puppet enhancements throughout the film. "In addition to enhancing the eyes, as we did in this final scene, there were some shots early on where in order to make A.X.L. look more aggressive we added more mechanics and gears whirring around — which is the kind of thing that was difficult to get into the puppet. But mostly we did eye replacements across the film because the eyes in the puppet didn't have the degree of expression that Oliver was looking for. Even though it is a robot made of metal and the like, the task was still to give it life and a personality — that's the same no matter what type of creature work you are doing."

The goal was the same at Cutting Edge, where artists reworked Method's models and texture maps to accommodate the company's Houdini pipeline, and then applied them to its own A.X.L. rig. As at Method, Cutting Edge's animation of A.X.L. was somewhat defined by the performance of the puppet on set. "The puppet set the parameters," said Cutting Edge visual effects supervisor Rangi Sutton. "Up to the point where the dog actually walks or runs, the movements and mechanisms were defined by the puppet. There were limitations that the puppet had that our CG A.X.L. didn't, of course, but we referenced the puppet frequently. At the same time, we had to make sure that our A.X.L. matched Method's A.X.L."

To inform the animation, Cutting Edge had conducted motion capture on a greyhound dog, whose lithe form clearly revealed its bone structure and musculature. "We intended to use the mocap as a motion test," said Sutton, "but also as a viability test to see if we could actually motion capture shots for the show. In the end, we concluded that because A.X.L. is acting in such a subtle way and the feedback was so refined, going with motion capture wasn't going to be an efficient way to do this

Key to the A.X.L. character was his high-tech 'A.X.L.-vision,' seen in numerous POV shots. To provide material for the POVs, volumetric capture supervisor Andrew Gant used Scatter's Depthkit to do extensive volumetric capture of characters and props against greenscreen. Gant's setup included a reconfigured X-Box Kinect — previously reworked as a depth sensor by Scatter personnel — a camera mounted on top, and a computer that ran the Depthkit program. Raw volumetric capture material was handed off to Territory Studio, which cleaned it up and added effects and graphics.





show. However, this mocap gave us a 3D-captured model of the dog, so we could look at how it behaved and what made it feel and look like a dog, because it was a dog, mapped into a robot dog. We ended up with a sample of seven or eight clips from our motion capture session — dog running, jumping, chasing, all sorts of dog behaviors — and that was all mapped into our robot. It was incredibly useful.”

Cutting Edge staff also brought in their own dogs so crews could film them acting out various behaviors. “One of the things we took from that was that dogs are very light on their feet,” said Sutton. “They jump around, and leap and hop; but of course our dog is hundreds of kilos of robot — so how do we get that light-footedness into our robot and still make it feel weighty? Having A.X.L. spin around on his hind legs, pouncing and skidding, was a big challenge.”

Cutting Edge delivered A.X.L. animation for a scene in which the robot goes into guard dog mode, jumping up and becoming aggressive with Miles’ friend Sara. “That was one of the trickier pieces of animation,” said Sutton, “just the way he turned on his tail and bolted off after her. In this sequence, A.X.L. is only just recently out in the open world, and so he has an aggressive and protective behavior that we wanted to get across — but

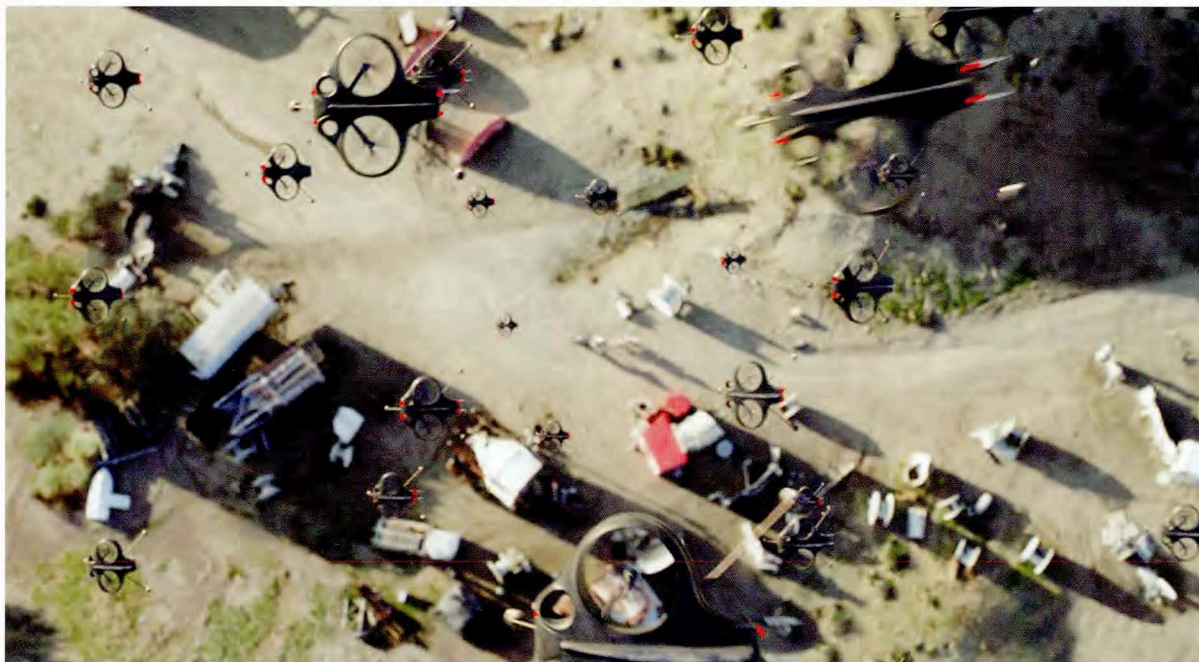
we always had to keep in mind that Oliver wanted the audience to like this dog. So we had to maintain a balance there. He couldn’t come across as a nasty Rottweiler, but rather, like a good dog being protective of someone. We were always walking that line.

“We also had to work to the puppet in that sequence. There were shots of the puppet spinning and gnashing its teeth and so forth, and to some extent, we were locked to that.”

Later in the movie, Miles takes a damaged A.X.L. to the Craine Systems 3-D printing lab, his intention to grow new parts so that he can make repairs on his newfound friend. “That’s all done off-screen,” said Sutton. “Where we come in is when A.X.L. is going through his reboot cycle, and the antagonists arrive with their rifles to take him away. Then there is a fight scene where he becomes super-aggressive A.X.L. Again, we had to match to the puppet, and the lighting had to be perfect because we were going from a shot of the puppet to our CG shot, back to back. We did some augmentation to his eyes as he comes out of sleep mode, just to make them more expressive. We did some small animations inside his eyes and gave him very slight eyebrows.” The villains shoot A.X.L. with electrical-current bullets designed to shut him down. “When he gets hits with these bullets, we had to run this arcing electrical effect across

Now protective of Miles and his friends, A.X.L. attacks a bully outside a desert compound. Artists at Method Studios animated the A.X.L. attack, extrapolating from the puppet performance as established on set. To avoid obvious and jarring differences between the puppet and animated A.X.L.s, Method animators moved incrementally, through a series of shots, from a somewhat constrained A.X.L. performance to freer, more dynamic animation. A.X.L. became less robotic and more dog-like in his behavior as the story progressed.

Working under the guidance of visual effects supervisor Joshua Simmonds, Method Studios delivered a third-act sequence in which drones launched by Craine Systems – the manufacturer of the robotic military dog – hunt down A.X.L. in the desert. Method started with a plate shot by drone on location, then extended the camera so that approximately 70 percent of the shot was a computer generated camera move. The art department provided a base drone design, which Method then modified to include a taser-like attachment used to stun A.X.L. later in the film.



him and animate him being knocked back, and then recovering – so it was quite an intense fight scene, with that effects layer on top of the animation.”

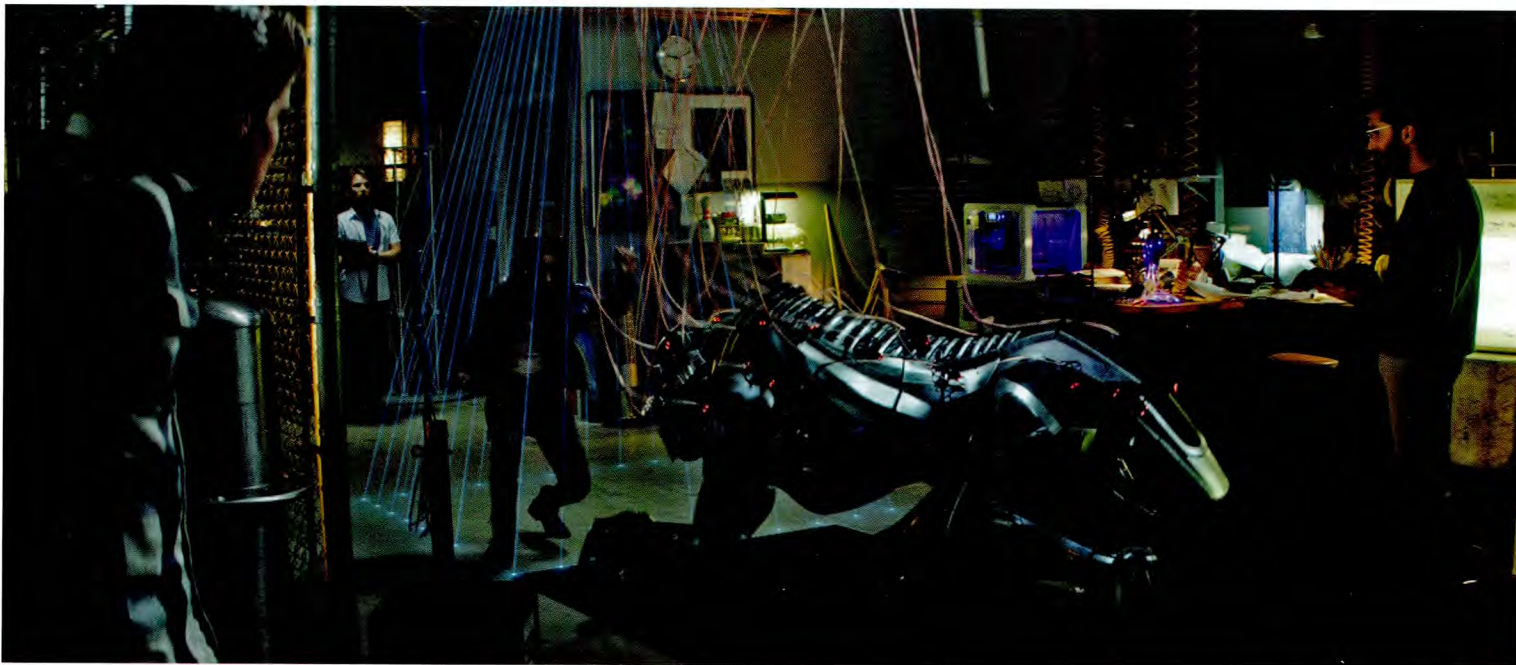
Drones wired to the ceiling of the lab attach themselves to A.X.L., overriding his natural responses and relegating him to computer-control by Andric. A.X.L.’s character had to come across as far more sinister than in previous sequences, indicating that he is under Andric’s control. “Before this,” said Sutton, “he’s either been acting in defense of himself or of Miles; but here, he’s a much more dangerous machine. That required a different style of animation, altogether.”

On set, crews had shot the puppet with a few practical drones attached to the body, the look of which Cutting Edge had to match in its shots. “Not only did we have to match all the lighting and the practical puppet in the scene,” said Sutton, “we also had to add these drones all across the body of A.X.L. Attaching the drones and all their dangling cables without them piercing through him was a challenge. The dog was made up of so many different pieces, to keep them from intersecting and popping through required robust Houdini simulations.” The drones on set, and in final animated shots, were attached to the ceiling of the lab on wires, requiring Cutting Edge’s effects team to develop a means by

which the drones could move with A.X.L. but without the wires tangling overhead. “To do that, we built a cable-control system above him, off-screen. In a practical setup, you’d have grips moving an array on the ceiling to keep the wires from tangling up. We had to do the same thing virtually. Throughout this sequence, we had to make sure that the wires from the drones were all behaving naturally.”

Like Method, Cutting Edge also had some puppet enhancements in its slate of shots. In one scene, A.X.L. flips a can off of his nose, a dog trick that had been attempted with the puppet, but without 100 percent success. “We ended up reconstructing that and augmenting it until it worked,” Sutton said. “We also changed his eye color in some cases, from black to blue or red, indicating his mood. Sometimes that would change from what had been filmed with the puppet, just due to editorial decisions. Those were all small things that added up to A.X.L. being who he is.”

Another key element of the A.X.L. characterization was the robot’s ‘A.X.L.-vision’ – his high-tech POV of the people and environments around him. “The POVs are rougher at the beginning,” noted James McQuaide, “when A.X.L. is more of a puppy. As he matures, the POVs become more refined. Overall, they are unlike any POVs I’ve seen in a movie before.”



The unique quality of the A.X.L.-vision shots was the result of experiments that Oliver Daly and volumetric capture supervisor Andrew Gant had done during the making of the *Miles* short, using a hardware and software solution called the Depthkit. "I met Andrew through the internet," said Oliver Daly, "and he had a way of doing volumetric capture that I thought was very interesting. So we went out and played with that, and wound up using it for A.X.L.'s POVs in the movie."

"There are two ways you can do volumetric capture when using the Depthkit," Andrew Gant explained. "You can build a mobile rig and do it on set, or you can use it in a studio environment, which can be a bit easier. Originally, we wanted to shoot everything live on set, with all the actors; but due to weather and other constraints, we wound up shooting it all in studio, against greenscreen, for two days at the end of principal photography."

Gant's setup included an X-Box Kinect, which had been reworked as a depth sensor by Scatter in New York. "These wonderful people began by using an X-Box Kinect several years ago and turning it into the Depthkit," said Gant. "The Depthkit now consists of a depth sensor, camera and a computer. Theoretically, you can pair any 1080p+ camera in the world to it — an iPhone, an Arri Alexa, a RED or any high-end camera. To pair the camera and the depth sensor together, there

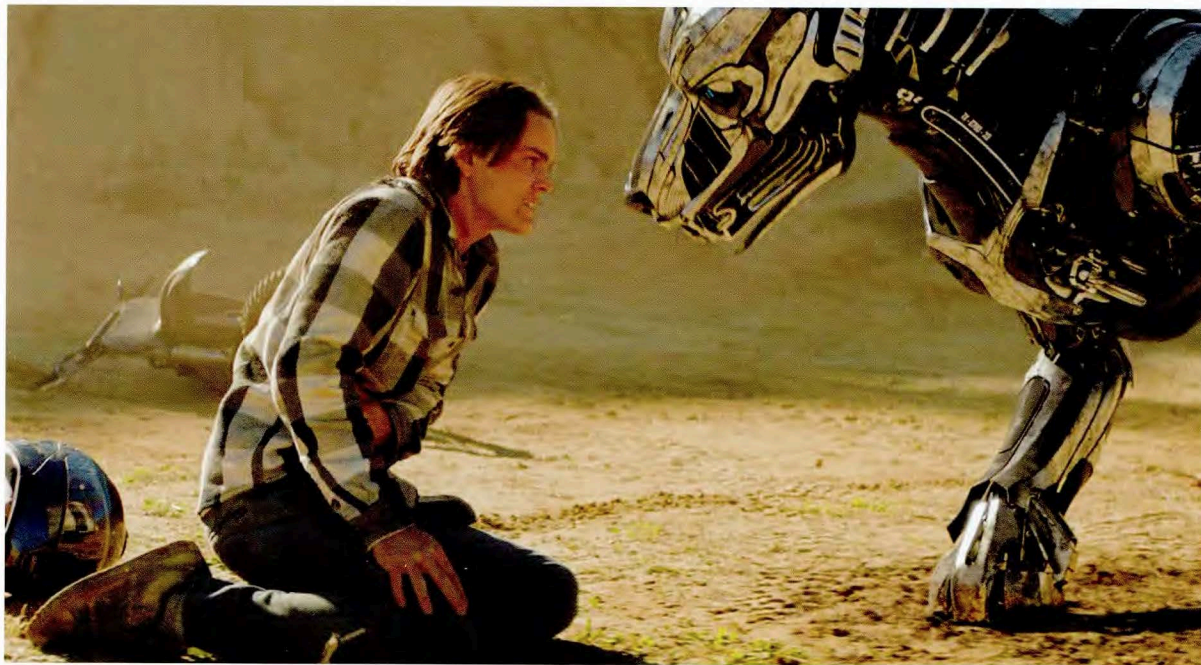
is a calibration stage where you use both a checkerboard and the Depthkit software. The software compares the two fields of view between both devices and syncs them together for filming/capturing. So on set we had a computer that attached to the depth sensor and ran the Depthkit program, and then we had the camera mounted on top of the depth sensor. A depth sensor, a camera and a computer are technically all you need to do this type of volumetric capture.

"One of the really cool things about it was that it was very much like the technology a robot like A.X.L. would really use — lidar and depth-sensing technologies. This was an organic way to shoot his vision, by actually using the technology that he would use if he was a real A.I. machine."

Using the Depthkit, Gant did volumetric capture of actors and props against greenscreen. "I was filming live," Gant explained, "and I could see the live view, in 3D, of what I was filming. And I was able to fly around, moving the digital camera around the actors to find the angles I wanted to capture." In addition to capturing the actors and prop pieces in studio, Gant captured a dirt bike that was mounted in place. "After I had captured the assets, I handed them off to Territory Studio, where they beautified the material, added effects and graphics, and brought it all to life."

Inside a Craine Systems lab, A.X.L. comes under the computer control of Andric (Dominic Rains). To sell the story point of A.X.L.'s natural responses being overridden by drones that are attached to his body and wired to the ceiling of the lab, Cutting Edge animators created an A.X.L. performance that was decidedly more sinister and aggressive than in previous scenes. Cutting Edge attached digital drones to the robot dog's body, matching the few practical drones used with the puppet on set, and ran Houdini simulations to create dangling cables that moved naturally through the sequence.

At movie's end, Miles and A.X.L. part ways in a tender scene that featured many closeups employing the A.X.L. puppet. Eyes, ears and jaw were all operated by radio control. Method Studios subtly enhanced the puppet's facial expressions, especially around the eyes, using a handful of animation controls. Method executed similar puppet enhancements throughout the film to create a more expressive performance, and also changed the color of the robot's LED-rigged eyes — which were illuminated blue or red, depending on his mood — for purposes of continuity.



Territory Studio had worked on the *Miles* short, creating A.X.L. POVs from Gant's volumetric capture material. "Going all the way back to that time," said Territory Studio visual effects supervisor Peter Eszenyi, "we had lengthy conversations with Oliver about how this robot dog might see the world, which might not necessarily be the way a human being sees the world. We were really keen on bringing in topological data, depth data, particles, curvature — all sorts of stuff that we thought was cool and would add to the look of this robot's vision of the world."

The aim, going into the feature film, was to push the POV effects further, using data that had been captured with an updated version of Depthkit, with higher resolution textures. "The technology was much better than it had been when we did the short," said Eszenyi, "but it still had a lot of rough edges and stray polygons and that type of thing. So we did quite extensive testing in Houdini. Effects artist Carl Fairweather built some tools that made it possible for us to get rid of the spikey edges and smooth out the polygons somewhat."

An anomaly that was purposely retained from the raw data were spikes that shot out from the capture subjects. "Because I was only using one sensor," explained Andrew Gant, "there was a point where it began to lose the body of the actor, for example, and that created a

beautiful effect. The sensor is searching for data but it's not there, so you get a bunch of jagged lines shooting off the sides of the body. That effect became a crucial part of the look of A.X.L.-vision."

"That was a happy accident, really," said Territory Studio creative director Andrew Popplestone, "a form of noise in the geometry that just happened to create a really cool look. We did some cleanup on it, and Carl came up with a way to reduce that to some degree; but we left most of that in because it looked so interesting."

Just as A.X.L.'s personality and behaviors evolve in the course of the story, so too does his POV. "A.X.L.'s A.I. changed and grew as he became more intelligent and less machine-like," said Popplestone. "The flexibility of our setup allowed us to play with that and show that his A.X.L.-vision had evolved. At the beginning of the film, when he's in his puppy mode, his vision is quite monochromatic, low-res and glitchy — it really just shows rudimentary outlines and forms. And so, initially, for these early shots, we had to hide a lot of the volumetric capture data. As the film progressed and the dog's vision evolved, we worked out ways of adding many, many more details, making it feel more advanced and organic, with more detail in what he's looking at."



Craine Systems drones attach themselves to A.X.L. and debilitate him with currents of electricity. Animators at Method Studios animated A.X.L.'s desperate run-for-his-life through the desert, and also animated the drones and integrated electrical charge effects generated in Houdini. Method artists added extensive dust and gravel interactions, also created in Houdini, and used lidar of the location to project a combination of matte painting and still photography for the background.

After ensuring that the captured characters looked good, Territory turned to backgrounds, building them from lidar data that had been captured on each of the film's sets and at every location. "To re-create those backgrounds," explained Territory Studio art director Nils Kloth, "we projected the textures back onto the meshes, which allowed us more freedom with the camera moves when we did those POV shots. We mixed the lidar data with extra modeled elements, as well. So the first part was making sure that the people looked good, and the second part was building the background using the lidar reference. If we had no data for a particular background, we rebuilt it from scratch."

Graphics attendant to the A.X.L.-vision were also generated by Territory Studio. "There was always a narrative that had to be explained in the graphics in A.X.L.'s POV," said Andrew Popplestone. "Those 2D graphics and text graphics helped to emphasize the story beats."

In the end, Territory Studio delivered 70-some A.X.L.-vision shots. "All the work we invested in the beginning really paid off in the final movie," said Peter Eszenyi. "From the short to the end of the feature, we had this quite long gestation period, and that was very useful for us. It gave us the time to experiment with different techniques and to work with Andrew Gant to make sure we used his capture data in the best possible fashion. Every-

one involved was very enthusiastic about this project, and really wanted to do it properly."

No one on the project was more enthusiastic than Oliver Daly, whose initial vision of a robotic creature within a motocross world fueled his creativity as a filmmaker for nearly five years. "I'm still a little bit in shock about the whole thing, to tell you the truth," said Daly just days before A.X.L.'s August 24 release. "But I'm humbled to have been able to work with these incredible professionals — John Rosengrant at Legacy Effects, and the teams at all the visual effects companies. These are some of the people who made movies I grew up with and loved, and working with them was a huge part of the great experience I had making this movie.

"Of course, as a director, you can drive yourself crazy thinking, 'I should have done this, I should have done that' — but I'm trying not to feed that demon. There is so much to be grateful for."

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