Restoring the Lion's Roar: Documenting and Replicating Limestone Structures Through Laser Scanning, 3D Computer Modeling, and CNC Machining

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In January 2011, Kreilick Conservation, LLC of Oreland, PA was engaged by Beaver Electric Co. Inc. to conserve the Branch Brook Park Prudential Lions. The Prudential Lions, sculpted by Karl Bitter (1867-1915), were installed over the doorway of the Prudential Insurance Company, Newark, New Jersey, in 1901. After the building was demolished, the Lions were installed in Branch Brook Park, Newark, New Jersey in 1959. In August 2011, after conservation work had begun on the sculptures, Kreilick Conservation was engaged by the Branch Brook Park Alliance to create full-scale replicas of the Lions. To complete the work, Kreilick Conservation put together a team of 3D documentation professionals, including Direct Dimensions, Inc., who undertook laser scanning and 3D computer modeling, and the Digital Atelier, LLC, who used the models for CNC machining foam.The Prudential Lions are carved limestone companion sculptures depicting seated male lions, each with a front paw resting on a sphere (see Figure 1). Each lion sat atop a concrete base. The bases originally had inscribed plaques which read, "Presented to the citizens of Essex County/by the Prudential Insurance Company of America/from 1892 to 1958, more

than half a century, this lion, with/its twin companion, sculpted by Karl Bitter, stood guard/over the doorway of the First Prudential Building in Newark/at 763 Broad Street, corner of Bank Street. They have witnessed/the growth of Newark from a town to a metropolis." The Lions are approximately seven feet tall and weigh 2,900 pounds each.

Before treatment, the limestone sculptures exhibited staining, biological growth, gypsum crusts, graffiti, mechanical damage, and erosion of details. In the last several years, a series of painting campaigns were undertaken to cover these conditions. After addressing the paint, surface soiling, and graffiti, the owners of the Lions were faced with the decision of how best to preserve the original statues for the future. This included questions about how to take advantage of their high visibility, and how to keep an accurate representation of their forms for the future. Several options were considered. Firstly, to do nothing beyond restoring and maintaining the originals. Secondly, to make molds off of the restored sculptures. Thirdly, to laser scan the sculptures and create digital models from which replicas and molds could be created.

Laser scanning and 3D modeling were eventually selected as the best option. In the past, these sculptures were subject to vandalism and wear and tear from park visitors. Some sort of documentation was desirable in anticipation of their continued use in a public space. Creating molds from the original statues would have had similar results to 3D modeling, however there were concerns about the storage and shelf life of large rubber molds, and the effect the mold-making process would have on the porous limestone and new repairs. In contrast, laser scanning could be done in a single day, in place, and without touching the stone surfaces. 3D modeling from the scans could provide a digital record accurate enough to negate the need for molds, while also giving the clients the opportunity to easily create replicas from various materials, at various sizes, for preservation and/or promotional purposes.

After restoring lost details on the Prudential Lions in clay, Direct Dimensions, Inc. came to the conservation studio to laser scan the statues. A Surphaser® 25HSX, a phase shift, hemispherical 3D scanner, was utilized (see Figure 2). This scanner has a 360° x 270° field-of-view and scan rate of up to 800,000 points per second. The scanner creates 3-dimensional electronic images that are accurate up to 2mm (.008″). This scanner collects point data to create polygonal computer models (STL files, see Figure 3). These files were edited by the Direct Dimensions technician to ensure accuracy and to fix any gaps in the data. Scanning the statues after clay repairs allowed work on the 3D and foam models to continue simultaneously with conservation work on the original statues, including Jahn mortar repairs, stone Dutchman, and consolidation. In contrast, mold-making would have had to have occurred either on the un-restored stone surfaces, meaning any replicas would not reflect the statues' restored appearances, or on newly patched and repaired stone surfaces, which would be vulnerable to damage during the mold-making process. After laser scanning, the finished STL files were given to the Digital Atelier in Mercerville, NJ. There a five-axis CNC (digitally automated via computer numerical control) machine was used to mill full-scale foam replicas in 6# urethane foam (see Figure 4). Kreilick Conservation worked with the Digital Atelier on the construction of the foam forms and the finishing of their surfaces (see Figure 5). These foam figures were then used by Metropole, Inc. to create molds for casting replicas (see Figure 6). In this way, new precast concrete statues were created without endangering the original limestone figures at any point in the process.

This project demonstrates a case in which 3D digital documentation provides the best and most appropriate option for a conservation project. The advantages for physical storage, long-term storage, relative ease of manipulation, accuracy, protection of original fabric, and protection of new repairs proved greater than those for more traditional methods of documentation, including 2-dimensional drawings, photographic documentation, and mold-making.

Transcript

Striegel: I would like to introduce Caitlin Smith, she received a Master's in Historic Preservation at the University of Pennsylvania, and undergraduate degrees in Historic Preservation and Political Science from the University of Mary Washington. Her graduate thesis was entitled Cleaning Methods for the Removal of Limewash and Painted Plaster Surface Utilizing Ion Exchange Resins on the Interior Architectural Finishes of the Capia de, I don't speak Spanish, I'm sorry, I'm not even going to attempt it. She has presented her work at the IIC 2010 Congress and at APT 2009. Caitlin.

Smith: Well good morning. So I'm Caitlin Smith. I work for Kreilick Conservation and my talk today is entitled, Restoring the Lion's Roar, Documenting and Replicating Limestone Sculptures Through Laser Scanning, 3-D Modeling, and C & C Machining. I'll go ahead and say right off the bat, I'm not the digital expert in this case, I'm the conservation professional, so I was the liaison between our client and the digital team that we put together. What you should get from this presentation is not that I'm going to wow you with our technical feats, but you'll get more of the process leading up to that, the discussions that we had with our client, what they needed and the tools we thought that would best achieve those goals.

So this presentation is a collaboration between Kreilick Conservation, Direct Dimensions, and the Digital Atelier, and I'm briefly going to touch on issues of data acquisition through 3-D scanning, data management issues such as storage, and data applications such as 3-D modeling and physical reconstruction. The authors of this presentation are myself, Scott Kreilick from Kreilick Conservation, Harry Abramson from Direct Dimensions, Glen Woodburn from Direct Dimensions and Jon Lash from the Digital Atelier. And I'll just point out that Jon Lash is here today as is Joe Nicoli from Direct Dimensions. So I hope you'll direct any real technical questions towards them later in the day.

So let me start out by introducing you to the Prudential lions. In 2011, Kreilick Conservation was engaged by Beaver Electric Company to conserve the Branch Brook Park lions. The Prudential lions were sculpted by Karl Bitter, who was a notable sculptor of the late nineteenth and early twentieth century's. He's the man with the amazing mustache above. He was born in Vienna, Austria and he emigrated to the U.S. in 1889. He worked on a number of notable public sculptures for major architects including Richard Morris Hunt and George B. Post. His private commissions are in a number of notable homes including those of the Vanderbilt's, the Astor's, and the Rockefeller's. Some of his most famous pieces you might be familiar with are the bronze gates of the Trinity Church in Manhattan, ornament for Hunt's Administration Building at the 1893 World's Columbian Exposition in Chicago, the decoration for post Wisconsin's capitol and the Pomona Fountain in front of New York's Plaza Hotel. He was Director of Sculpture at the Buffalo Pan American Exposition, the St. Louis World's Fair, the Panama Pacific Exposition and he was the President of the National Sculptures Society for a number of years.

Now the Prudential lions are not Karl Bitter's most famous works but in Newark they are beloved. The Prudential lions were originally installed over the doorway of the Prudential Insurance Company in Newark, New Jersey in 1901. They were inspired by the lion on the company's twenty year locket. They were meant to signify strength and being on guard.

After the building was demolished in 1959, the lions were reinstalled in Branch Brook Park in Newark. The quote you're seeing here comes from the plaque that was presented upon their installation and it notes that for more than half a century this lion with its companion, stood guard over the doorway of the first Prudential building. They have witnessed the growth of Newark from a town to a metropolis, and then for another fifty years, they sat in Branch Brook Park, where they soon became mascots for the park and importantly for us for the Park Alliance. Children played on them, vandals painted them. Finally in 2011, the Park Alliance decided to revamp the area where the lions were installed and that's when we became involved.

So here are the lions as we first met them. Their carved limestone companion sculptures depicting seated male lions with a front paw on a sphere. They are approximately seven feet tall and weigh about 2900 pounds each. Before treatment the limestone exhibited staining, biological growth, gypsum crust, graffitis, scratchitti, mechanical damage, spalling and erosion of details. There were missing portions of their tails, teeth, claws, ears, manes, snouts, etcetera, etcetera. On top of all of this, to cover these conditions, at some point, someone decided to take as a maintenance intervention, painting of the lions, which gives them sort of this modeled tannish appearance that they have here.

It was these conditions that we were originally hired to address. Of course what we didn't know when we got them was that under all that paint, was a massive amount of graffiti, which I'll show later. Anyway for our purposes, I'm going to briefly touch on the restoration and conservation efforts because really what we're interested in here is the restoration process and the final product.

Our conservation effort included treatments such as water misting, paint removal, poulticing, laser cleaning, Dutchman and things of that nature. It was later that the project was expanded to include full scale replica's of the lions. This shift came from a desire of our client to do more to protect the original fabric and they had four goals in mind when they came to us with this; 1. again they wanted to preserve the original fabric, which was difficult in a place where the lions were so public, where they actively encouraged people to touch them and play on them; 2. they wanted to take advantage of their high visibility for promotional purposes; 3. like I said, they wanted to keep them highly accessible to the public which is hard when you're trying to protect the original fabric but it was something that they highly valued; 4. they wanted to have an accurate record of the lions. Since they were going to remain out in the public and they were going to continue to deteriorate, they wanted to have a record of them as they were now.

So with these goals in mind, we came up with several options for them; 1. we could simply restore the originals and help them come up with a plan to maintain them; 2. we could restore them and then make molds off of them; or 3. we could go a step further. We could restore them and then we could laser scan them and create digital models. Clearly the last one is the option they went with and there were several reasons that they chose this option.

In the past, these sculptures were subject to vandalism and wear and tear from park visitors. So some sort of documentation was necessary in their eyes. Creating molds from the original sculptures would have had similar results to 3-D modeling however, there were concerns about the storage and shelf life of forever molds and the effect that mold making would have on the new repairs we had just installed. In contrast, laser scanning could be done in one day. It could be done in place and it could be done without physically touching the sculptures at any time. 3-D modeling from the scans would provide an accurate digital record that was accurate enough to negate the necessity for rubber molds at all. It would also give the client the opportunity to create replica's in miniatures from the 3-D models and create them out various materials for promotional purposes. In fact, it was this capability that allowed the lions to go a step further than they had originally planned to remove the original sculptures from the park, put them in a slightly safer location and to put replica's into the park.

So to complete this work, we put together a team of digital documentation professionals. We contacted Direct Dimensions for the laser scanning and 3-D computer modeling and the Digital Atelier for the C&C machining of foam which is ultimately used to create molds off of and make precast concrete replica's.

So one other important consideration when we talked to them about laser scanning was when the scanning would take place and how many scans they wanted. There were discussions at first about doing scans of the original fabric as it was

and also of the lions after they were fully restored. So we gave them four basic options for when the scanning could happen; 1. it could happen before they moved the lions in case of a catastrophic event. The image you're seeing there is of when we moved the lions, they were flying through the air and there were some concerns about that; the second time would be at a point at which cleaning had already occurred but no permanent physical alterations had been made to the lions, so we would have had an accurate record of the lions as they were but it wouldn't have been an accurate record of the changes we made; 3. we could have done it after conservation and reconstruction had occurred so it would have been at the very end of the process; or fourthly, what we ended up doing was we could do the scanning after we had cleaned and after we reconstructed all the details that they really wanted in clay and then we scanned them at that point so that two things could happen at the same time. We could continue working on the original sculptures putting our repairs on, while at the same time, the digital component was going on, the 3-D models were being made, the C&C machining was happening and the precast concrete replica's were made so it was a bit of a time saver for us.

This also had the advantage for our client of they actually wanted to have a sculptor involved. They could have had the lions scanned earlier and we could have recreated the details in the digital model and use that but instead, they wanted to physically recreate the details with the sculptor to be able to touch them, to have some input, and to adjust them as needed, so that was their choice.

So after they had looked at the clay models that we did, after they had adjusted them and approved them, we began the laser scanning process. Direct Dimensions came to the conservation studio to laser scan the statues. They used a Surphaser 25 HSX, a phase shift hemispherical 3-D scanner. The scanner has a 360 degree by 270 degree field of view and a scan rate of up to 800,000 points per second. The scanner creates 3 dimensional electronic images that are accurate up to 1 millimeter or better. The scanner collects point data to create polygonal computer models or STL files in this case. The files were then taken by Direct Dimensions back to their studios where a technician adjusted them for accuracy and to fix any gaps in the data.

So scanning the statues after clay repairs allowed work on the 3-D and foam models to continue simultaneously with the conservation work on the original statues which for us included Jahn mortar repairs, Dutchman repairs and consolidation. In contrast, the mold making process would have had to occur either on the unrepaired original surfaces or they would have had to occur on the newly patched surfaces, which we were concerned about protecting.

So after laser scanning, the files were sent to the Digital Atelier where a five axis C&C machine was used to mill full scale replica's in six pound urethane foam. Kreilick Conservation then worked with Digital Atelier on the construction of the foam form and the finishing of their surfaces. Each of the lions were created in eleven separate pieces of foam. After the pieces were glued together, the surfaces had to be reworked. As excellent as the technology is, there is still a need for artistic involvement in the process. This is for two reasons; for one the bits used to cut the hard foam are not able to cut any deeper than they are wide, so the recesses and overhangs in the replicas weren't quite as deep as they would have been in the originals. In addition, the small bits used by the machine leave a regular groove pattern across the surface and that needed to be carved back and minimized. So conservators and a sculptor worked together with the Digital Atelier staff to rework the entire surface of the lions and redefine the recesses. We did this work based off of historic documentation and our own documentation.

So here you see the finished foam models and you can see they were sent to Metropol Inc. to cast the pre-concrete replicas. You can see the molds going around the foam forms. Here you have the fruits of our labors. Here we went from two severely aged lion stone sculptures to four fierce lions. This image is of the newly christened Pat. He was renamed for

one of the donors to the park. On the left is Pat the original and on the right is Pat, the new and improved, so you have Pat version 1.0 and Pat version 2.0. Here you can see Pat and Art, newly christened after the donors at home in the park awaiting visitation.

So what did this project represent for us? We believe it represented a case which 3-D documentation provided the best option for a conservation project. The advantages here proved greater than those from more traditional methods of documentation including two dimensional drawings, photographic documentation, and mold making. In our case the benefits included those of physical storage because it eliminated the need for storing large rubber molds for an extended period of time; 2. it had the advantages of long term storage, it is easier for our client to store a digital file then again to store large rubber molds. There was the relative ease of manipulation. In future the files can be manipulated to make changes to the models, to make enlargements or miniatures, and to make castings in a variety of materials for promotional purposes, which they are very excited about. There was the benefit of accuracy, forgetting the surface textures that they wanted to document, which is a little easier in 3-D form than it is in a two dimensional drawing. We wanted to protect the original fabric, particularly the porous weathered limestone. We also wanted to protect the new repairs. By scanning, we were able to allow our repairs to have more time to cure and we had more time to make them.

We were however, aware of the disadvantages and we had a lot of discussions with our client about these. There was the cost of the technology, though for them there was a trade-off between the cost of mold storage and the cost of digital file and foam creation. There were other costs of accuracy. If you want more accuracy, you have to pay for more accuracy. But for our client, they went for a little less accuracy in exchange for the involvement of an artist and that was their choice.

Several people have touched on this in their talks, the digital files have to be kept up to date. We have to keep up with the technology and for our client if they don't use it, they're probably going to lose it. There are issues of file size and storage. A client may not have, doesn't normally work with files this large.

There was a loss of detail on the replica's. One drawback to the scanning, the model making, the machining and the reworking process is that there is a slight loss of details in each step. We lost the surface texture. We lost the eroded bedding planes of the originals. They're all minimized in the final product. So in the end, the replica's have a much smoother appearance than the originals. But in our case, our client was willing to accept some degree of change because really what they wanted were not the exact replicas of the originals, what they really wanted was a copy of what they thought the lions would have looked like in 1901 when they were first installed on the Prudential buildings. So they were alright with a little bit of loss of detail.

But this then relates to my last point, that the originals and the replicas are not the same and you can see it best maybe in this image. Because of the timing of the scans, because we did the scanning in the middle of the process, the replica and the original aren't the same. In our case, the client was okay with that because again, they wanted sort of the idealized version of the 1901 lion but then they wanted to protect the original fabric. For us and for me, the advantage was this; it was that when we did the clay repairs we were really aggressive. Every little detail, every little detail on the mane, the ears, the nose, the eyes, every little thing that they wanted to give the character, they really wanted to restore the personality of the lions. That was their wording. So we went really hard on that in the clay and that's what was scanned. But in the originals, when we had them in our studio, when we went to repair them, the repairs had to stand up to a lot of use. They're going to be outside, they're going to be climbed on by visitors probably, so we were doing repairs in things like Jahn repair mortar and limestone Dutchman. So to do that of course, you have to cut away at original material to install the repairs, which always makes me a little nervous. I don't really like to lose original fabric, especially when you

have some of those original sculpted details.

So what we were able to do because we had done something more aggressive in the clay, was when we went to repair the originals, we didn't take it quite as far. We didn't add quite as much material and we are okay with that difference. I am at peace with this decision. So that's the end of my talk.

Thank you very much. If you have any questions, feel free to ask me later or talk to Jon Lash or Joe Nicoli from Direct Dimensions. Thank you.

Speaker Bio

Caitlin Smith is an architectural and sculptural conservator for Kreilick Conservation, LLC. She received a Master of Science in Historic Preservation from the University of Pennsylvania, and undergraduate degrees in Historic Preservation and Political Science from the University of Mary Washington. Her graduate thesis, Cleaning Methods for the Removal of Limewash from Painted Plaster Surfaces: Utilizing Ion Exchange Resins on the Interior Architectural Finishes of the Capilla de Nuestra Señora del Rosario in Iglesia San José in San Juan, Puerto Rico, was presented at the IIC 2010 Congress and the APT 2009 Conference. She has worked with the Architectural Conservation Laboratory at the University of Pennsylvania, the Fairmount Park Historic Preservation Trust, the Jekyll Island Historic Preservation Internship Program, Kenmore Mansion, and the US/ICOMOS International Exchange Program.

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