

A VISUAL BREAKDOWN OF THE FLYING GANTRY ANIMATION

JOHN DRAISEY

Enclos Corp leads the way with cutting-edge technology. On a recent highrise project in New York City, a new picking method was needed to accommodate the difficult spatial limitations of the site. Enclos engineers developed a custom flying gantry rig that could hang from a crane hook and handle immense curtainwall loads. What set this gantry apart was its unique ability to trolley the loads straight onto floors without any loading platforms. As designs for this new rig were finalized, a hurdle arose for the operations team. They would not be able to test the rig in the field without first getting the approval of the Department of Buildings.

Utilizing the 3D abilities of the visualization department, Enclos used still image renders and animations to obtain city approval. The complexity of the flying gantry design was due to its multiple moving parts, all controlled via wireless remote. Showing how these parts would move, as well as how the construction crew could safely interact with the gantry, were key points when planning the animated film. This all needed to be completed in a short amount of time and as accurately as possible.

The storyboarding process became pivotal in the success of the narrative (Fig 1). Animation is time consuming and does not lend itself well to quick change requests. The means and methods script was used to methodically break down each step into *shots*, short animation sequences defined by camera cuts. The visualization department's goal was to ensure that anyone could view these shots and instantly understand how the flying gantry worked. If viewers understood the storyboarded shots, then they were guaranteed to understand the 3D animation. The ability to share and discuss the storyboard with the project manager enabled the animator to include every crucial detail, while eliminating redundancy.

When designing shots, it is important to ask, "what message is being communicated to the viewer," and "how can we give viewers the best possible camera angle?" By minimizing camera cuts in the final edit, viewers are less likely to become distracted or confused since each *cut* requires time to reorient oneself within the geography of a scene. An advantage of storyboarding is the speed and flexibility it lends to the creative process. Rather than the hours needed to set up even the most basic 3D scene, hand drawn storyboard revisions can be made in a matter of minutes. This is a crucial step of the pipeline that ensures a high quality, on-time product.

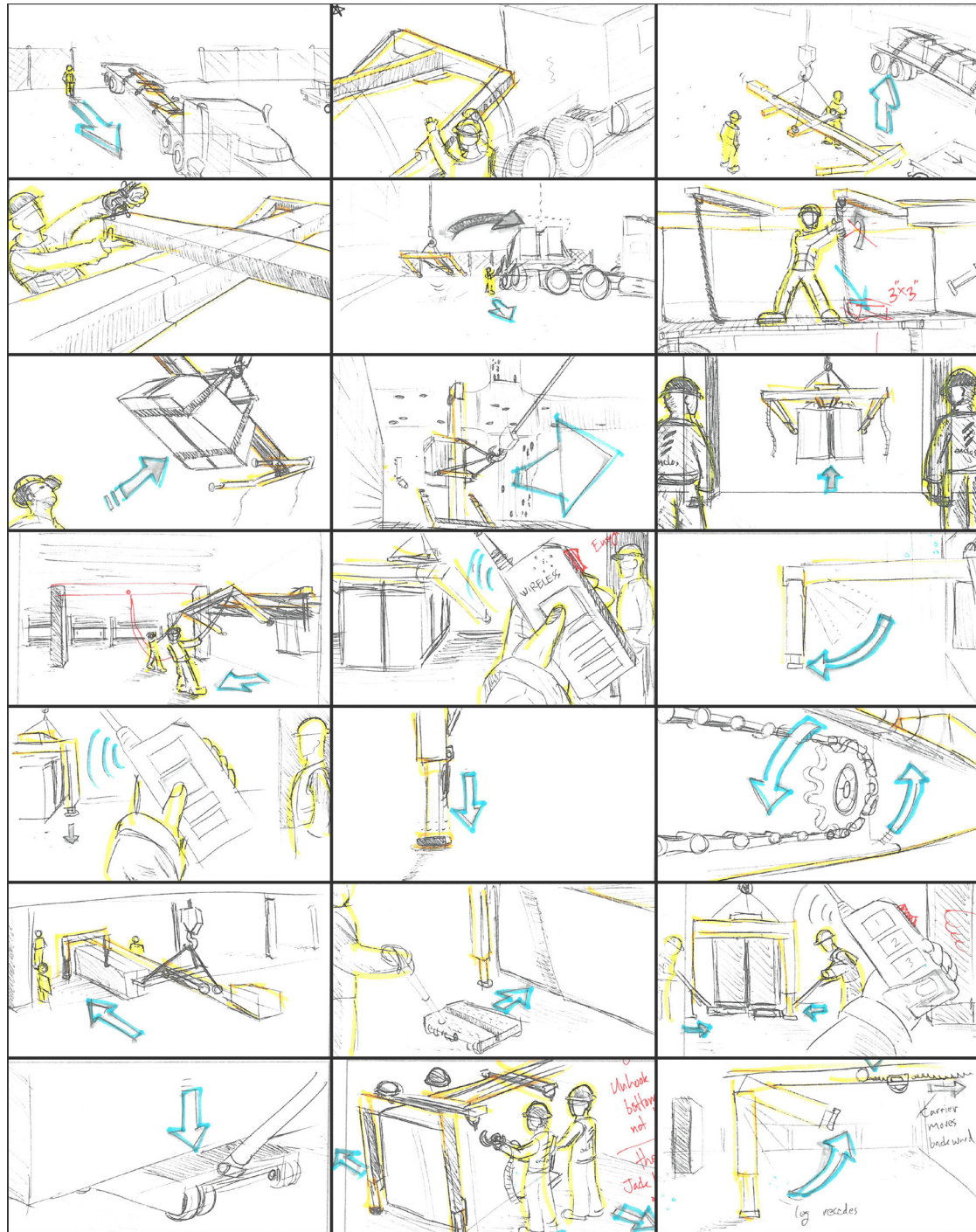
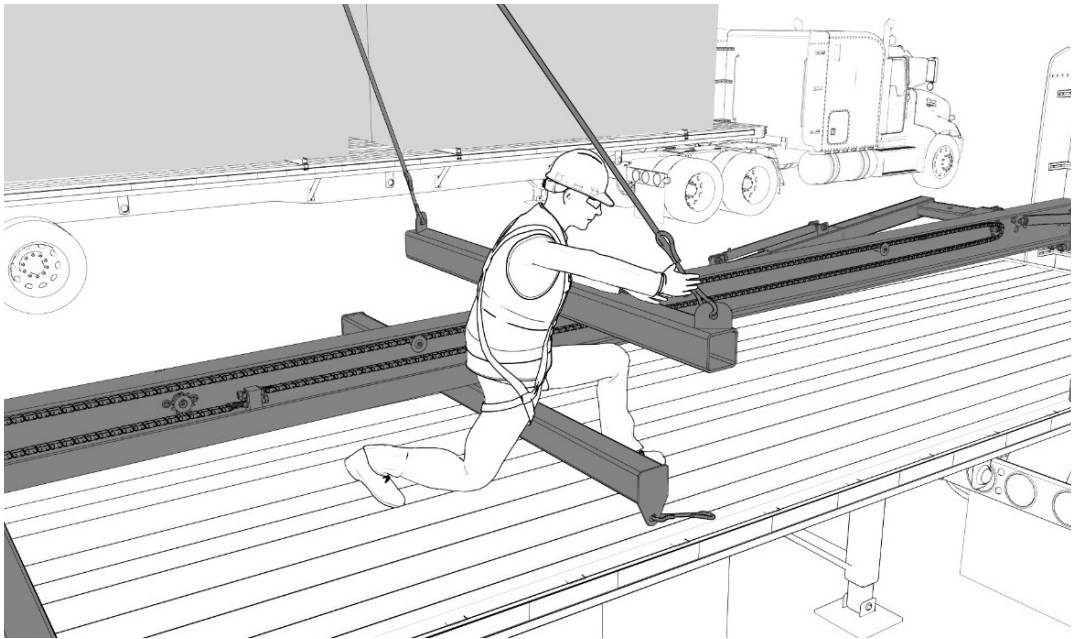


FIGURE 1
The final storyboard consisted of 24 shots with important details highlighted in yellow and movement arrows highlighted in blue.

FIGURE 2
Toon shading is a powerful visual tool that displays 3D geometry as comic book style renders.



Halfway through the approval process the project leads saw a need for print resolution, shaded storyboards to be included with the gantry proposal drawings. It was clear that providing drawings alone would not be enough; the gantry needed to be shown in context. Hand-drawn storyboard frames are loosely sketched by pen, making them poor candidates for a proposal package. A cleaner method would be to carefully draw and paint every frame in Photoshop to reduce visual discrepancies between the gantry drawings and storyboards. But the amount of time required to do so would require several additional days of work by the visualization team. A faster approach was needed.

Luckily, there is a little-known feature in the animation program Maya that allows 3D scenes to be rendered with cartoon style shading (i.e. toon shade). The visualization team concluded that scenes normally set up for animation could also be used to render out toon-shaded

still frames, and this approach ended up being successful. Toon-shaded 3D models were rendered as clean, comic book style images that matched each storyboarded shot. Every prop and character were separate 3D objects and could be assigned arbitrary tones such as white, light gray, and dark gray. The benefit of drawing the contour lines in 3D space is that characters and objects closest to the camera receive thicker outlines, giving them additional visual emphasis. Once the toon-shaded renders were delivered, work began on the animation rig for the gantry. Manually animating dozens of parts frame by frame can be tedious and time consuming; to avoid this pitfall, work was done up front to automate the movement of these parts with Maya's *set driven key* tool. At its core, Maya's animation system is built on per-object timeline curves. And set driven keys allows movement of one curve to drive the movement of another curve, or multiple curves.

In essence, the rotation of the gantry's arms from a compact pose to an extended pose was set up to drive the movement of multiple pistons. All the animator had to do was instruct Maya on what positions and rotations each part should have when the gantry was compact, and then when extended. Maya then interpolates all movement between those two poses. If an animator was told to speed up the extension of the gantry arms, only the arm animation would have to be adjusted. The pistons would adjust accordingly, saving valuable man-hours.

Automation also proved useful when animating the load-bearing straps that hang from the gantry's moving carriage unit. The animator relied on Maya's powerful *nCloth* simulation system to calculate movement of the gantry's straps for several shots. Maya nCloth gives 3D objects a vast array of physical properties such as mass, bendability, friction and elasticity. Even wind and gravity are provided as options.



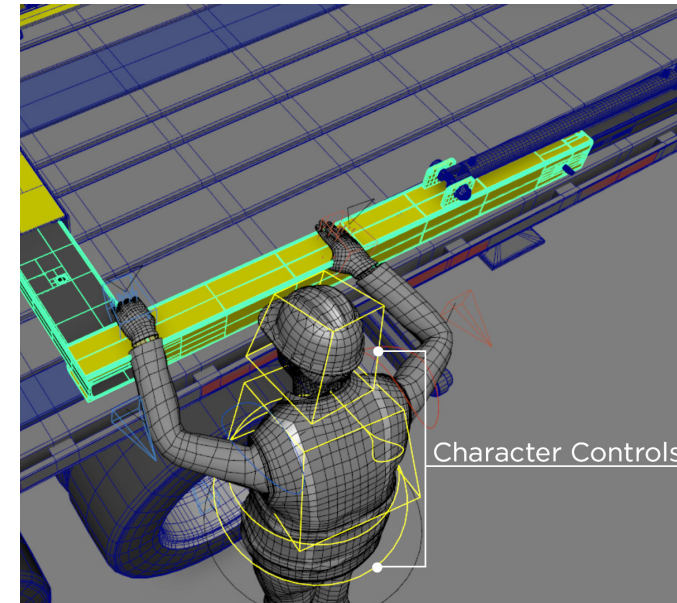
FIGURE 3
A still frame demonstrates the delivery and preparation of the flying gantry as it arrives onsite.



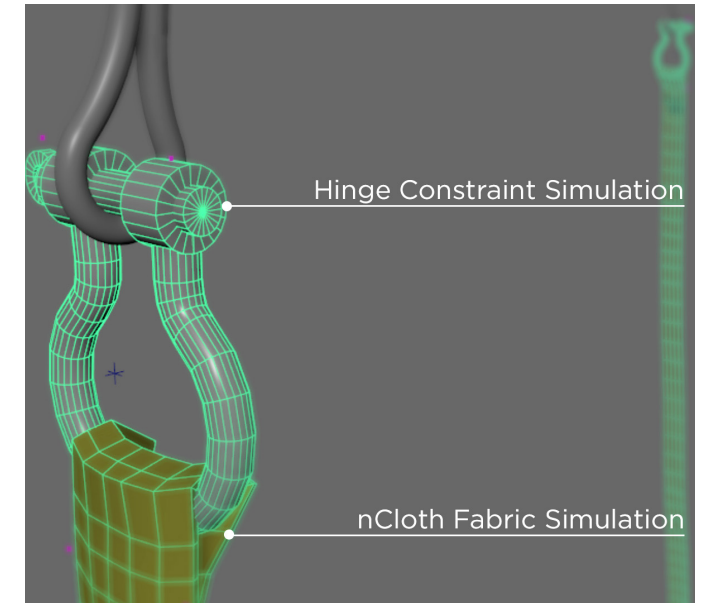
FIGURE 4
A construction worker prepares to load a curtainwall bunk onto his dolly, offloading it from the gantry.

FIGURE 5
Character animation controls.

Figure 6
Hinge *nCloth* simulation.



Character Controls



Hinge Constraint Simulation

nCloth Fabric Simulation

While requiring additional setup time, the advantage of simulating rather than animating all four gantry straps was that any movement from the flying gantry rig would immediately result in realistic movement of the straps, a huge time saver. The nCloth system works best with real-world scale, which was perfect since the flying gantry and building structural models originated from CAD. A second gantry rig was also developed with some physical nCloth properties disabled, allowing the 3D construction crew characters to hold onto the ends of the straps while hooking them into the curtainwall bunks.

Once the nCloth rigs were set up, the next big step was animating the cameras, characters and props that were set up for the toon-shaded renders. The challenge of creating a 3D animation is keeping the computer responsive enough that animation sequences can be played back at a real-time frame rate of 24 frames per second. As more and more geometry is added to a scene, the less responsive the program becomes during animation playback. And unless

the scene is playing at a consistent frame rate, the animator cannot tell with certainty if their animated characters and props have believable movement.

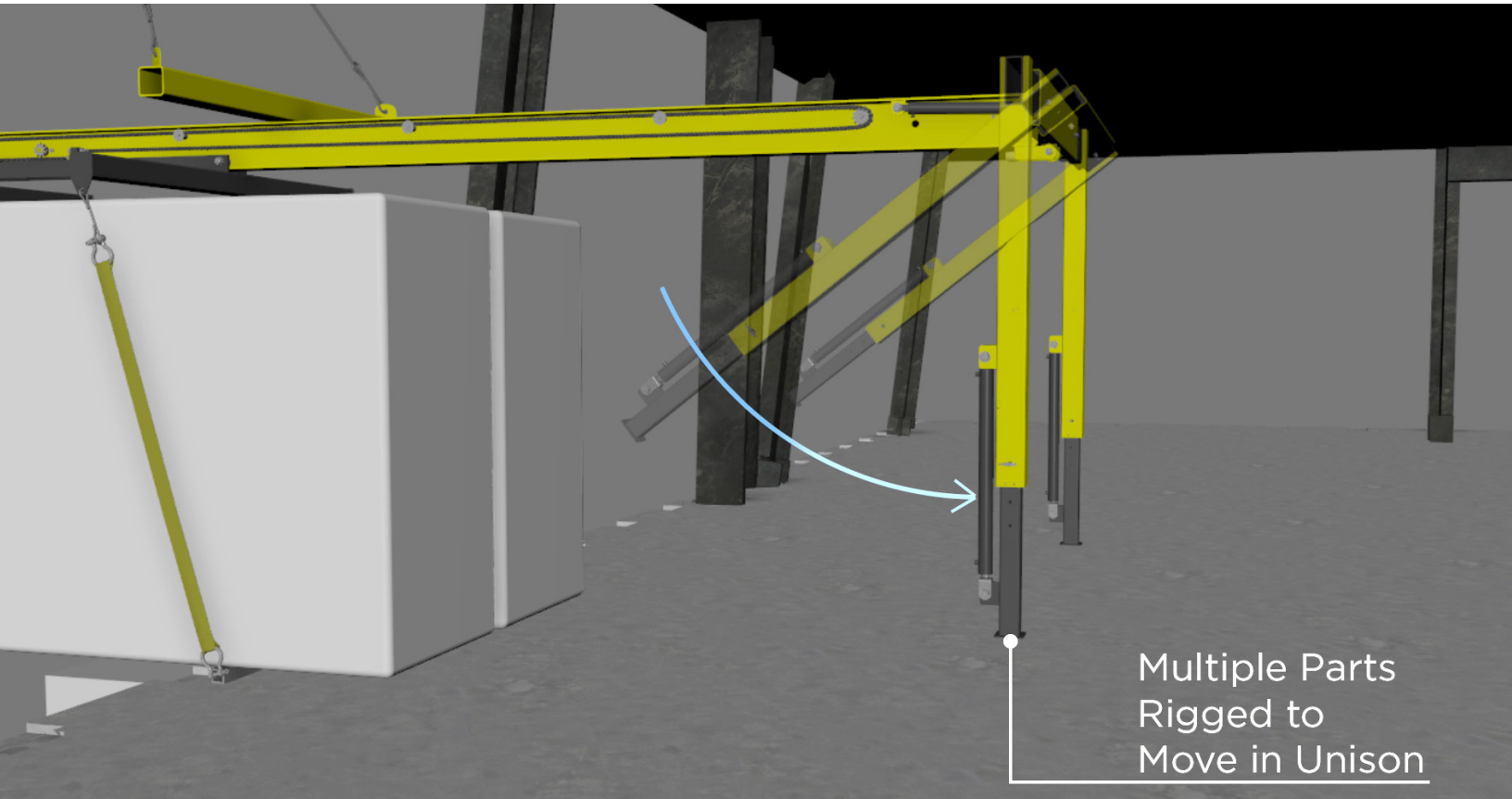
To keep application performance as responsive as possible, each shot was animated with proxy, low detail environment geometry. So long as there is geometry that accurately represents the boundaries of floors, ceilings and major obstacles, animators can confidently approach each proxy environment knowing full well that high detail environments and realistic lighting can be swapped in after their task is complete.

Proxy geometry introduces another benefit, which is the ability to keep most of a scene's detail stored in offline files. Geometric data is loaded into the computer's memory strictly during render time and only if the proxy geometry intersects with the render region. This allows Maya artists to build very large scenes that are not limited by RAM, and the proxy method lends itself well to repeating objects such as vehicles,

trees, street lamps, etc. Even an entire city can be saved as a proxy, which is exactly what we do when using an environment such as New York City for animations.

Scenes built primarily with proxy geometry load quickly, respond fast during animation, and are easy to update. If 30 animation files using the same proxy city environment require a change to that environment model, none of those files need to be opened and edited. So long as the proxy model is updated, all animation files using that proxy will automatically use the latest version of the city environment and can be rendered immediately.

Rendering each animated shot can be a 12 to 24-hour process. To avoid inefficiency, most of the rendering in Maya was done after completing the final edit of the film. When editing an animated film, entire seconds of each sequence may need to be shaved off or added to make the camera cuts flow better. To ensure not a minute of CPU time was wasted, animations were rendered out



using Maya's *playblast* function, which takes a screenshot of every animation frame and saves them as low resolution movie files. The movie files were then edited together in Adobe After Effects, allowing the animator to preview the entire gantry animation from beginning to end. As long as the file names of the preview footage match the file names of the final renders, the final renders would automatically replace the preview files as shots were completed.

The animator kept a log of any unused frames, then removed those frames shot by shot from the render queue. Ultimately, 15 seconds of animation were removed, saving more than

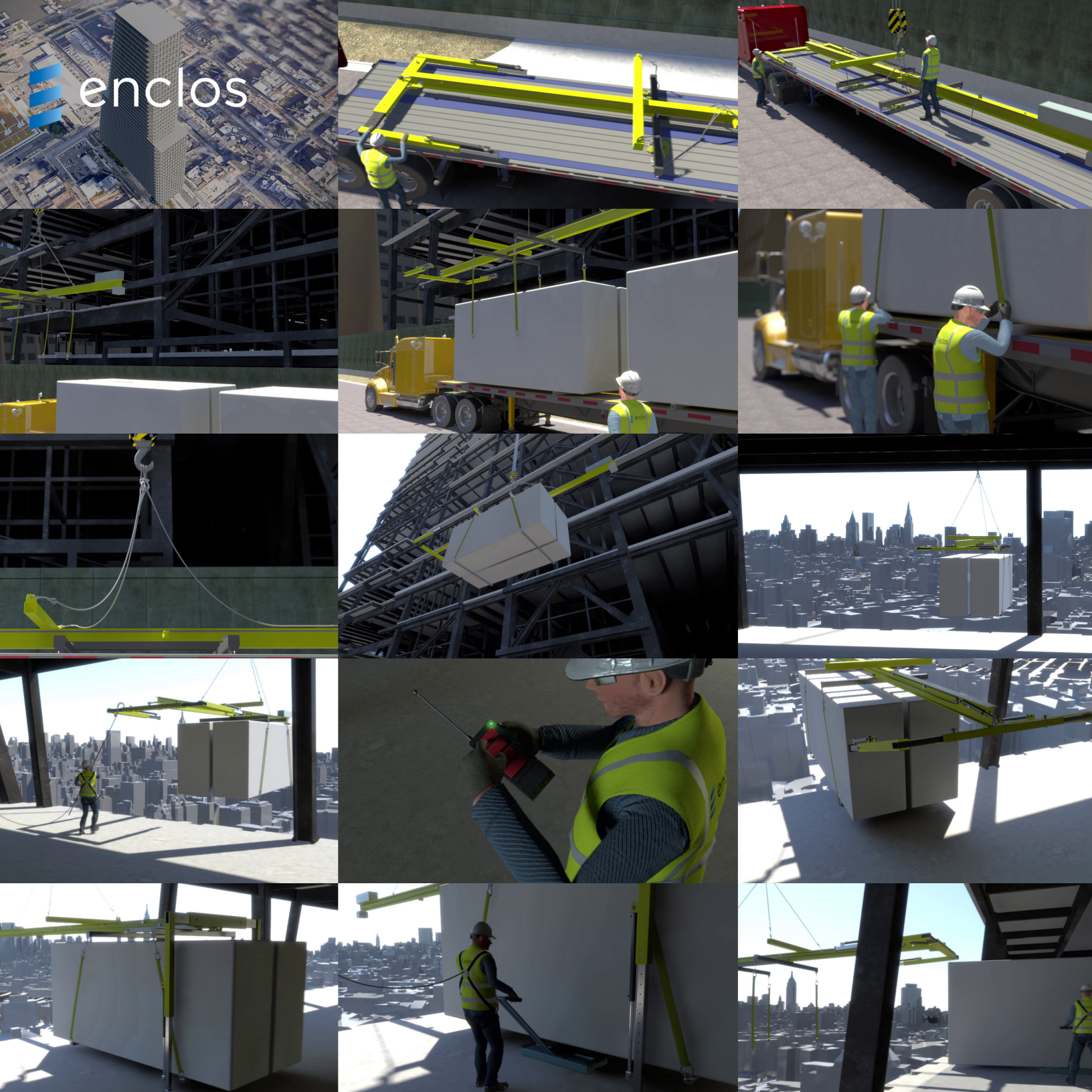
a day's worth of render time. On top of that, the output resolution and render quality were adjusted on several shots to account for spikes in rendering complexity. While flat, diffuse materials such as concrete or cloth render quite fast, reflective materials such as the metal and paint take longer to render since more ray tracing is required. To reduce overall render time, a few shots had animated render settings that reduced gradually as the gantry moved closer in proximity to the camera.

Despite the variable render settings, the one compromise that was not made was in lighting. The use of high dynamic range (HDR) lighting

FIGURE 7
Multiple gantry parts rigged to move in unison.

FIGURE 8 + 9
Photos of the flying gantry in use on the NYMoMA tower (aka 53W53).





and an HDR compatible image format meant that even the smallest details were never obscured in the shadows. If a render looks too dark or too bright, HDR lighting allows the brightness of the image to be adjusted without affecting the details hidden within highlights or shadows. A major component of the post-rendering process is raising the brightness of shadows and lowering the brightness of extreme highlights. This process of toning shadows and highlights in rendered image is identical to how the human eye reacts to fluctuations in brightness. And the closer we can get our animations to reality, the better. If the construction crew can immediately identify equipment and site elevations by watching our animations, then we have done our job correctly. The visualization team's goal is to ensure that the animations we produce look as close to the real thing as possible. And sometimes that means treating our digital scenes like movie sets. If a scene is so dark that even toning the brightness does not work, we will add additional sky colored fill lights to bring out the detail in that scene.

The flying gantry animation proved to be both informative and aesthetically pleasing. Depth of field, a camera effect where part of a shot is out of focus, was utilized on several animation shots to ensure that viewers focused on the most important aspects of those scenes. Though Maya has depth of field (DOF) included as a render option, the downside is render times can double or triple with DOF enabled. Thankfully, After Effects has a post process depth of field effect that can read depth files and apply DOF to perfectly crisp shots. In the interest of time, this option was utilized to draw the viewer's eye to important aspects of each shot that would correspond to subtleties in the final edit.

The flying gantry animation showed remarkable coordination and teamwork between our engineers, operations and visualization team. And because of the forethought put into storyboards and time saving tactics in Maya, the animation was delivered on time and with minimal visual compromises. The visualization department is constantly evolving, and we look forward to future collaborative challenges.

<
FIGURE 10
Filmstrip selections from the
flying gantry animation.