# The Use of Miniatures in Modern Filmmaking

**Innovations Project Report**

**By Chris Clough**

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## Abstract

I have always been amazed by the ingenuity and innovation of the early pioneers of special effects for film, not using computer graphics but scale miniatures and practical effects, and the old-fashioned methods for combining images on screen. From epic environments to violent explosions, they were all done with cameras before they were done with computers.

In a way, I think it's sad that digital effects have completely taken over in most modern films. I think the mystery of how these effects were created added a lot to the enjoyment and magic of the cinema experience in the past, but now that we have entered the digital age, pretty much anything can be created inside the computer and because of this, I think some of the magic has been lost.

I would like to believe that there is still a place for these "old-fashioned" techniques on today's digital-dominated cinema screens, and so for this project I wanted to learn more about the history of these techniques, and by building a practical model, see how the traditional use of scale miniatures compares to modern digital techniques.

## Introduction

I started out by researching a little about the history of special effects in film, focusing specifically on the use of miniatures, and how this changed over the years with the introduction of computer graphics. I found that the use of miniatures tied in very closely with development of early compositing techniques, so I had a look at the history of this as well. I found this very interesting, but it didn't really fit into my main area of investigation, so I have included this information on compositing in Appendix A.

I then set about building a scale miniature of my own. For me, the objective of the project was simply to experiment with miniatures, and find out a little about the techniques for building them. I wanted to find out about the advantages of using miniatures, and any problems and limitations of working with them, to gain a better understanding of when they could be used as an alternative to computer graphics. I was just trying to learn, not necessarily trying to produce a perfect, photoreal model that I could seamlessly integrate with live-action.

I would then be able to evaluate how realistic the results were, compared to my previous experience with using computer graphics. I could compare how long it would take to obtain acceptable results, and how easy it was to composite some live-action footage with the images produced.

I chose to build a small section of a ruined city as a miniature, since I already had some experience at creating this digitally; I made a 3D ruined city in Maya for my 1st Year group project, and a 2D matte painting in my 2nd Year Specialist project. I think there is a kind of beauty in the dysfunction of ruined cities, which is what draws me to them . I thought that a ruined city would work well as a miniature, because of the complex, jagged shapes of walls, and broken rubble, which were difficult to achieve in Maya.

## Research: A Brief History of Miniatures in Film

For as long as the medium of film has existed, filmmakers have been looking for ways to draw in as large an audience as possible, and one way of doing this has been by creating stunning visual sequences unlike anything they've ever seen before, leaving them amazed and astounded. To create these epic scenes, such as classical cities or alien landscapes, at full size on a large film set would of course have been tremendously expensive, and so for budgetary reasons, directors tried to find other ways to create them. *Matte painting* was one such way, and was developed around 1920. This used to be done on panes of glass positioned a few feet in front of the camera, and the live-action was filmed through a clear, unpainted window left in the middle of the glass. Obviously, these paintings could show environments far too big to build in real life.

The picture on the left here shows the principle of matte painting on a pane of glass, positioned in front of the camera, with the subject being filmed though the clear part of the glass. The second picture shows the results. *(Ref 1)*

This technique worked well enough, but was often given away by inconsistencies in the lighting, if the lighting conditions changed in between painting the picture and filming the action. In the picture above, you can see from the shadows that the sun is to the left of the subject, but the sky in the matte painting suggests the sun should be behind him. One way of avoiding this problem was to do the matte painting after the live-action had been filmed, and then capture the painting in a separate exposure, although this was a fairly complicated process (methods of doing this are explained in detail in Appendix A).

Another method of creating fantastic environments that were too big to build in real life was to use miniatures. Like with matte painting, the miniatures could either be

positioned in front of the camera and shot with the live-action in a single exposure, or they could be filmed afterwards in a second exposure, using a *matte box* to mask part of the frame (see Appendix A for a detailed explanation of the matte box). The miniature would extend the existing set upwards or outwards. The actors would have to stay within the confines of the set, otherwise they would disappear behind the miniature, when it should appear as though the miniature is behind the actor from the camera's point of view. If done in a single exposure, one advantage of using miniatures over matte painting was that the lighting on the miniature would almost always match that of the live-action. This method of shooting a miniature in the same exposure as the live-action was called the *hanging miniature*, since the miniature often extended the real film set upwards, and so had to be hung above the height of the camera.

In this shot from the original 1925 version of Ben Hur, only the lowest tier of the Coliseum was built as a real set. The majority of the stands – including the crowd inhabiting them – were built as a hanging miniature that was positioned in front of the camera. Although the stands appear to be further away than the racing chariots, they are in fact only a few feet in front of the camera. *(Ref 2).*

Alexander Korda used the *matte box* in his 1936 film *Things to Come*, to combine live-action footage with a scale miniature in the background. Although the line between the two exposures is clearly visible, the technique was convincing enough for its time (*Ref 3*).

Whether hung in front of the camera and filmed with the live-action, or filmed in a separate exposure afterwards, a lot more detail could often be built into a miniature than could be painted onto a matte painting, but great care would have to be taken to ensure the perspective of the miniature lined up correctly with that of the set.

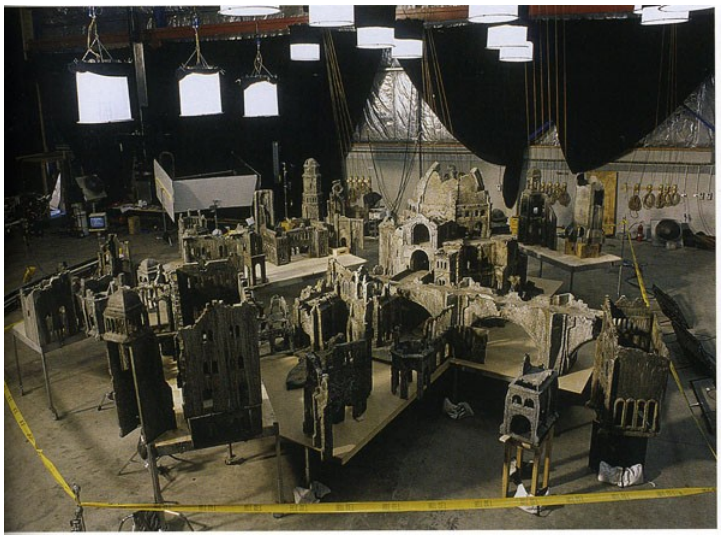
Another use for miniatures was as sets for stop-frame animation, a special effects technique used to create creatures. King Kong, made in 1933, was one of the first films to use stop-frame animation. Since the foreground elements were to miniature scale, in this case the matte painting could be positioned behind them, and the whole frame photographed in a single exposure. *(Ref 4).*

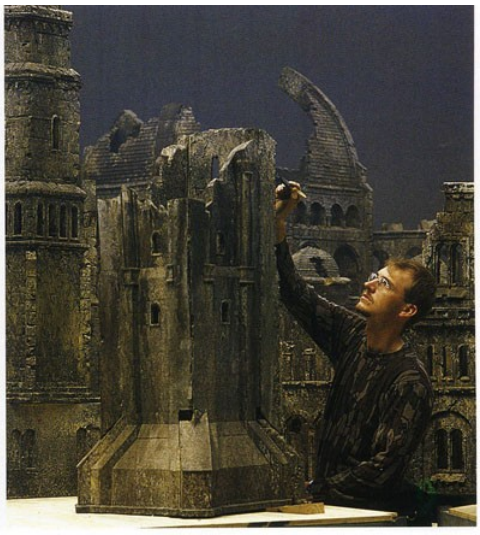
However, with both matte paintings on glass and the hanging miniature, the camera had to remain completely still, otherwise the illusion would be ruined. That was until the mid 1920s, and the invention of the *travelling matte*, a way of masking an area of the frame that could change shape over time (see Appendix A). This allowed artists to cut around the edges of a film set as the camera moved, and more importantly, to cut around actors as they performed. This meant that for the first time, actors could be placed into entirely miniature environments, without necessarily needing a set at all, and so miniatures became an even more powerful creative tool.

The 1950s saw the beginning of various bluescreen techniques, which made it quicker and cheaper to composite live-action with miniatures, and so they were used even more often, in increasingly complicated shots (again, see Appendix A for more information on the process). The development of computer-controlled cameras around 1970, or *motion control,* allowed for incredibly complex shots, with multiple elements moving relative to a moving camera. 1977's Star Wars was one of the first films to take full advantage of this.

Miniatures have been used to create some of the most iconic film locations over the years. George Lucas founded the company Industrial Light and Magic in 1975 to complete the miniature effects on Star Wars, released two years later. Ever since, ILM have been one of the leading miniature effects companies in the world. *(Ref 5).*

Digital compositing for film, which grew out of technology originally developed for television in the 1980s, simplified the process of combining miniatures with live-action, making it even more accessible to filmmakers, and is still used with miniatures today, although computer graphics are becoming increasingly dominant as we move further into the digital age.



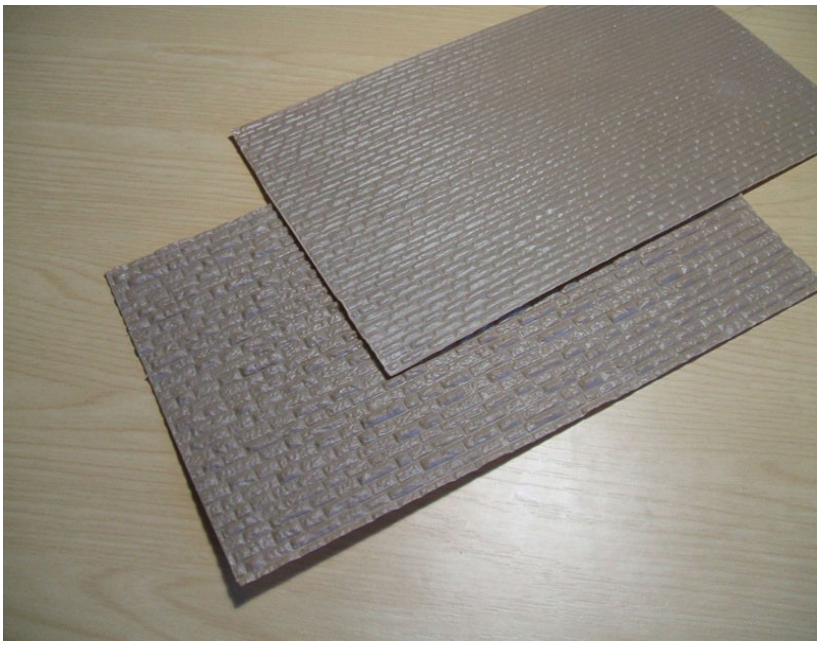


Some of the most notable films recently to make strong use of miniatures were Peter Jackson's Lord of the Rings trilogy. Pretty much every environment in the films was either a miniature or a matte painting. *(Ref 6).*

**Pre-Production: Investigating Materials**

Coming from an artistic background, I already had some experience at making things with my hands. I had done some sculpture in art classes at school, building things up out of clay, and hacking at blocks of stone and plaster with a hammer and chisel. I had assembled various plastic model kits, and having played the role-play game Warhammer 40,000 for several years, I had played around with cardboard and pâpier maché to build scenery and terrain, and painted them to look nice. But I hadn't ever attempted to build a photorealistic miniature before, so there would be a lot of new skills and techniques to learn along the way.

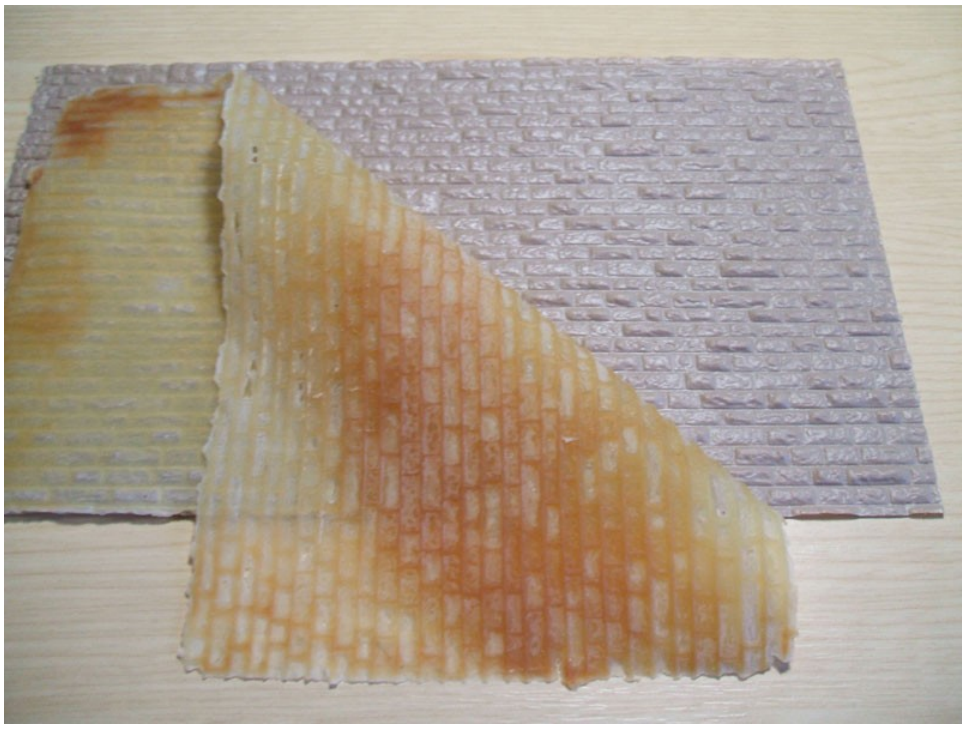
I started out by making a visit to all the local model shops, to see what materials were available to build the miniature from. There were many pre-made kits designed to decorate model railway sets; small houses, shops and of course, station buildings. But none of these really seamed suitable for a miniature, since at 1:48 scale, they were too small to have enough detail. Also, being made from tough plastic, they would have been difficult to cut or modify in any way. The starting point I chose was to use some thin plastic sheets with a brick texture impressed into them; these were to a much larger scale, though at this stage I didn't know what scale I would be building the miniature to.



I took them home and started to experiment with cutting and joining them, to make small sections of buildings. They were easy enough to cut, but gluing them at 90 degrees to each other was a challenge, since they were less than a millimetre thick. I found I had to stick them to a wooden frame, but that was difficult in itself; I tried using polystyrene cement, PVA glue and even superglue, but none of them really bonded with the plastic, even superglue just peeled off pretty much straight away. I wanted to use the texture of the plastic bricks, but made from a thicker material that I could glue more easily; this led me to settle on plaster, a material I had used a lot for

sculpture in the past. All I had to do was make a mould from the brick texture that I could use to cast sheets of plaster in.

I knew that once I'd started making small sections of buildings, I'd have to find a way to duplicate them quickly, rather than waste a lot of time modelling the same bits over and over again, from scratch. It wouldn't be as simple as clicking the "Duplicate" button in Maya. So I started to look into ways of making moulds, so I could reproduce the different sections, and indeed, the plaster walls in the first place. Following advice from the shopkeeper in my local model shop, I used rubber latex to make the mould. This came as a liquid in a bottle, which I poured over the plastic sheets, and left to dry. It took several layers to cover the brick texture completely, and each layer took several hours to dry, but when it was ready, I peeled the rubber latex off the plastic, and the latex had captured every tiny detail from the surface of the brick texture. It worked extremely well, despite the unpleasant smell.



I used this latex mould to cast many flat sheets of plaster, each typically 5mm thick, and all with the detailed brick texture on. They were easy enough to cut, although they did tend to break quite easily, and I found the PVA glue stuck them together well.

I also wanted to get some advice from someone with some experience in the area, so I emailed Claire Holman, the senior Lecturer on the BA Modelmaking for Design and Multimedia course at the Arts Institute Bournemouth. She said this technique would work fine, but that I might want to try using thin sheets of plywood and stencil a brick pattern onto them. I did a few quick tests with plywood, but I wasn't able to produce anything as realistic as the brick texture cast in plaster. Some useful advice she did give me though was to pay careful attention to the colours I used, and not to make them too bright.

## Production: Building the Miniature

Now able to cast sheets of plaster with a detailed, realistic brick texture on it, I was able to start building the miniature. I decided on a rough layout, with a street down the middle, three buildings down one side, and two on the other; I wanted it to be fairly epic and grand, but not so big that I'd run out of time building it, so I felt this was a good compromise. Without being too specific, I decided on a rough scale for the miniature, with a person being about 6cm tall, which made the scale approximately 1:30. Again, I had to compromise between making too much work for myself and making it large enough to accommodate a lot of detail.

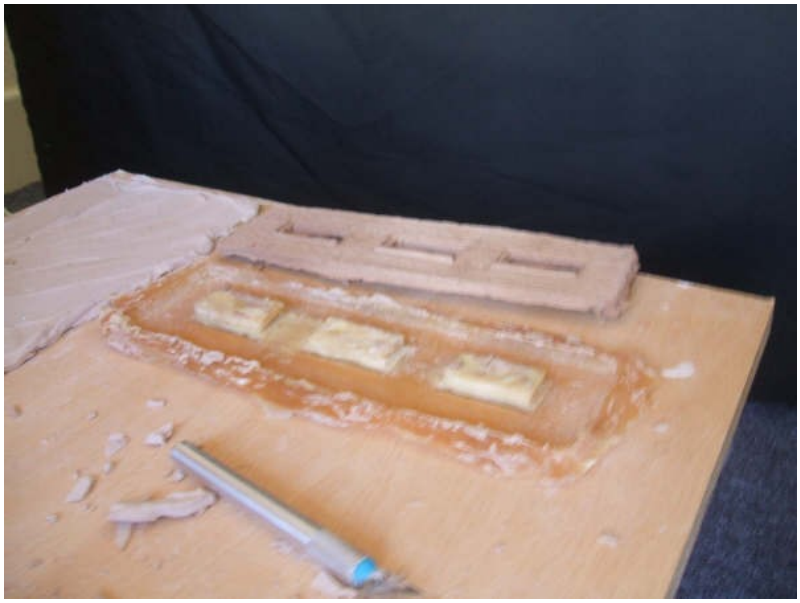
I designed two different styles of building, one looking like a block of flats, with windows over many different floors, and one looking more like a factory building, with only a single floor and big tall windows down the side to let a lot of light into a tall workspace. So I set about building a small section of each building that I could cast over and over again to make each building. For the factory building, I modelled one brick column that would stand upright against the section of wall between each window, as shown in the picture below.

This is the column I modelled for the factory building in my miniature. I built it onto a sheet of plastic so that when I made the latex mould, the latex wouldn't run underneath it and cover the back of it. The section of wall in the bottom right shows where other walls would sit under the windows in the finished building, though this was not part of the mould.

I was then able to make a mould from this section of wall:

It took several layers of liquid latex to make the mould thick enough to hold its shape. This mould was for the brick columns and part of the walls either side of it. Despite its thickness, it was quite wobbly and I had to be careful to make sure the edges were straight when I used it to cast more columns.

For the block of flats, I modelled a flat section of wall the size of one floor, with three windows cut into it. I then made a latex mould from it.



I used some thin strips of wood to model detailed frames around each window on the first wall section for the block of flats. Using a latex mould meant I only had cut out three windows and model frames around them, rather than for every window separately over the two buildings.

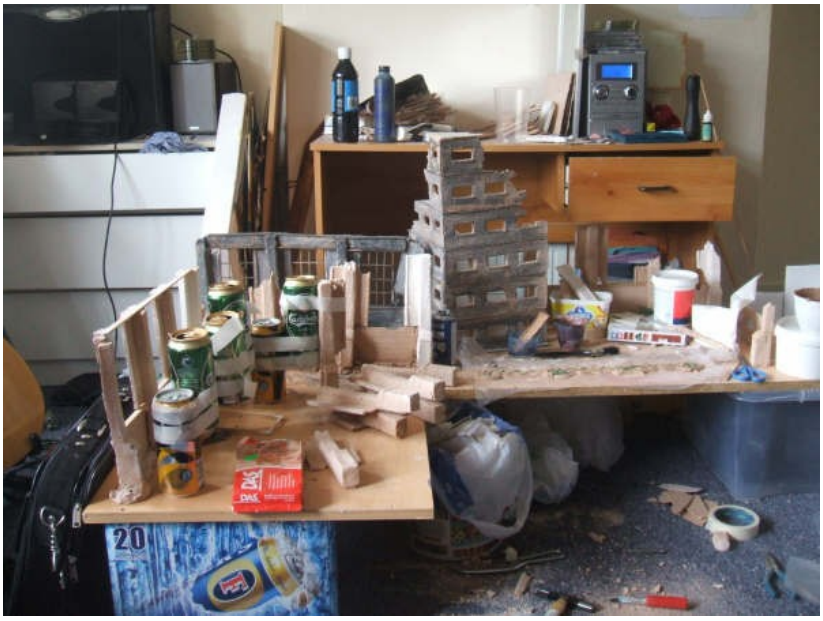
With my two latex moulds now complete, I set about casting many duplicates of each part; I needed 30 wall sections for the two blocks of flats, and 24 brick columns for the three factory buildings. This was a very time-consuming process; it typically took about 15 minutes to mix up enough plaster, and fill the two moulds. I then had to leave the plaster to dry for about 8 hours, before I could remove it from the moulds and cast the next pieces; any shorter and the plaster wouldn't be strong enough to take out of the mould without it breaking. I had to trim the edges of each piece with a sharp scalpel after removing it from the mould, before I could start to assemble the pieces into complete buildings.


I used plaster re-enforced with wooden strips for the base of each factory wall. I stood the columns up in the plaster while it was still wet, and used beer cans as a kind of scaffolding to hold them upright while the plaster dried.

Since the city was going to be in ruins, I wanted some parts of the buildings to be falling down, looking very rough and worn, so I didn't stick the pieces together too neatly. If a piece of plaster broke while I was trimming or gluing it, I tended to leave it broken, so that damage to buildings was more random. I also deliberately broke some pieces; simply snapping sheets of plaster in half gave nicely textures edges, which closely resembled broken down walls.

I modelled the windows and some other details on the walls using wooden strips, which I stuck together with PVA glue. Each window used nearly 2 metres of wood, and on the whole project, I used nearly 50 metres. I felt this attention to detail was important to sell the miniature as being *real*.

I joined the different floors of the tower blocks together, again using PVA glue. I used thin sheets of balsa wood for the floors, which I scored and cut to look like broken floorboards. I let these sheets stick out on the outside of the building to add some interest to the surfaces; I felt that defining where the floors were helped put the windows into context; without them, the windows would have just looked like random holes.



Production of the miniatures took over my entire bedroom, which was one drawback of using miniatures over computer graphics. I had little room to move, and the carpet was constantly messy.

As well as building the main five buildings, I cast a lot of extra flat walls that I broke up to use as rubble lying in the street. I set these into wet plaster that would hold them sticking into the air at different angles, to make several small piles of rubble. I used the same technique to adorn the corrugated cardboard that I mounted the buildings on.

I then set about painting the miniatures. I used some watered down black poster paint to wash over the surface of the plaster; this sank into all of the tiny cracks, accentuating the details in the surface, and worked very nicely with the porous nature of the plaster. This let quite a lot of the colour of the plaster show through, which looked good. I then used a sponge to pick out some of the raised detail on the surfaces, using a thick, light grey poster paint, and I was happy to leave the finish like that. I hadn't done a lot of work with the paint, but I didn't really need to because of the quality of the texture in the plaster.

So I was ready to take the miniature into the studio for filming.

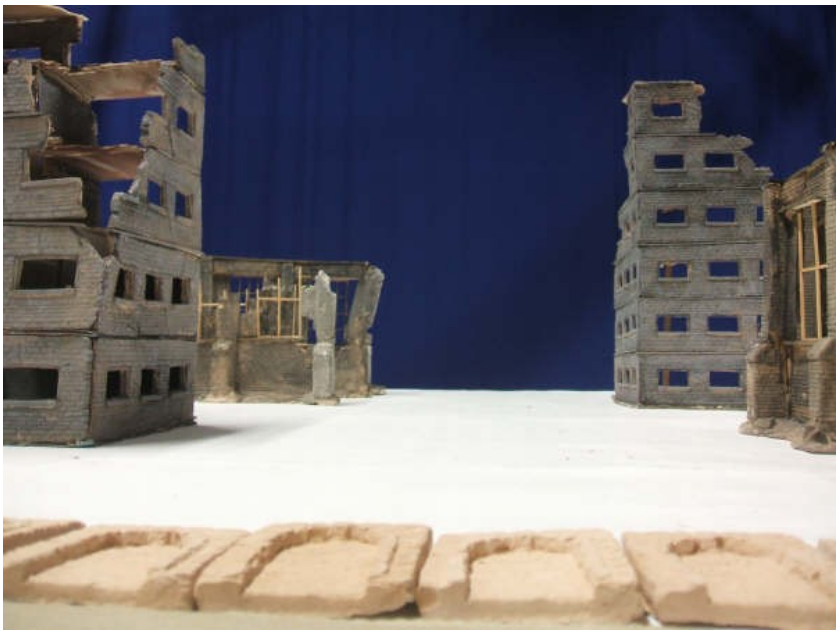
## Cost breakdown

I wanted to see how much I would spend on this project, so I kept a record of all the modelling materials I bought for comparison afterwards; this would be an additional cost not incurred through using computer graphics. Some of the quantities I used were quite remarkable:

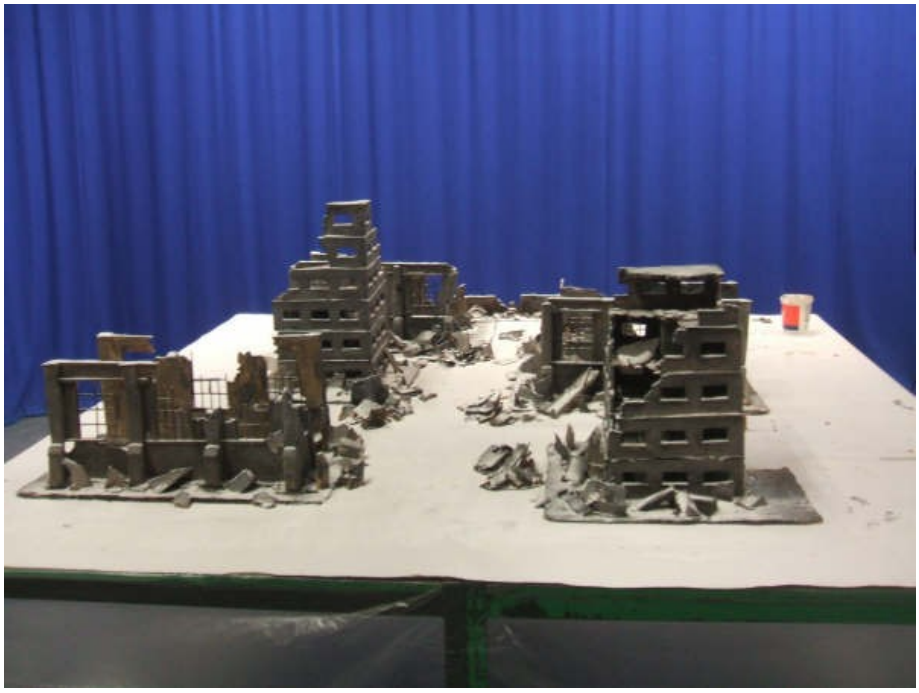
| Material | Quantity | Price |
|---|---|---|
| Plaster | 24.4Kg | £22.70 |
| Latex | 1 litre | £9.99 |
| Wood | 58m of strips | £28.00 |
| Plastic sheets | 5xA4 size | £7.50 |
| Glue | | £6.40 |
| Miscellaneous | | £6.00 |
| Paint | | £4.00 |
| Salt | 1.5Kg | £0.58 |
| | | £85 |

## Filming the miniature

Before I could start filming in the TV studio, I had to set the miniature up, and apply a few finishing touches. I wanted to add some snow to the miniature to make it look more interesting, and having snow on the ground had made it easier to shoot the live-action the week before. I had read that Industrial Light and Magic used table salt for snow on miniatures, because it has similar light-reflecting properties to snow, so tried using it and it worked brilliantly.



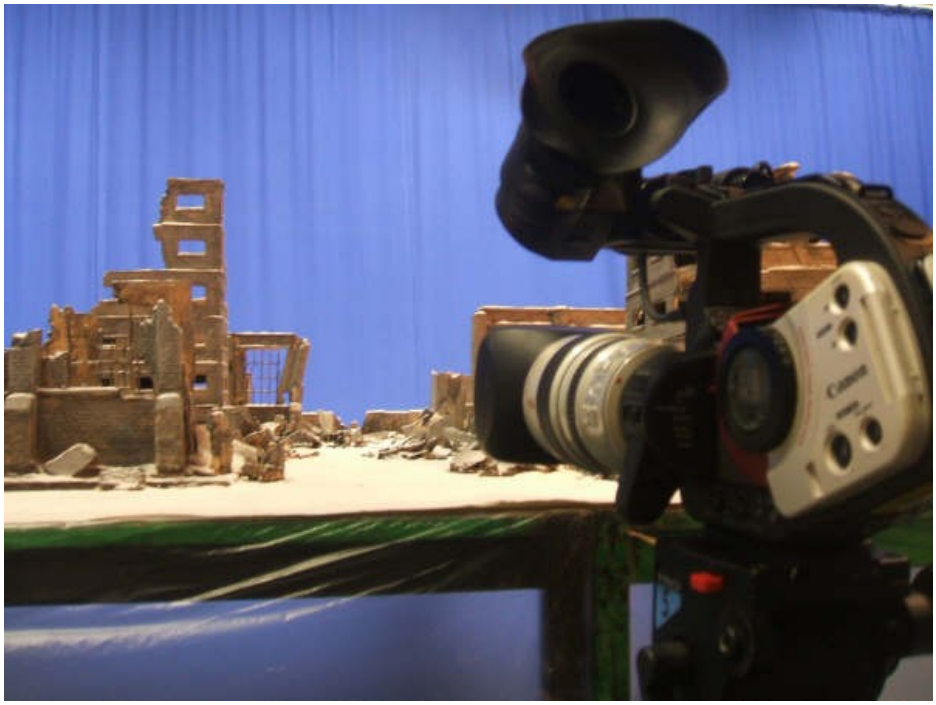
The miniature looked very flat and empty without any piles of rubble or snow in it, which goes to show the importance of fine detail and dressing the miniature.



I used PVA glue to stick salt to ledges on the buildings, and I piled up the rubble in the street. This extra detail made the miniature look a lot more believable.

I decided to film the miniature with two different lighting set-us, one for a dull overcast day, typical of most gritty war films with a desaturated look, and one with a bright sunset in the background reflecting off the buildings. This would help me to see any imperfection in the detail of the miniature, each potentially showing up flaws that the other wouldn't, and so further my understanding of the limitations of using miniatures. It was a lot easier to match the lighting on the miniature to the live-action than in my previous experience of working with computer graphics, something I would be very glad of later, in the compositing stage.

I had already filmed the live-action footage the week before, of soldiers walking, running and falling, so I had to try to approximate the camera angles I had used for this on the miniature. Of course, normally miniatures would be shot using a motion control rig, so that the camera move would match that of the live-action exactly. But I didn't have access to such a rig, so I knew I was going to have difficulty matching the camera moves, if I had any. Because of this, I did a lot of shots from locked-off camera angles, so there wouldn't be any movement to match up. However, as this was the Innovations project, the whole point of the project was to experiment, and I wanted to find out the limitations of what I could do with miniatures, so I wanted to try some shots with a moving camera. I knew there was a good chance they wouldn't work, so I tried to limit the degrees of movement the camera had for shooting the live-action and the miniature, to try to increase the chances that it would work. For all the moving shots, I either kept the camera on a tripod and simply rotated it, or I mounted the camera on a trolley to track sideways, parallel to the soldiers walking. In both cases, I just had to try to approximately match the speed it was moving for filming the miniature and live-action, and hope for the best.



Following advice from Claire Holman, I kept the camera down at ground level in every shot, sticking to camera angles that you could realistically film in real life. Looking up at the building from this low point of view made them look more life-size.

I could only leave the miniature set up for one day, so I made sure I got all the shots I needed while it was set up. I shot a lot more footage than I would need, so after filming, I went though the long process of sorting through all the footage to find the shots that best matched the live-action. I could then take these shots into the compositing phase.

## Compositing

The biggest problem I had in compositing was extracting a good matte from the bluescreen around the miniature, due to the camera that I used for filming it. For all of the shots where the camera moved, I had used a Canon XL1, and since it uses mini-DV tapes, it used a lot of digital compression on the footage, which gave horrible, flickering edges to the matte. I tried all of the different keying nodes in Shake to try and fix this, and found that the Primatte node gave the best results, but these still weren't great. The flickering was less obvious around the live-action of the soldiers, since they were moving, and I didn't have this problem with the locked-off shots, since I used a 5 megapixel still camera to capture the still background plates, which gave great results. Of course, extracting a clean matte is one step that isn't necessary with a computer-generated environment, since most renders will automatically contain an alpha channel already made.

The flickering is especially bad around the edges of the miniature in this shot, with the bright sunset in the background, because of the high contrast between the sky and the buildings.

For the shots with the camera moving, I then had to do my best to match up the movement between the miniature and the live-action. I had tried to approximate the same camera move when filming the two elements, but obviously this was far from accurate. So I used a Stabilise node in Shake to take out the camera move from the footage of the soldiers; the ground stayed in roughly the same place, but still had the perspective-shift from the camera move, which would be important later. I then used another Stabilise node to capture the 2D movement across the screen of a point on the miniature background, and then copied this movement onto the foreground soldiers. A bit of tweaking, and I was surprised by the quality of the results; although there was a bit of slipping between the foreground and background, you probably wouldn't notice it unless you were looking for it. Obviously, the static shots didn't need any tracking, and they worked very well.

Matching the colours and grain in the images was very important. At the top you can see the original colours in the footage of the soldiers, and they really stand out from the background. In the picture beneath it, I have adjusted the black levels and highlights on the soldiers, as well as reducing the saturation and removing the blue-spill around the edges. I didn't need to match the film grain between the soldiers and the miniature since they were shot with the same camera, but I added grain to the still background images in other shots, and to the sky in this shot, since it was just a still image too.

Just as an experiment, I shot a practical smoke element to use as an explosion in the foreground. I took the confetti out of a party-popper, replaced it with crumbled plaster and small splinters of balsa wood, and filmed it against a black sheet of fabric. I then darkened it down and used a Lumakey to composite it over the live-action footage. The results were reasonable, but I think it looks a little flat. Adding in some extra layers, with larger chunks of rubble would help a lot.

**Comparing Results: Miniatures vs. Computer Graphics**

Completing this project, I suppose the most surprising thing I found was how similar the overall process of building miniatures was to using computer graphics. In both cases, you would start by modelling some small building blocks for the environment that you could then duplicate over and over. Though of course, this is a lot easier in a computer. You would then paint – or texture – the model, and add in some finishing touches. Lighting the miniature in the TV studio was very similar to lighting a digital model, constantly adjusting the brightness of lights and moving them around, though this was far more intuitive on the miniature. Filming the miniature was obviously equivalent to animating a camera in Maya and rendering the sequence, and compositing with both techniques was almost exactly the same.

Looking at the results, I think I can honestly say that the level of detail I was able to model into the miniature does stand up to that of computer graphics. At the scale I used, approximately 1:30, there was more than enough detail in the surfaces and shapes; I even had to blur some of it out slightly to match live-action better. The characteristics of the images produced by the two techniques are very different; computer-generated images tend to be clean and precise, sometimes very flat and plastic-like, whereas the results I got from the miniature were a lot more rough and unrefined, with more texture and depth - this look was very well suited for a ruined city. Indeed, I think the quality of surfaces in the miniature was so good that if I were building a digital model of something similar, it might be worthwhile building some small sections as a miniature simply to photograph and use as textures on the digital model. The only thing inferior about the images I produced from the miniature was the flickering edges of the matte around the miniature, but this could easily be remedied by using a different camera that doesn't use as much digital compression. It's ironic that the biggest fault in my experiment with this traditional technique was actually down to the digital stage of the process.

When I was filming the miniature I had to duplicate the camera move from the live-action by eye. After stabilising the footage in 2D using Shake, the footage did line up surprisingly well, but the results were slightly flawed; the live-action slides around on top of the miniature a small bit, but not so much as to ruin the shots. Of course, using a motion-control rig would avoid this problem, allowing you to track the camera's movement in 3D, and then reproduce that movement exactly over the miniature, but this is obviously a very specialised piece of equipment. For large companies that do a lot of work with miniatures, motion control is a worthwhile investment, but not really for Bournemouth University. You would get better results than I attained by tracking a virtual camera in 3D with Maya, although that isn't always perfect. The shots I did with a locked-off camera worked very well; obviously these didn't need tracking.

Working on a digital model, I would normally spend a few hours on it at a time, but building the miniature I often had to spend about fifteen minutes at a time mixing plaster and filling a mould, and then I would have to leave it to dry. It was a different way of working, which was sometimes frustrating. Because of this, it wasn't really possible to keep an accurate record of how many hours I worked on the miniature, but I would guess that overall, the time I spent on it was fairly similar to what it would

have taken to build a digital model of a similar size. However, if I had wanted to build a larger expanse of a cityscape, it would have been a lot quicker with a digital model, since obviously, you can just duplicate buildings at the click of a button instead of going through the lengthy process of casting separate walls using moulds.

On the whole project, I spent about £85 on modelling materials to build the miniature; this is one cost that could have been avoided by using computer graphics. But from a company's point of view, with CG there are the other, less obvious costs of keeping hardware and software up-to-date, by replacing computers and programs on them every few months, so overall, the resources for building miniatures probably cost the same, if not less than using computer graphics.

## Conclusions

Overall, I don't think it's possible to say that miniatures or computer graphics are better than the other for creating environments outright; the results they give are both of a similar quality, and both require a similar amount of time and energy. I think that in the end, the choice of which technique to use should really come down to the nature of the environment you want to create; miniatures work especially well for creating rough textures, broken-down buildings and rubble, but I think computer graphics are better for doing environments on a larger scale, like entire cities, since it is so much easier to duplicate the work that you do digitally.

Completing this project has given me a useful and interesting insight into the other side of the visual effects industry, of using traditional techniques such as miniatures instead of Computer Graphics. I have discovered that they require a lot of common skills, the only difference being how you apply them, be it working with your hands, or with software and code. I definitely enjoyed doing some work with my hands again; it gave me a break from staring at a screen for a while, and to be honest, it was quite fun making a mess in my bedroom for a few weeks.

It would be very sad if the use of miniatures in film dies out all together, as digital effects become ever more dominant in the industry, but these two different techniques are perhaps strongest when used together. Working with miniatures would be very difficult without the use of digital compositing, and by combining miniatures with computer graphics, each can make up for the other's weaknesses.

## Appendix A: The History of Matte Techniques on Film

Special Effects have existed in film for almost as long as film itself. The very first effects were developed not for the moving image, but in still photography around the start of the 20th Century. I found a lot of the following information in the book Digital Domain: The Leading Edge of Visual Effects, written by Piers Bizony and published by Atrium Press in 2001.

The most basic of these early effects was the double-exposure, which was achieved by photographing two separate objects onto the same film, so the two images were overlaid and blended together. A very common use for this was to create ghost-like figures standing in the background of portraits, which would increase their value. The photographer would take a picture of the client in a studio, and once the client had left, he would photograph another figure onto the same film. The general public were unfamiliar with the technique, and could often be convinced it was the ghost of a loved one, especially with the onset of the First World War. The key to making this scam work was to make sure the second figure was photographed against a black background, because film doesn't "see" black. It is light that causes the chemical change on film to capture the image, and black is simply the absence of light, so only the ghost would show up from the second exposure, and not the background.

This was the beginning of the *matte process*, which is where unwanted objects are masked by areas of black to stop them from registering on the film. This led on to the invention of the *matte box* for still photography and moving image around 1910, a device which fitted onto the front of the camera, and used black card to mask off parts of the picture in different exposures. For example, if the photographer was filming a landscape on a dull, overcast day, he could mask off the sky and expose only ground onto the film. He could then wait a few days for a more interesting, dramatic sky, and then swap the mask over to protect the image of the ground already on the film, before exposing the separate sky onto the same film. This technique was only as accurate as the shapes cut out of the black card, and was therefore restricted to only very simple shapes, such as a straight horizon line, or the straight edges of a set. When used in movies, the camera had to be *locked-off* (not moving), since the matte could not be moved to match up with the subject.

Often, filmmakers wanted to create environments that were far too big to build as a practical set, such as classical cities or alien landscapes, so the technique of *Matte Painting* was developed around 1920. Part of the environment would be painted onto a pane of glass, which was positioned a few feet in front of the camera, and then live-action could be filmed though the transparent, unpainted sections of the glass.

This technique worked well enough, but was often given away by inconsistencies in the lighting, if the lighting conditions changed in between painting the picture and filming the action, like in the picture on Page 3 *(Ref 1).* One way of avoiding this problem was to paint black onto the glass to mask out the areas that would be filled by the painting, a *matte*, so that part of the film wasn't exposed when the live-action was

shot. The painting could then be completed over the top of the black after the live-action had been filmed, so that the lighting could match that of the live-action. The painting would then be photographed onto the same film as the live-action, in a second exposure, fitting neatly into the masked area on the film that was previously black. The rest of the glass would be filled in with black, to protect the live-action already exposed on the film, so the process worked in a similar way to the matte box, using black to mask half the picture at a time.

This shot from 1939's The Wizard of Oz used a matte box to mask the area around a minimal set, so the matte painting could be added in later. Since the matte-box is placed only a few centimetres in front of the camera, it is out of focus, so the edges are naturally very soft, and are almost seamless. *(Ref 7).*

Another method of creating fantastic environments that were too big to build in real life was to use miniatures. Like with matte painting, the miniatures could either be positioned in front of the camera and shot with the live-action in a single exposure, or they could be filmed afterwards in a second exposure, using a matte box to mask part of the frame. The miniature would extend the existing set upwards or outwards. The actors would have to stay within the confines of the set, otherwise they would disappear behind the miniature, when it should appear as though the miniature is behind the actor from the camera's point of view. If done in a single exposure, one advantage of using miniatures over matte painting was that the lighting on the miniature would almost always match that of the live-action. In both cases, a lot more detail could often be built into a miniature than could be painted onto a matte painting, but great care would have to be taken to ensure the perspective of the miniature lined up correctly with that of the set.

With miniatures, matte painting and matte-box techniques, the process was all carried out inside the camera, in one or more exposures, but was restricted to only being used for static, locked-off shots. It was the development of *rotoscoping* for film in the 1920s and 30s that allowed directors to combine different exposures whilst the camera was moving, and this was the beginning of the *travelling matte*, a term used to describe

mattes that change shape over time. The *Rotoscope* was a projector invented by Max Fleischer in 1915 for use in animation, and was used to project images onto sheets of acetate for artists to trace round. When it was adapted for use in film a few years later, actors' outlines could be traced frame-by-frame onto the acetate, and the area around them filled in with black. The design of the Rotoscope then allowed it to be converted into a camera, to photograph these acetate sheets onto black-and-white film. Since film captures a negative image of whatever is photographed onto it, the resulting film held the shape of the actors in solid black, while the area around them was transparent, creating a matte that would protect the image of the actor.

This matte could then be used in a device called an *Optical Printer*, which was used to copy footage from one filmstrip to another, frame-by-frame. The background image, filmed separately, could be copied onto a new reel of film, but with the matte pressed up against it to protect the shape of the actor and stop the background image registering on that part of the new film, producing a copy of the background with a black silhouette of the actor on top. The matte would then have to be copied onto another reel of black and white negative, to produce a *counter-matte*, which held the transparent shape of the actor surrounded by solid black. The original footage of the actor could then be copied over the silhouette on the new background reel, with this counter-matte protecting the background that has already been exposed. The matte and counter-matte should fit together exactly, so that all of the film is exposed, but without any overlap between the background and the actor in the foreground.

As well as using the Rotoscope to trace around actors, it could be used to mask around sets, miniatures or any other objects that changed shape on screen, which needed to be cut out. Obviously, this was a very long and tedious process, but it was the beginning of *compositing*, a term for layering together different images, which is still used today in the digital world.

Optical Printers are incredibly complex machines that consist of a projector (able to project double-thickness film to allow for layering with the mattes) linked to a film camera, to copy footage from one filmstrip to another. *(Ref 8).*

Aside from the complex process of copying and rephotographing many different reels of film, the main drawback of this technique was that every frame had to be drawn around by hand, and this often led to wobbly, flickering edges around the foreground elements, as well as being very time-consuming. The use of blue-screen was developed in the 1950s, to automate the keying process and avoid the need for rotoscoping. The simplest blue-screen technique was the *colour difference* process, in which the subject would be filmed against a flat, evenly lit bluescreen. The film would be processed, and then copied onto black and white film negative through a blue filter. The filter would only allow blue light from the original plate to pass through it, so the area filled by the bluescreen would be exposed onto the negative, but not the subject. Very high-contrast black and white film was used, so that the resulting matte comprised only of a completely transparent area where the subject was, surrounded by solid black where the bluescreen was (since the film stored a negative of the light that it received). This matte would mask the area filled by the background, allowing the foreground subject to be copied to a new reel of film, just like with the rotoscoped travelling matte process. And similarly, a negative counter-matte would have to be made from this matte, which would mask foreground subject and allow the background to be copied onto the new reel. Arthur Widmer and Petro Vlahos were two of the early pioneers who developed this technique, and both won Academy Awards for their achievements.

A more advanced method of bluescreen compositing was the *colour separation* process, developed in the 1970s. This technique used filtrated copying from the original footage, in a far more complicated photo-chemical process that relied on the fact that the blue content of most real-world colours was very similar to the green content. This technique gave better results than the colour difference process, but was made difficult by the endless possible combinations of film stock and chemistry.

Photochemical compositing reached its pinnacle in 1983, with the film *Star Wars VI: Return of the Jedi*, said to be the most complicated photo-chemical movie ever made. Since then, digital compositing has taken over, due to the cost-efficiency of it. *(Ref 9).*

Since the 1970s, digital effects started to appear in TV. Coverage of the 1976 Olympic Games in Montreal featured multiple camera angles shown simultaneously on split-screens, using technology developed by a company called Quantel. A few years later, the *Chromakey* tool allowed multiple-element digital compositing for TV in a similar way to the blue-screen techniques used for film. Pixels of a certain colour could be swapped with those of a different background, on a pixel-by-pixel basis. This was done in real-time, by copying images from multiple reels of videotape being played back at the same time. It became fairly common-place in television in the early 1980s, often being used in TV weather forecasts. Star Trek II: The Wrath of Khan, made in 1984, was one of the first films to be composited digitally, however, due to difficulties in digitizing film accurately, it was another 10 years before digital compositing of film footage became widely used. This footage had to be stored on computer hard-disks rather than tape, which were very expensive until recently, and the optical printer remained the preferred method of compositing until the early 1990s.

Quantel dominated the market in digital compositing technology, with their series of "Paintbox" suites, until another company, Discreet Logic, released their own compositing suite, "Flame," which was based on hardware developed by SGI. However, the cost of these suites, at upwards of $500,000 in the early 1990s, made them out of reach for a lot of smaller post-production houses, and a Mac-based program called AfterEffects became a popular budget alternative. This was followed by many other software packages for Mac and PC, such as Shake and Combustion, which have brought digital compositing into the modern age.

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*Ref 1:* image by Mark Bosko, 2001
Image taken from http://www.videomaker.com/article/8208/

*Ref 2:* "Ben Hur," 1925
Image taken from www.pbs.org/wgbh/nova/specialfx2/1920.html

*Ref 3:* "Things to Come" by Alexander Korda, 1936
Image taken from "Digital Domain: The Leading Edge of Visual Effects"
By Piers Bizony, Atrium Press, 2001

*Ref 4:* "King Kong" directed by Merian C. Cooper and Ernest B. Schoedsack
Image taken from www.imdb.com

*Ref 5:* "Star Wars," Directed by George Lucas, 1977
Image taken from Cinefex magazine.

*Ref 6*: "Lord of the Rings: The Return of The King," Directed by Peter Jackson, 2003
Image taken from Cinefex magazine.

*Ref 7*: "The Wizard of Oz," Directed by Victor Fleming, 1939
Image taken from www.imdb.com

*Ref 8*: The Beast, an example of an optical printer
Image taken from http://seriss.com/people/erco/korea-july-2001/page2.html

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