STEREOSCOPY'S IMPACT ON THE MAKING OF DIGITAL VISUAL EFFECTS IN FILMS

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After **Esther Jacopin** completed a three-year practice-based doctoral programme to explore stereoscopy's artistic potential, during which she made two S3D short films, Esther Jacopin resumed her script supervising activities, while continuing to be in academic research.

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Abstract

Since *Avatar* (Cameron, 2009) was released, almost every stereoscopic 3D (S3D) film has contained digital visual effects (VFX). Assuming that stereoscopy and VFX nowadays go hand in hand, this article aims to study the impact of stereoscopy on the making of digital VFX. It will cross-reference information with crew members' witnesses from the production of the French films *Amazonia* (Ragobert, 2013), *Astérix & Obélix* (Tirard, 2012), and *The Young and Prodigious T.S. Spivet* (Jeunet, 2013). This case study-oriented approach will go through the three film production's stages: pre-production, on-set principal photography, and post-production, in order to provide an overview of changes in cinematographic techniques that occur when designing stereoscopic-VFX, as well as how cinema technicians manage to adapt their skills to make stereoscopic and visual effects cohabit in film images.

Keywords: stereoscopy, digital visual effects, space consistency, pre-production, post-production, film workflow.

Introduction

On the very first page of his book *Digital Visual Effects in Cinema (The Seduction of Reality)*, Stephen Prince (2017, p. 1) wrote: '*Avatar*, *Alice in Wonderland*, *Iron Man*, *Lord of the Rings*—these are the kinds of movies that people think of when the subject of "special effects" comes up.' He is indubitably right: all these movies show spectacular effects. It is however interesting to notice that three of the four movies he cited, were released in stereoscopic 3D (S3D), and that director Peter Jackson prolonged the *Lord of the Rings*' trilogy with the one of *The Hobbit*, for which he experimented with HFR-S3D at 48FPS. As most 'special effects-films' are nowadays also '3D-films', it becomes harder not to consider the former without the latter.

On the one hand, stereoscopy is an optical technique that fools the audience, giving them the impression that what they are watching really *is* in 3D. The three-dimensional aspect of the scene even appears as evidence the very moment the audience put their glasses on: stereoscopy does not hide the device that make it works. On the other hand, digital visual effects make the audience believe that the characters are walking on the moon or that they are seriously injured after an accident. But contrary to stereoscopy, as Réjane Hamus-Vallée (2004, p. 9) notices in her study on special effects, 'to ensure the level of realism required for a doubtless identification, the effect must appear… without its cause'. Like magic tricks, VFX tools and devices must remain invisible, and the audience should only see the result: the film's credibility is at stake. Nowadays, in the digital film era, most stereoscopic 3D films contain VFX shots. How do filmmakers make these illusions work together within a film, while saving the consistency of images?

I decided to focus on the technical aspects of this issue, instead of evaluating the results of VFX in S3D films through their aesthetics. This article is therefore a case study, presenting witnesses who are film crew members, especially the visual effects supervisors Christian Rajaud,[1] Rodolphe Chabrier[2] and Guillaume Le Gouez,[3] who shared their experience on the French films *Amazonia* (Ragobert, 2013), *Astérix et Obélix au service de Sa Majesté* [*Astérix & Obélix: God Save Britannia*] (Tirard, 2012), and *The Young and Prodigious T.S. Spivet* (Jeunet, 2013). This case study will, in this way, explore

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1)   Christian Rajaud's words are retrieved from personal emails we exchanged in April 2013.
2)   Rodolphe Chabrier's words are retrieved from interviews published in VFX magazines, and completed by a phone call-interview on February 11th, 2019. These latter are asterisked (*).
3)   Guillaume Le Gouez's words are retrieved from an unpublished interview held on March 19th, 2019 at Compagnie Générale des Effets Visuels' studio in Paris.

the impact of stereoscopy on VFX production, following the workflows of films from the pre-production to post-production stages.

Pre-production: Anticipating Stereography and VFX

As stated by Cédric Plessiet (2014, p. 15), 'A director could hardly take time on set to experiment spatial arrangement, cameras' or characters' positions… or visual effects that are too complex to be conceived and designed at the very last moment'. Though it is worth thinking of the scenes' breakdowns and shot lists in advance, many elements might remain uncertain during the pre-production of a feature film such as *Amazonia*. The film, directed by Thierry Ragobert, was released in France in November 2013. It depicts Amazonian wildlife through the adventures of a small monkey, raised by humans, who returns to his natural habitat after the aeroplane that was transporting him crashes in the Amazonian forest. Eran Dinur (2017, p. 115) counts the storyboard as one of the VFX pre-production steps. A storyboard was made prior to the filming of *Amazonia*: 'We had in mind that some camera movements don't look that good on screen when the stereography is strong (such as horizontal pans), whereas it could be interesting to play with depth within the frame', explained storyboard artist Loïc Fontimpe.[4] However, '[t]he director, the stereographer, and I, rather focused on the story. How to tell a 90 minutes long story which main character is a non-speaking monkey? […] So the storyboard looked as usual, with simple drawings.

Choices regarding 3D could be mentioned below them', recalled Loïc Fontimpe.

Script supervisor Laurence Couturier's shooting storyboard (Unknown, 2011) of *Astérix & Obélix: God Save Britannia (Astérix & Obélix au service de sa Majesté)* shows some notes as well, regarding both S3D and VFX. The film adapted the French popular comics *The Adventures of Astérix* (*Les Aventures d'Astérix*), created by René Goscinny and Albert Uderzo in the 1960s, telling the adventures of Astérix, a Gaul who, with the people from his village, always defeats the Roman army thanks to a magic potion that makes them invincible. Laurence Couturier's notes on the storyboard regarding VFX are more numerous compared to the S3D notes, which mostly mention negative parallax effects. All the notes are hand-written, which confirms, as cinematographer Denis Rouden told me during a discussion we had when the film was released, that it was not the director Laurent Tirard's first intention to make the film in 3D: the notes were more likely the results of pre-production meetings and artistic discussions prior to the filming.

On the contrary, it was director Jean-Pierre Jeunet's first wish to adapt Reif Larsen's novel (published in 2009), *The Young and Prodigious T.S. Spivet* into S3D for his seventh feature film. 'The main character is a child, a young scientist who imagines lots of things', explained Jean-Pierre Jeunet. 'If you look at the book, there are plenty of drawings in the margins, that illustrate what the boy has in mind. So I immediately thought it would be valuable to make the film in 3D. What really pays

you back in 3D are objects coming out of the frame, floating, that you want to grab. […] So I really thought the film for 3D, storyboarded it for 3D, wrote the script for 3D.'[5] The film is therefore full of objects, and even playlets that appear in negative parallax. Its storyboard appears to be the most precise of our study.[6] The entire shooting script is colour-coded and replicated next to the black and white drawings: it is more a 'storyboarded-script' than a usual storyboard. 'A document of such precision is a valuable tool', commented Guillaume Le Gouez, who supervised the film's VFX in post-production. Scene numbers appear in red, action is kept in black whereas the dialogues are purple. Technical information regarding camera angles and movements, as well as scenes' expected timing are green. Blue notes concern S3D, which is often

connected with VFX, for instance when it says (p. 75): 'a huge and appetizing hot-dog appears superimposed and floating in 3D'.

All three storyboards differ in the way they treat VFX and S3D, and how precise they are regarding the latter. Such disparities challenge the purpose of a storyboard: what is it aimed at? And, most importantly, is it the same in 3D as in 2D? 'In 3D, a storyboard has the same function as in 2D', stated *Amazonia*'s VFX supervisor Christian Rajaud. 'We use it as a reference, but we rarely follow it to the letter. I mostly use the information I get from a storyboard to design a methodology, and my VFX breakdown permits me to make a preliminary estimate to the production. It will evolve during the shooting, depending on the real conditions.' In other words, a storyboard, whether the film is in 3D or in 2D, is aimed at giving the entire film crew the same document, indicating the artistic direction decided for the film. People are therefore able to start their prep-work and decide the working-method that suits the best the filming conditions during principal photography… While juggling with the unknowns in the equation: '*Amazonia*'s storyboard was made without precise knowledge of the locations, nor the system to shoot the plane while it's flying', related Christian Rajaud.

On the contrary, when the film's specificity allows the director and the production team to know about the filming conditions in advance, the storyboard is then a solid reference that allows the VFX team to push forward the previsualisation

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4)   Loïc Fontimpe's words are retrieved from personal emails we exchanged in March, 2019.

5)   Jean-Pierre Jeunet, apud Miguel Almiron, Esther Jacopin & Giusy Pisano (Eds.) (2018). Rencontre avec Jean-Pierre Jeunet et Demetri Portelli. *Stéréoscopie et illusion*. Villeneuve d'Ascq: Presses Universitaires du Septentrion, p. 229.

6)   Included in the French collector Blu-ray edition.

process. 'We shot some VFX scenes as tests, two months before the shooting started', recalled Guillaume Le Gouez about *T.S. Spivet*'s pre-production. 'Both for technical purposes (in order to anticipate the problems we might face on set, as well as setting the proper workflow) and artistic reasons, so as to present Jean-Pierre Jeunet the stereographic possibilities for his film.'

Considering the pre-production stage of these three French films, stereoscopy did not have much impact on the VFX production workflow. It is however the principal photography itself that usually concentrates everyone's attention.

Managing Stereography *and* VFX on Set: A Space Affair

When asked[7] about her experience on *T.S. Spivet*, script supervisor Anne Wermelinger said she sometimes reminded stereographer Demetri Portelli that the current shot was a VFX one, and that computer graphics (CG) objects would be added in negative parallax, so that he would not set a strong depth budget for the live action material. Indeed, if the shot already had strong negative parallax effects, all the CG objects added in post should have more negative parallax than the live action elements, so as to avoid some kind of 'depth conflict'. It would have increased the negative parallax budget and caused visual eyestrain. Watching the making-of the film, one could witness that it concerns all types of VFX, and not only those with CG elements. This happened, for instance, when T.S. is being told-off by his teacher: the shot 'freezes' to let a playlet superimpose itself over the first shot, playing what the boy would love to give as a reply to his professor. The shot was made of two live-action layers: the one of T.S. being told-off, and the one of his dreamt response. The making-of the film shows Jean-Pierre Jeunet and crew members checking the shot, watching the on-set monitoring equipment providing real-time play-back of the two live-action shots superimposed. The S3D monitor shows the variations of disparity between left- and right-images while the stereographer is carefully increasing the stereographic settings of T.S.'s response-shot (the superimposed one), to make it grow in the negative parallax space. The issue here was then to ensure the audience's visual comfort on the one hand, as well as spatial compatibility between stereography and digital VFX

on the other hand, which actually reveals itself to be the biggest issue on set.

In his book, Stephen Prince (2017, p. 4) notices that nowadays 'virtual environments […] are indistinguishable from real locations'. His observation follows the same lines as Réjane Hamus-Vallée's words quoted in the introduction, and therefore brings two issues out regarding the making of digital visual effects, and their reception. The first one is that any special effect is achieved if it fits the image, and therefore viewers should not be able to see any difference between the effect itself and the rest of the image, nor be able to identify the 'welding point' between them. This also consequently means that CG elements within the frame must look as if they are there *for real*, and their apparent position in space needs to be consistent with live-action elements: the effects' credibility is at stake. This is where difficulties start for the VFX crew, as stereoscopy, which is based on human binocular vision, gives the viewers a more precise awareness of space: they are now able to *see* dimensions and distances between objects within the S3D frame.[8] Information related to space then becomes very important on set:

In the case of CG objects, you must get the camera's coordinates (lens, high, distance, tilt…), everything that informs the camera's spatial position on set, so as to be able to create a digital replica according to the three axes. You also need to

take spherical HDRis[9] to get references about the lighting, so as to replicate it on 3D objects and characters. Such information is needed whatever you're making a film in 2D or in 3D.

What Christian Rajaud underlines here is the importance of space. Besides collecting the usual data, 'specific measurements you need for 3D are the interaxial and the convergence', explained Christian Rajaud. The script supervisor sometimes helps by noting them down on his/her continuity notes. During the principal photography of *Astérix & Obélix*, for instance, script supervisor Laurence Couturier designed her continuity notes, adding a column dedicated to stereographic data:

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8)   Laure Leroy's research demonstrated viewers' visual sensations when watching stereoscopic images. See: Leroy L. (2009). *Interfaçage visuel stéréoscopique: diminution de la fatigue visuelle et caractérisation de la perception des formes* [Unpublished doctoral dissertation]. École Nationale Supérieure des Mines de Paris; and Leroy L. (2018). Explorer la stéréoscopie intermittente: son influence sur la perception et la fatigue visuelle (pp. 23-41). In M. Almiron, E. Jacopin, & G. Pisano (Eds.). *Stéréoscopie et illusion*.

9)   High Dynamic Range images (see Dinur, 2017, pp. 152-153, for more details about the use of spherical HDRi light domes for CG lighting).

7)   Unpublished interview held in May, 2013, for prior research.

FIDÉLITÉ FILMS			ASTÉRIX GOD SAVE BRITANNIA			CARD No.		
						CARD No.		
LAURENT TIRARD			DENIS ROUDEN			DATE		
				VFX		3D		RIG
SHOT	TAKE	CLIP	LENS	HIGH TILT	DEPTH	STEREO WINDOW	INT.AX	MISCELLANEOUS NOTES

Fig. 5 Reproduction of continuity notes form designed by script supervisor Laurence Couturier and used during the principal photography of *Astérix & Obélix*. Courtesy Laurence Couturier.

The spatial data collected on set are then used by graphic artists to replicate the filming conditions in virtual environments and spaces of computer graphic imagery. Though no graphic artists and VFX supervisors who were interrogated during this survey contested their usefulness, visual effects supervisor and co-founder of Mac Guff studio Rodolphe Chabrier remained cautious about the true efficiency of on-set spatial and optical data:

It can be useful to get the maximum of on-set information, but in many cases, we can work without them, by cheating or just by looking at the images. If there is a camera movement, we can either get the spatial datas directly (on set, or from the motion control computer), or we can retrieve them from 3D tracking, which means analysing the optical flow. It happened many times that the result looked great though our spatial coordinates were different from those of the cameras on set!*

However, as achieving VFX is delicate work, 'it is always better to have redundant info than missing info', as Eran Dinur advised. And VFX teams may need any kind of support to start working properly.

Matching Spaces in Post-Production

There are a few difficulties that VFX teams may face working on a S3D project, mostly due to stereoscopy's specificities. Indeed, as stereoscopy relies on a *pair* of images, it requires the stereo-pairs to be constantly checked, starting from the very beginning with some adjustments, as Guillaume Le Gouez related:

Before being hired on *Spivet*, I had worked in London on the VFX production of *Pirates of the Caribbean 4*, that was shot in 3D. I learnt that 3D images need to be 'calibrated' prior to start working, otherwise you may lay the foundations the wrong way: every graphic artist painstakingly calibrated each shot before starting to work. So when I came on *T.S. Spivet*, I suggested to have a team dedicated to this work, and we organised rotations to avoid people to spend the whole production only calibrating images. Otherwise some would have turned crazy, spending six month calibrating the images without being allowed to do any creative work on it.[10]

Moreover, working on pairs of images for each shot, consequently increases the amount of data that the VFX production generates and the time for rendering, and increases the need for powerful computers. For instance, the 270 VFX shots MacGuff designed on *Astérix & Obélix* generated a total amount of 40 TB.[11]

The post-production of *Astérix & Obélix* was originally planned at Duran-Duboi laboratory and VFX studio: they had already supervised the VFX production of the three other *Astérix* films, and got the contract for the fourth one as well. 'We accepted it', recalled Rodolphe Chabrier (Biélik, October/November 2012, p. 32). But they had not reckoned with some unexpected events during post-production, as Alain Biélik (2012)

related when the film was released: 'after Duboi's owner Quinta Industries went to bankrupt, the studio was put into liquidation. Producers of *Astérix* found themselves without VFX provider, with a release date already announced, and a month behind schedule.' Fortunately, the production companies[12] were allowed to get their dailies back, before they finally shut down the machines and closed the studio. This is how Mac Guff finally got the contract for *Astérix & Obélix*'s VFX production, shared with Mikros Image Montréal VFX teams. They then started working with a rather strong handicap, considering that the film contained 620 VFX shots (Biélik, 2012). 'After that, the very first difficulty was to resume a project that we haven't supervised on set',* recalled Rodolphe Chabrier:

When you're working on such project, it is essential to have a strong pipeline and to get the maximum amount of datas back. We never got the script supervisor's logs. Hopefully, stereographer Alain Derobe and his crew, especially his daughter Joséphine, had systematically written down the datas for each shot: the interaxial, the effect, if they had any problems with the cameras, their places. […] As far as I remember, things went rather well.*

10) Although the on-set S3D team take all possible precautions and double-check the S3D rig, camera misalignment may remain (or occur while filming). That is one of the reasons why, once the editing and colour grading are over, the stereo-supervisor proceeds to a 'stereographic grading' to correct misalignments and to adjust the depth-budget according to the final editing (see Mendiburu, 2011, pp. 200–202, for more details).

11) According to Rodolphe Chabrier (apud Biélik, October/November 2012, p. 33).

12) *Astérix & Obélix* was not the only film for which Duran-Duboi got the contract for the post-production at that time.

Thus, it was not Mac Guff's first stereographic attempt. The studio had already invested in some equipment and acquired stereographic skills:

We had already experimented 3D twenty years ago. And as we also do *morphing*, for which we have to settle a consistent Z axis for a given space, we're used to check our work on 3D monitors. Besides, we've worked on animated movies that we converted, for instance those of Michel Ocelot's. So we already had all the computer graphic tools, as well as the monitoring equipment, so that CG artists could actually see their work in 3D.*

T.S. Spivet's VFX production also found itself connected to Duran-Duboi's story: indeed, Alain Carsoux was one of its VFX supervisor.[13] When Duran-Duboi closed, he founded his own studio named Compagnie Générale des Effets Visuels (CGEV), specifically to answer Jean-Pierre Jeunet's wish to supervise the VFX of his new film, as he had supervised the VFX of all Jeunet's films before. Besides the project's challenges of combining both VFX and stereoscopy, the new-born company had to deal with a tight schedule to produce the 350 to 400 VFX shots the film contains.[14] 'We usually start working once the editing is "locked"', explained Guillaume Le Gouez. 'But for *T.S. Spivet*, we worked a bit differently: I started working alone in December 2012, right after the end of principal photography, then we really started the VFX production in January. If I remember well, we worked until June. So we were working at the same time with the editing, mostly

because the effects gave the film a different rhythm, and also because stereoscopy imposes its rhythm to the film.' This led Alain Carsoux to settle the VFX production at Digimage laboratory, where Jean-Pierre Jeunet and editor Hervé Schneid were working: 'it allowed us to green-light VFX shots in 3D as quickly as possible, which required the screening room to be large enough. Indeed, you need to get back far enough from the screen to evaluate how it looks in 3D', commented Alain Carsoux (Hamus-Vallée, 2018, p. 208). And he was right to take such precautions, as the film — like the two others in our study — had some surprises in store for the graphic artists.

Spatial Anomalies and Distortions: Stereoscopy's Traps

VFX supervisors' witnesses brought to light the importance of space consistency for both stereography and VFX. When the two meet in a single film, the smallest details are of great importance. It becomes harder for the VFX team to maintain the illusion within the frame's space, and stereoscopy and digital visual effects sometimes come into conflict.

As an optical technique, stereoscopy allows directors and artists to create (depending on the stereographic settings) spatial distortions *on purpose*, according to their artistic wills, as Guillaume Le Gouez related about one of *T.S. Spivet*'s effects:

Jean-Pierre Jeunet had the idea of a Dolly zoom shot, for which he wanted the child to be in negative parallax at the

end. So we ran a test-shot in a large room, a rather profound one. We put objects in between the boy and the camera, and also behind him — I can't remember whether we did it on purpose. The Dolly zoom worked pretty well: objects were moving in depth, with some objects behind the child coming to the front... It was a really interesting effect, and as the results were rather satisfying, it gave us confidence. But we finally faced difficulties when the time came to achieve the effect, because the final set was unfortunately not as deep as the test shot-room, and it was not possible to put objects behind the child. It has been more difficult for us to reproduce the effects we got from the test shot. I remember that this Dolly zoom effect had been challenging...

Mac Guff studio's VFX team also faced some challenges when working on *Astérix & Obélix: God Save Britannia*, but these were unexpected. The film's screenplay mainly adapted *Astérix in Britain*, with some narrative elements and characters from *Astérix and the Normans*. The movie starts with the Roman invasion of Britain: the entire Roman fleet crosses the Channel, with Julius Cesar at its head. It had been planned to make digital replicas of the Roman galley that had been filmed on set, but the entire scene finally required digital VFX. Rodolphe Chabrier (apud Biélik, October/November, 2012, p. 33) still recalled that episode:

Malta's studio has an outdoor pool, where they filmed the action on Roman galley's bridge. It is actually an overflowing sea-pool, which means the water merges with the Mediterranean Sea behind. It works perfectly in a 2D film, but the

illusion doesn't work anymore in 3D: as 3D permits you to see the distances, you immediately notice that the pool is in the front, whereas the sea is far behind... As a result, we had to systematically replace the sea with full-CG-3D-animated water.

Moreover, mattes, rotos, and other compositing work may look perfect on right- and left-images *separately*, and yet reveal flaws when being viewed as a stereo-*pair*. 'We could have a perfect roto on both left- and right-images, but when we discovered the stereo pair, it didn't work anymore: we could see a slight shift between the two masks...', related Rodolphe Chabrier (apud Biélik, October/November, 2012, p. 33) in reference to the Roman galleys.

Christian Rajaud also raised the fact that 'when you're doing compositing, you may play on the character's size very often, in order to make him perfectly fitting the set's space. But if you do that in 3D, that might change the character's position

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13) He had indeed supervised the VFX of the first two *Astérix* films (Biélik, 2012).

14) Although he was not able to say how many VFX shots there are exactly in *T.S. Spivet*, Guillaume Le Gouez asserted that all the film's 170 scenes had up to 2 or 3 VFX shots.

15) Retrieved from: https://www.pixelcreation.fr/3d-video/filmvideo/asterix-et-obelix-au-service-de-sa-majeste/. (Accessed: 15th November 2020)

in depth as well, so that method wouldn't work.' As he recalled one of *Amazonia*'s blue-screen shot, made of a group of monkeys in a tree, later on composited with a plate of jungle trees, the VFX supervisor continued his explanation: 'the plate was shot from a high tower above the forest, but it couldn't frame other trees that were too close from the main one, otherwise that might have created a "depth conflict" if we had to change one of the trees' size according to the others.'

Stereoscopic VFX: Elements for Conclusion

It has been years now that visual effects have carved out a place for themselves within the films' production workflows. Although it was invented long before the cinema, stereoscopy remains 'young' in comparison. But after more than a century of 'flat' cinema, technicians and artists still have not completely mastered the results of the stereoscopic illusion. It is only necessary to have a look at the differences between pre-production documents' precision, such as the storyboard, to notice how difficult it is for some directors to envision their film *in* 3D, that is to say *with* the stereographic effects. Making stereoscopy and VFX cohabit within a single film certainly gives a 'wow' effect for the audience (even with discreet VFX and few negative parallax effects), but it definitely adds difficulties for the VFX teams as we observed all through our survey. Besides the amount of work, as well as the time required to achieve such effects (that VFX studios often vaunt when Hollywood blockbusters are released – to demonstrate how big the challenge was, as well as for self-promotional purposes), it is the quality of the spatial illusion that is at stake. Integrating VFX within stereoscopic images indeed requires great rigor during the principal photography, taking

precise measurements that are necessary when the time comes to achieve the VFX in post-production. When shooting in S3D, VFX teams and on-set crew members therefore pay more attention to the on-set spatial organisation and technical equipment as to the on-set elements, and note down the stereographic settings that will impact the spatial representation within the frame. One might think these spatial and optical data are enough; however, stereo-3D VFX shots revealed themselves to be more complex to produce than they seemed to be at first look. They can even surprise VFX and post-production teams, challenging their *savoir-faire* because of unexpected results of effects they are familiar with. VFX supervisors and graphic artists have then adapted their working-method, and the VFX post-production workflow, to stereoscopy's specificities. They now carefully pay attention to both images separately as much as to the pairs, starting from the very beginning by calibrating them to check if the stereography is right before going any further. VFX teams have also invested in special equipment. Watching the effects on appropriate monitors allowing real-time playback both on set and later on during the post-production, before checking them on a projection screen, reveals itself to be necessary, and remains the best way to make sure that VFX-3D space will fit the images' stereoscopic space... And it is also the way to stay close to the director's artistic vision.

Acknowledgement

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