Going to the Movies: Lessons from the Film Industry for 3D Libraries

Neil A. Dodgson

The Computer Laboratory, University of Cambridge,
15 J J Thomson Avenue, Cambridge, UK CB3 0FD
Neil.Dodgson@cl.cam.ac.uk

Abstract. The film industry can provide insights for researchers in cultural heritage. Modern movies require the management of an enormous number of digital assets, analogous to how digital assets are managed in cultural heritage. Furthermore, movies are cultural artefacts in their own right: the preservation of movies gives lessons in the preservation of other ephemera, including all of those digital assets. Finally, some movies use historical contexts and there are lessons in why collaboration between cultural historians and movie-makers can be unsatisfying.

Keywords: culture, heritage, history, film, movie, 3D, modelling.

1 Introduction

Cultural heritage applications often involve the acquisition or creation of 3D models. Two industries drive development in 3D modelling: games and movies. The use of 3D modelling in movie production is either ahead of academic research or actively using the most recent academic research. Key milestones in the history of 3D modelling in the movies are:

- *Jurassic Park* (1993), widely regarded as the first major motion picture to use photorealistic digitally created 3D characters in a central role.
- *Toy Story* (1995), the first feature film with completely computer-rendered 3D characters.
- *Final Fantasy* (2001), the first computer-generated animated motion picture with photo-realistic 3D humanoid characters.
- *Avatar* (2009), large-scale use of live-action motion capture that directly drove computer-generated 3D rendering.

The rise in use of 3D models has been dramatic. It is now possible to make a live-action movie that is largely rendered from 3D models and almost all major animated motion pictures are now rendered in fully-realised 3D worlds. The largest visual effects companies (e.g., Pixar, Disney, Weta) today have their own research divisions, which publish in the major research venues. This multi-million euro industry has the resources to create 3D models of stunning quality. It has to manage large volumes of

data. In many ways, it provides lessons for the use of 3D modelling in cultural heritage.

With regard to managing digital 3D libraries, the American Academy of Motion Pictures Art and Sciences reports: "Current practices in other sectors such as medical, earth science, government, corporate businesses and supercomputing have spotlighted two major findings of interest to the motion picture industry: (1) Every enterprise has similar problems and issues with digital data preservation. (2) No enterprise yet has a long-term strategy or solution that does not require significant and on-going capital investment and operational expense." [1]

Most of this paper is concerned with lessons that can be learnt from the film industry. However, I begin by considering movies as cultural heritage in their own right. In particular, asking how well we have been preserving movies for posterity.

2 Movies as Cultural Artefacts

I visited CineSite in London in 2008 [2]. My host expressed concern about how many movies remained undigitised in the British Film Institute (BFI) archive. This is a big problem: the BFI has an archive of 150,000 movies: a thousand million feet (300,000 kilometers) of physical film. These movies are themselves only one third of the BFI's total archive of footage [3]. I was given the impression that time was pressing and that the BFI risked losing precious heritage to the inevitable deterioration of physical media. However, further investigation reveals that this is overly pessimistic. Stored correctly, physical film has a better chance of survival than some digital media.

2.1 Preserving Film

Physical film has interesting properties that make it challenging to store. It is constructed from layers of different materials on a robust but flexible substrate. It can fail in several ways. For example, the layers can detach from one another making replay impossible and reconstruction difficult [4]. More dramatic are some of the failure modes of the flexible substrate. The earliest films used nitrocellulose. It was chosen because it has the required flexibility and robustness. Unfortunately it is also highly flammable. This *nitrate* film has a tendency to burst into flame spontaneously, and then to burn uncontrollably because its combustion releases oxygen that fuels further combustion. Despite this challenging drawback, it was used in the early decades of movie production because there was no other cheap material with the required properties.

Acetate film replaced nitrate film in the early 1950s. Acetate film does not spontaneously combust. Unfortunately, after many years of using acetate, it was discovered that it has its own dramatic failure mode. If stored in poor conditions, the film slowly releases acetic acid (the acid in vinegar). This causes the film substrate to become brittle and shrink, destroying the ability to play it back and badly affecting the image quality. Worse still, acetic acid fumes from one reel of film initiate decay in any reels stored nearby, thereby multiplying the loss. Nitrate film is, of course, even

more dramatic in its multiplicative loss, because the combustion of a single reel of nitrate film can lead to the loss of an entire archive to fire.

To someone indoctrinated in the superiority of digital media, this bodes ill for the future preservation of movies. Simply put: a lot of archive material is preserved only on film and film deteriorates over time. However, the situation is not as bad as it seems. Organisations like the BFI invest heavily in preservation. Some film has already survived reasonably intact over 70 years [3]. More crucially, our understanding of ideal storage conditions has improved dramatically over the last century [4]. We now know the ideal conditions for preservation of acetate and nitrate film. They need to be stored cold and dry. That is, near freezing point (0°C) and at low relative humidity (below about 40%). In these conditions, we expect physical film to remain intact and usable for centuries [4].

Compare this to storage on digital media. Half-inch digital archive tape (LTO Ultrium) has a predicted life of 30 years [5]. While impressive, for digital media, it is far short of the centuries promised for physical film. Furthermore, digital media bring other issues: we must preserve the playback mechanism, spare parts for the playback mechanism, and software that can interpret the digital format. In contrast to the view that physical film is a poor storage medium, it seems that preserving movies on physical film may be a better bet than preserving them on digital tape.

However, digital tape is decreasingly used for archive. The trend is to keep archives on permanently spinning media. By using disc, and by continually upgrading and updating the disc store, we are able to guarantee storage for as long as the electricity supply continues and for as long as we can buy those upgrades and updates to the disc store. Furthermore, just as disc supplanted tape, it is possible that solid-state memory will replace disc as the storage medium of choice.

But this does not solve the whole problem. There is also the question of format and playback. Physical film is well-understood and the methods of playback have changed little in decades. By contrast, new digital formats are constantly being introduced and existing formats updated. In 2008–10, the American Academy of Motion Pictures Art and Sciences undertook a case study in digital preservation [6], considering archive of two hours of film and associated media. Although the project concerned itself with archiving only film and photographs, the team still had to deal with seven known file types and several unknown (and therefore unarchivable) file types. Another report from the same organisation [1] estimates that the annual cost of preserving archival footage is about US$1,000 per title on physical film but US$12,500 in digital formats owing to the significant and perpetual spending required to maintain accessibility of digital media.

So, the first lessons we learn from the movies are that the digital brings a slew of new problems not faced by physical storage and that preservation of any medium requires continual investment. We can preserve movies as cultural artefacts for a long time, provided we have sufficient funds either to pay for the air conditioning in our physical film stores or to pay for continual upgrades and replacements of disc drives and software in our digital stores. The good news is that, so long as we maintain a necessary level of investment (and of civilisation), we can essentially achieve permanent archive.

2.2 Lost Movies

This discussion of movie archive leads us to another question: how many movies have been lost over the 120 years since the first movies were made? The answer is that about 3500 movies are documented as being lost, 90% of which were produced before 1940, and that almost nothing has been lost since 1970 [7]. The industry has become remarkably good at preserving its product [1]. Over 7,000 movies are being made each year[1] and all of them are archived in some way. The lesson we can learn here is that what we tend to lose are the products of early days of a new medium. What is true of movies (most of the loss is pre-1940) is also true of television (most of the loss is pre-1975).

3 Lessons from Movie Production

Let us now turn to consider lessons from production in the movie industry. In particular, lessons that we can learn about creating and maintaining 3D models, such as models of buildings. These artefacts are similar to those that are created and maintained by certain parts of the cultural heritage community.

For this, I draw on the "What's up Prof?" study[2] from December 2008. In that study, a small team of professors visited visual effects and post-production houses in London. Our aim was primarily to discover the challenges they face. We hoped to find computer graphics research problems with which the universities could help. What we found instead was a set of challenging infrastructure problems. Our summary report was published in the February 2010 issue of Leonardo [2]. Here, I provided longer descriptions of those challenges that can be related to cultural heritage. The challenges came in three flavours: technical, infrastructure, and people.

3.1 Technical Issues

Repurposing. Movie companies tend not to re-use existing 3D models. At present, 3D models tend to be made anew for each sequel of a movie. This is understandable as technology moves on between a movie and its sequel. However, we also find that the 3D models used for a movie are not used for the accompanying game. There is thus enormous duplication of effort across time and across different organisations.

This has resonances with 3D in cultural heritage, where each organisation constructs models using their own software, in whatever format is most convenient, with whatever metadata they think necessary. Repurposing this 3D data for other applications can be challenging. The movie industry has tended to avoid doing this at all, which indicates that 3D modelling is not yet mature enough for it to be advantageous to attempt to reuse rather than build from scratch. The CAD industry,

[1] Source for 7,000 new movies per year is the Internet Movie Database [8], which reported 6,886 feature films released in 2009, and higher numbers in subsequent years.

[2] For those who miss the cultural reference here: the title "What's up Prof?" is a reference to "What's up doc?", the catch-phrase of the Warner Brothers' cartoon character Bugs Bunny.

by contrast, has faced the problem of multiple data formats for decades. There is an active market for software (e.g., TranscenData's *CADfix*) that accurately converts 3D models between different, often partially-incompatible, formats.

Finding assets (indexing). An individual movie will now use millions of assets, including 3D models, texture maps, and image layers. Any asset may appear in several different versions. Almost anything that is generated as an intermediate product will also be stored, because it is easier to store it "just in case" than to delete it and then have to rebuild it. A movie will employ hundreds of effects artists making hundred of shots over two or three years. It is vital that those digital assets are well indexed, so that an artist can easily find the correct version of an asset for the particular job at hand. The databases of assets are now so large that we need better ways to search images and 3D models.

These problems are also faced in cultural heritage, with the added disadvantage that we are not aiming for some finished product (the movie), after which we can discard the assets and their index, but rather we need to preserve the assets, their relationships, and a good index for decades. We also need to ensure that our meta-data remains accurate as our database matures.

Metadata matters. The Academy's case study on archiving digital film underscores the importance of metadata:

> "Archival processing efforts and costs increase exponentially if digital materials are not 'born archival.' That is, metadata should be captured and created at the time of content creation, and organization of materials for archiving should be considered and implemented as part of the production process." [6]

In both movies and cultural heritage applications, it is vital that the metadata is created alongside the object. Generating metadata later is expensive and prone to inaccuracy.

3D reconstruction. In 2008, the "What's up Prof?" team was told that "reasonable methods" exist for the reconstruction of 3D objects but that they work best with frame-synchronised views from binocular cameras. Support for 3D (stereoscopic) movie-making became a priority for the industry following the popularity of 3D releases like *Avatar* (2009) [9]. This led to high-quality binocular cameras being readily available, and such cameras are expected to bring benefits to cultural heritage by providing cheap, rapid capture of 3D objects. Extraction of point clouds from video or stereoscopic video seems well advanced. Extraction of data of *good enough quality* for the reconstruction of a complete 3D scene from multiple movie cameras is still challenging. As this technology matures, it will become readily applicable to cultural heritage applications.

3.2 Infrastructure issues

Trans-coding media between digital formats. There has been a proliferation of formats, which means that, for example, when producing advertisements, a single advert can be required in 10 different formats. To compound this, different subsets of

Table 1. Statistics from the making of *The Tale of Despereaux* (2008) [provided by Framestore]

Item	Statistic
Number of shots	1713
Number of locations	63
Number of (hero) characters	53
Number of variants in crowds	263
Number of props	1080
Number of 3D models	6098
Crew size (peak)	280
Render farm (CPUs)	4500
On-line data	150 terabytes
Number of published versions of assets	4,031,382
Dependencies between assets	20,375,436
Metadata (number of objects)	29,797,895
Metadata (number of attributes associated with objects)	397,714,992

those 10 will be required for each country in which the advert is used. Further, a contract may be for up to 100 adverts. The net result is that a lot of CPU time and staff time is spent in converting between video formats. Some effects houses have staff whose entire job is to trans-code between formats.

Consider archiving this digital artefact: how many of those formats should be archived? Is there a definitive version that should be stored for posterity? The movie industry has had a traditional policy of "save everything", which is unsustainable [1].

This has resonances in cultural heritage when we generate derivative artefacts. Should there be one master 3D file for a given object? Should we archive the derivatives of that file? What do we do if the original object changes in some way? How many versions do we keep? What is a significant change?

Transmission of large quantities of data including backup of large data stores. A post-production or visual effects house will produce gigabytes of new data each day. One company reported that no vendor of off-site backup was able to cope with the quantity of new data that they produce. Two companies commented that, because of this, they maintain their backups on site, with the obvious security risk. Images, video, and 3D models all require a lot of storage space. How much space should we reasonably allocate to them? Who will decide what should be archived, what should be backed-up, and what is ephemeral?

Again, this has resonance with cultural heritage projects, where vast amounts of data can be generated on site. It is important to realise that the film industry still struggles to handle large quantities of data, and it will be useful to get that industry's advice on practical solutions to these serious infrastructure problems.

Keeping up with technology. In parts of the industry, the basic algorithms have changed little in the past decade. The key problem faced in these parts of the industry is making best use of new technology to speed up processes and to keep ahead of the competition. For example, one company reported that only 10–20% of their code

performed image processing, with the rest of the code being required for data management.

The lesson for cultural heritage is that there is much more to 3D modelling than the algorithms for generating and manipulating the models themselves; there are also considerable challenges in ensuring that we can continue to store, retrieve, use, modify and manipulate those models.

Archiving and cataloguing assets. Archiving everything is problematic. If we do archive then cataloguing is important so that we know where to find things. For example, *The Tale of Desperaux*[3] (2008) has 1700 effects shots, with 4 million assets, with variations on those assets producing 10 million identifiable objects (see Table 1). These take up several hundred terabytes. The Academy suggests that this is small for a modern movie; it estimates that a single digital motion picture will generating upwards of two petabytes of data [1]. How do you archive something like this? How do you manage the archive? There are many subsidiary questions within this problem: for example, is it sufficient to store the original imagery and models along with a description of the process to get from those to the final shot?

This is an area in which cultural heritage researchers are likely ahead of the film industry. With tighter budgets and a need to preserve the important material for posterity, the cultural heritage industry has already had to face questions of just what should be stored and in what format.

3.3 People and Process Issues

Managing artists. Fifteen years ago, the creative 3D artists in the film industry were generally aware of the underlying technology and of the entire pipeline of getting from concept to the finished film. Today, these 3D artists are often less technically knowledgeable. Because the 3D modelling world has become specialised, artists are now able to concentrate on their creative role, but this leaves them with less knowledge of the technical underpinnings of their tools. This leads, inevitably, to situations where they fail to use the full power of the tools or fail to understand the implications of their actions for the later stages of the pipeline. On the other side of the emerging divide are technologists who understand the computer systems but not the ways in which artists work. The film industry greatly values those people who can bridge this divide: those who are experts in one domain, but who understand, respect, and can talk intelligently with those in the other domain.

This has echoes in the cultural heritage arena, where we have experts in complementary disciplines who can easily fail to understand one another. We need expert historians, archaeologist, technologists, and computer scientists. We need to train people who will become expert in one field but who will understand, respect, and be able to talk intelligently with the complementary experts.

Managing a large workforce. The film industry once consisted of small companies within which everyone knew everyone else. Over the last decade, several of the

[3] *The Tale of Desperaux* is an animated fairy story, produced largely by Framestore in London.

companies have become too large to work in this way. They are struggling with managing a creative, collaborative process when people in different parts of the chain do not know each other and have only a basic understanding of each other's roles.

This is, of course, true of any large organisation that has grown from a small one. If you watch the credits of any modern movie that involves much 3D modelling, you will see hundreds of names scroll past. Producing 3D models has become an intensive business, involving increasingly specialised experts. One cannot expect to do this successfully without good managers to oversee the process.

4 Cooperation between Film Production and Cultural Heritage

Finally, let us consider cooperation between film production and cultural heritage. Naïvely, we might expect there to be substantial scope for mutual benefit between the two. In particular, we might hope that cultural heritage researchers could re-use 3D models that have been created for historical movies.

The movie industry has vast resources and directors often want historical verisimilitude. There is certainly scope for cultural heritage researchers to advise on the historical details of a movie's production. For example, Kathleen Coleman, Professor of Classics at Harvard, was chief academic consultant on Ridley Scott's *Gladiator* (2000). However, she reflects that it is impossible for a single consultant to have an effect on every historical detail [10]. In the case of *Gladiator*, she was only one of over 800 people involved in the movie [8]. Pasinetti makes similar comments on his experience of Mankiewicz's *Julius Caesar* (1953) [11]. Both commentaries are clear that historical consultants play a useful role in such movies; they are not there simply to provide some academic credibility. However, they are also clear that the historical consultant cannot possibly check every detail of a movie.

Given the desire for historical accuracy, it seems sensible to ask whether we can use the movie industry's ability to generate realistic 3D models. For example, could a we arrange for a license to use any 3D models that are created on a movie? This seems a reasonable proposition. The models that are created are of little use to the production house, once the movie is complete, and they have had effort put into them well in excess of what could be funded by an academic project. Compare, for example, the incredible detail in the models in the movie *Gladiator* with the detail that has been possible to include in the academic project, Rome Reborn [12].

Experience of the movie industry indicates that this rosy view of mutually-beneficial work is unlikely to be effective in practice. There are several reasons, most of which reduce to the conflicting aims of the academic researcher and the movie director.

Accuracy *vs* Story-Telling. The academic wants accuracy. The director wants to tell a story. The movie company is paying the bill, so the story-telling takes precedence. If historical accuracy makes for a worse story, historical accuracy will be discarded. In *Gladiator*, the director Ridley Scott wished to produce an historically accurate movie. However, many of the details were altered to make a better story. He comments "I felt

the priority was to stay true to the spirit of the period, but not necessarily to adhere to facts. We were, after all, creating fiction, not practicing archaeology." [13]

Winkler highlights this problem in his essay on the movie *Gladiator* [14]: "The appeal of such works rests at least as much on their fictional as on their factual side. Most of the time, the fiction is even more important than the facts because the story being told is what primarily interests us."

For example, the Roman ampitheatre (the Colosseum) was allegedly made larger than real-life because Ridley Scott thought the real one to be too small for the effect he was seeking. There is an irony here: the Colosseum is one of the largest buildings of antiquity. Winkler goes so far as to say that its "…very size and height are proof of Roman hubris." [15] What excess of hubris, then, to require that the movie's version be even larger?

The Impossibility of Accuracy. Where we do not know the historical truth, we have conjectures of various possibilities. Like Schrödinger's Cat, we can hold these in superposition: the truth might have been this or perhaps it was that. A movie, however, must have a definitive version that can be put on screen. The movie's creators must open the box to see whether the cat is alive or dead. Pasinetti, advisor on *Julius Caesar* (1953), comments that "…one crucial difference between scholarship and film making [is that], while the former can afford to be vague in its results, the latter cannot." [11]

Concentration on Hero Buildings. Movies tend to concentrate on spectacle. Much effort will be invested in the big, well-known buildings. If we were to engage in a long-term relationship with the movie studies then, over time, we would end up with several, probably contradictory, models of hero buildings such as the Circus Maximus (e.g., *Ben Hur* (1925)), the Colosseum (e.g., *Gladiator*), the Parthenon, and Tower Bridge (e.g., *Sherlock Holmes* (2009)). Less effort will be invested in the everyday buildings. For example, Weta Digital's reconstruction of 1930s New York for *King Kong* (2005) used procedural modelling for many of the buildings, rather than painstaking hand-crafting [16]. These computer-generated approximations to the true buildings were sufficient for story-telling but would not stand up to scrutiny of the historical detail. The same would be true of a street scene in Pompeii or Athens: so long as it looked reasonable, it would be acceptable, even if it bore only a vague resemblance to what had stood on that street at the purported time of the movie's action. Winkler, again: "If this fiction is based on or embellished by historical or archaeological facts, so much the better, but the appeal of such authenticity is limited. For example, who among the audiences of Cecil B. DeMille's *The Sign of the Cross* (1932) or Mervyn LeRoy's *Quo Vadis* (1951) paid attention to, or remembered afterwards, that most of the décor of these films was highly authentic and had been re-created lovingly and at great expense?" [14]. Coleman puts it more succintly: "Detail is incidental to plot." [10]

Reference to Earlier Movies. Rather than referring to the historically accurate, movies often refer back to historical inaccuracies of earlier movies. Coleman comments, on the clothing in *Gladiator*: "…the costumes are simultaneously a tribute

to the Rome created by Hollywood and an acknowledgement that the Rome that Hollywood created is now the only Rome that is universally familiar." [10]

Concentration on What Can Be Seen. A 3D model for a movie needs only to be visually convincing. Any detail that cannot be seen will not be modelled. Just like a stage set, there is nothing round the back to match what can be seen out the front. This means that a model made for a movie is, at best, just a starting point for a cultural historian. This leads to further problems of finding the staff time to consolidate the model.

File formats. Finally, we return to a problem we alluded to in Sections 2 and 3. A 3D model for a movie is likely to be constructed in a software environment tailored towards movie making. Exporting that into a software environment tailored for cultural heritage is likely to be difficult, as the requirements of the two environments are likely to have considerable differences.

5 Conclusion

Movies are cultural artefacts in their own right; the preservation of movies gives lessons in the preservation of other ephemera, including all of those digital assets. The particular lesson here is that preservation on physical media should not be idly dismissed as somehow inferior to preservation digitally. There are substantial challenges in the long-term archiving of digital media and often advantages in the careful archiving of physical media.

The film industry requires the management of an enormous number of digital assets, analogous to how digital assets are managed in cultural heritage. The size of the film industry means that they are hitting problems that are faced in cultural heritage, probably before those problems become apparent in the latter field. The economic motivation of the film industry means that they are finding solutions to those problems, or identifying that there is currently no acceptable solution and that a work-around is all that can be done at the present time. Lessons learned here will help researchers in cultural heritage avoid attempts at solving the currently insoluble.

Finally, while collaboration between movie making and cultural heritage seems attractive, the difference in motivation makes it challenging. There is a fundamental tension between wanting scholarly accuracy and wanting to tell a good story.

Acknowlegements

Thanks to the participants at the 2012 EuroMed Workshop on Computational Geometry and Ontologies for Cultural Heritage 3D Digital Libraries who, through discussions at the workshop, contributed many of the ideas on how these lessons apply in cultural heritage. Thanks also to my co-authors on the What's up Prof? project [2]: Dr John Patterson (University of Glasgow) and Prof. Phil Willis (University of Bath).

References

1. Academy of Motion Picture Arts and Sciences: The Digital Dilemma, 2007, http://www.oscars.org/science-technology/council/projects/digitaldilemma
2. Dodgson, N.A., Patterson, J., Willis, P.J.: What's up Prof? Current issues in the visual effects and post-production industry, Leonardo 43(1):92–93 (2010)
3. British Film Institute National Archive, http://www.bfi.org.uk/archive-collections
4. Riley, J.M., IPI Storage Guide for Acetate Film, Image Permanence Institute, 1993, http://acetguid.notlong.com (PDF)
5. HP Ultrium Media QuickSpecs, version 13 DA-11529, http://www.ccidistribution.co.uk/datasheets/2010/apr/LTO.pdf (PDF)
6. Academy of Motion Picture Arts and Sciences: Long-Term Management and Storage of Digital Motion Picture Materials, 2010, ISBN 978-0-615-39095-6, http://www.oscars.org/science-technology/council/projects/casestudy/
7. Lost Films, http://lost-films.eu
8. The Internet Movie Database, http://imdb.com
9. Lipton, L.: Digital stereoscopic cinema: the 21st century, Proc. SPIE 6803 (2008)
10. Coleman, K.C.: The Pedant Goes to Hollywood: The Role of the Academic Consultant. In: Winkler, M.M. (ed) Gladiator: Film and History, pp. 45–52. Blackwell, Oxford (2004)
11. Pasinetti, P.M. *Julius Caesar*: The Role of the Technical Adviser. The Quarterly of Film Radio and Television 8(2):131–138 (1953)
12. Rome Reborn
    Video of version 2.2 (25 August 2011) http://www.youtube.com/watch?v=vrIEwjgfbYs
    Project website: http://www.romereborn.virginia.edu
13. Landau, D. (ed) *Gladiator*: The Making of the Ridley Scott Epic. Newmarket Press, New York (2000). Cited in [12]
14. Winkler, M.M.: *Gladiator* and the Traditions of Historical Cinema. In: Winkler, M.M. (ed) Gladiator: Film and History, pp. 16–30. Blackwell, Oxford (2004)
15. Winkler, M.M.: *Gladiator* and the Colosseum: Ambiguities of Spectacle. In: Winkler, M.M. (ed) Gladiator: Film and History, pp. 87–110. Blackwell, Oxford (2004)
16. White C.: *King Kong*: The Building of 1933 New York City. In SIGGRAPH '06: ACM SIGGRAPH 2006 Sketches, p. 96. ACM, New York (2006)

All links to websites were checked as correct on 15th August 2013.