A Spectacular History of Survey by Flying Machine!

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Cambridge Archaeological Journal / Volume 22 / Issue 01 / February 2012, pp 71 - 88
DOI: 10.1017/S0959774312000054, Published online: 28 February 2012

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The origins of archaeological methods are often surprising, revealing unexpected connections between science, art and entertainment. This article explores aerial survey, a visual method commonly represented as distancing or objective. We show how aerial survey's visualizing practices embody subjective notions of vision emerging throughout the nineteenth century. Aerial survey smashes linear perspective, fragments time-space, and places radical doubt at the root of claims to truth. Its techniques involve hallucination, and its affinities are with stop-motion photography and cinema. Exposing the juvenile dementia of aerial survey's infancy releases practitioners and critics from the impulse to defend or demolish its 'enlightenment' credentials.

Aerial survey symbolizes an ideal of scientific vision. The distance between aircraft and earth forms an epistemological metaphor in which the scientist stands apart from the object of knowledge, viewing it remotely through instrumentation. Only once data have been collected — preferably with as little 'bias' as possible — does the potentially subjective work of 'interpretation' begin. This metaphor of distance has been useful both for aerial archaeologists and their critics; but it misrepresents both aerial survey itself (which actually involves a range of visualizing practices most of which do not take place in the air) and the ways in which it builds knowledge. This article offers a genealogy of aerial survey as a visualizing practice, uncovering historical connections between aerial archaeology and popular spectacle. Aerial survey's past relates to wider changes in perceptions of space and time and the nature of subjectivity, changes only partially explored in previous accounts.

Previous literature persistently places the origins of aerial survey in the First World War. Although that conflict was crucial to the subsequent adoption of aerial survey in a range of disciplines including cartography, geography and archaeology, aerial survey's roots actually developed over a much longer period, beginning in the late eighteenth century. While previous histories treat photography and aeroplanes as the technologies defining aerial survey, we emphasize other devices and, above all, practices. Aerial survey is not defined by the airborne camera, so much as by the formation of a particular regime of attentiveness.

We begin with a brief review of previous histories, highlighting dimensions neglected by existing accounts. Examining aerial survey's background in the changing visualities of the eighteenth and nineteenth centuries, we outline some important discontinuities in the ways in which vision was understood and experienced before and after the early nineteenth century. We contrast 'enlightenment' visualities embodied in perspective drawings, bird's-eye plans and the very earliest balloon drawings, with the 'subjective' visualities connected to panoramas, early aerial photography and stereoscopy. It is primarily these modern, subjective, visualizing practices that prefigure aerial survey. We then apply this history of vision to a reconsideration of aerial survey. If anything can be said to truly define aerial survey, it was not flight or photography, but the fragmentation of time-space into sequences of images and the development of new regimes for disciplining attention to detail and directing its interpretation. Contemporary aerial survey is the inheritor of modernity's derangement and subjectivization of vision, from which, paradoxically, a fantasy of totalization can be glimpsed. In conclusion we suggest that embracing this inheritance might liberate aerial archaeology from its own empiricist dreams of progress.

Cambridge Archaeological Journal 22:1, 71–88
doi:10.1017/S0959774312000054 Received 2 Aug 2010; Accepted 29 Oct 2010; Revised 11 Jul 2011

Critique of aerial archaeology

For many years those who wrote about aerial survey in archaeology tended to fall into two camps. On the one hand, practitioners, who wrote accounts of survey methods and (sometimes) histories (e.g. Wilson 2000), but seldom interrogated the wider meaning or conceptual background of their practice. On the other, theoreticians, who assimilated aerial survey within general critiques of landscape archaeology (e.g. Thomas 1993; Johnson 2006), but seldom considered its practices or their genealogies in detail. Recently aerial archaeology has taken a new turn, with the emergence of an internal critique engaged with both practice and theory (Raçzkowski 2002; Baines 2005; Brophy & Cowley 2005). Detailed critical histories have also emerged from outside (e.g. Stepney 2005; Hauser 2007; 2008; Wilkinson 2008), highlighting the richness of aerial archaeology as a resource for archaeological theory and interdisciplinary visual studies, but by no means exhausting its potential.

Until recently, histories of aerial survey offered a narrative of progress based on a restricted range of technological and methodological advances. Developments in photography and the invention of the aeroplane were taken as explaining aerial survey's emergence and writers saw little need to examine its social or cultural history as a visualizing practice. Histories of aerial survey were stories of big men getting airborne with big cameras; aerial archaeology was reduced to aerial photography.

The assumption that aerial survey is equivalent to airborne photography is shared by critics of aerial archaeology, who see it as embodying a 'male gaze'.[1] There are two important features of this gaze: firstly, it prizes literal and metaphorical distance between observer and observed, subject and object; secondly, it is 'totalizing' — aspiring to the impossible condition of making a complete and absolute reality totally visible. Aerial photography exemplifies this gaze, Thomas claims, because it implies 'a considerable distance between subject and object' (Thomas 1993, 25), and because of the encompassing scope of the elevated view (Thomas 2008, 7). The defining characteristics of aerial survey are thus those of the single aerial photograph — distance and height. In many accounts it appears that writers are reflecting on isolated oblique photos, such as might be used to illustrate publications, rather than the procedures of aerial survey, which deploy sequences of imagery in specific ways. Johnson, for example, discusses the aesthetic appeal of 'air photos', emphasizing their 'anecdotal' and illustrative uses (Johnson 2006, 89–93). While acknowledging that the craft of 'decoding' air photos is 'every bit as complex and full of its own lore as excavation' (Johnson 2006, 90) he does not specify any equipment or techniques involved. There is little appreciation of how the specialized visualizing practices of aerial survey differ from the practices which non-specialists use to look at or write about photographs. Aerial survey is not photography in general (see Baines 2005; Raçzkowski 2002, 321–2), and for this reason, critical perspectives borrowed from literature on mainstream popular, commercial and artistic photography (e.g. Sontag or Barthes) are of limited application.

Histories specifically concerned with aerial survey rarely look further back than the early twentieth century, all but ignoring earlier periods. In archaeology, O.G.S. Crawford's historical note in *Wessex from the Air* (Crawford & Keiller 1928, 3–5) placed the origins of aerial survey after 1900, emphasizing the First World War. The continuing assumption that few of aerial survey's practices were possible before the aeroplane has prevented sustained engagement with earlier visualization in these texts. For more sustained engagement with visual history we must look to Julian Thomas's accounts of archaeology's 'distancing gaze'. Thomas argues that this gaze emerges in the sixteenth and seventeenth centuries, associated with 'a growth of interest in the camera obscura, which harmonized with a growing emphasis on empirical observation in science' (Thomas 2008, 2). The gaze manifested itself in the linear perspective of Italian and Flemish art, and in cartography, facilitated by the sixteenth-century Mercator projection (Thomas 2008, 4). Thomas's history thus subsumes a very wide range of visualities, creating a continuity in which techniques including aerial survey appear to grow out of linear perspective. Perspective, cartography and aerial survey are all lumped together under the umbrella of archaeology's modernity,which, for Thomas, is 'less a block of time with hard edges and more a process' (2004, 3, emphasis removed). The ambition of Thomas's project (concerned with archaeology in general, not with aerial survey specifically) justifies his generalizing approach, but his history is of limited use for detailed investigation of how specific sub-fields and techniques emerged (see Wickstead 2009). Using this approach we can say how visual techniques are similar, but not so much about how and why they differ. What is needed is a genealogy of aerial survey's specific practices and equipment that is nonetheless able to situate its particularities in a wider temporal and cultural field.

Aerial survey is not best approached through individual aerial photographs and cannot be reduced to distance and height. Its practices are antithetical

to the 'aesthetic' singularized image. The individual obliques that find their way into publications are carefully selected, and often shot for that purpose. Certainly some aerial photographers, particularly those undertaking reconnaissance or prospection with hand-held cameras, intentionally produced images displaying a concern for aesthetic composition, but on their own such images misrepresent aerial survey. The aerial-survey image belongs, above all, in series, and the techniques of aerial survey are based on relations among images rather than on isolated photographs. Some recognition of this is found in critiques that dwell on aerial archaeology as 'narrative' (Raçzkowski 2002, 320–23; Baines 2005, 179) or through 'flight biographies' (Cowley & Gilmour 2005; Brophy 2005). However, these 'subjective', phenomenological approaches continue the 'men in the air' tendency of previous aerial histories, downplaying earth-bound non-photographic activities (i.e. manipulation, stereoscopy, analysis, classification, transcription). They have difficulty incorporating the imagery that most distinguishes aerial survey and remote sensing — overlapping vertical sequences shot automatically, and industrially, by machine.

The complexity of aerial visuality generally, and of aerial survey specifically, is just beginning to be appreciated (e.g. Hauser 2007; Wilkinson 2008). While some previous criticism seems to label all aerial viewing as panoptic and totalizing, there is now more understanding of the ambiguity and diversity within and between aerial visualizations: 'Adopting an aerial perspective has different consequences depending on the specificity of the medium and its experience' (Wilkinson 2008, 36; see also Barber & Wickstead 2010). The plurality of visual practices contained by aerial survey has hardly begun to be investigated. These practices 'need to be found and delineated, and their effects documented' (Wilkinson 2008, 36) and their history traced in relation to visualizing practices that predate the camera and the aeroplane.

Histories of vision

From the early decades of the nineteenth century, time-space and the nature of perception itself began to change. Classic accounts of these transformations emphasize innovation in transport and communications linked to the increasingly global movement of capital (Harvey 1991). More recent approaches highlight equally important changes in the ways that people saw the world and themselves as seeing subjects. After *c.* 1820 there was an explosion of novel visualizing devices and technologies, avidly consumed by the masses as well as within the increasingly professionalized world of science (Crary 1992). With the invention of photography, 'timespace compression' assumed visual form, causing contemporaries to declare that time and space had ceased to exist (Schwartz & Ryan 2003, 2). Mechanical reproduction of mass-produced images, first through photography and later the half-tone process, transformed the status of the artwork. Representations of landscape proliferated and circulated in new ways — as postcards, stereoscopic views, illustrations or souvenirs (della Dora 2009). Towards the end of the nineteenth century, electric light blurred the distinction between night and day, giving previously familiar city streets the aspect of Phantasmagoria or Magic Lantern shows (May & Thrift 2001, 11). Moving pictures fragmented reality, rendering time-space discontinuous and reversible (Clarke & Doel 2005).

Changing ways of seeing were linked to a shift in how vision itself was understood. Jonathan Crary approaches this shift by contrasting two models of vision: a classical model prevalent in the eighteenth century (which he calls 'enlightenment vision'), and a new model of vision developing after *c.* 1820 ('subjective vision') (Crary 1992, 116–26). In the enlightenment model the observer is a passive receiver of vision, separated from the external object. Sight is not primarily a matter of the observer's sensory perception, but instead involves the application of reason — a process through which the rational mind arrived at an objective truth. The paradigmatic figure of enlightenment vision is the *camera obscura*, which projects an image into a controlled environment outside the body of the observer. A function of the *camera obscura* was to separate the act of seeing from the corporeal frame of the observer; to situate vision outside the body as subject to rational interrogation. In fact, in the eighteenth century, altering a literal depiction to make a fabricated image that was considered more typical, representative or orderly did not detract from scientific objectivity (Daston & Galison 1992). On the contrary, the exercise of reason was an essential component of objective visual truth.

'Subjective vision' emerged in the decades after 1820, as vision itself became an object of systematic observation. Scientists began to investigate a range of phenomena such as after-images, blind-spots and binocular disparities, all of which suggested that vision was temporal, fallible and individual. At the same time, the nature of the eye became an important issue in evolutionary theory. During Crary's period of 'enlightenment vision', scientists working in the Natural Theology tradition had argued that the design of the eye was so intricate and contrived that 'it would be alone sufficient to support ... the necessity of an

intelligent Creator' (Paley, cited in Lightman 2000, 655). Likened to a *camera obscura*, the mechanism of the eye not only supplied proof of God's existence, but also testified that God intended his work to be apparent to rational observers. In contrast, Darwin's discussion of the eye in *On the Origin of Species* proposed an eye continually adapted through natural selection; an eye that was flawed, temporary and entangled in its own perceptual processes (Lightman 2000, 656). Gradually, physiological and evolutionary science located vision within 'the unstable physiology and temporality of the human body' (Crary 1992, 70). Rather than manifesting universal laws of reason, vision now resided in the anatomy of the individual's eye — it became subjective.

Scientific analysis of vision's subjective and temporal qualities prompted the invention of a range of visual gadgets which soon became mass-marketed, popular entertainments. Many of these (such as the phenakistiscope and zoetrope) depended on the after-image to create an illusion of moving images using the same principles as would later characterize cinema. Others, such as the stereoscope and anaglyph, depended on binocular disparity, creating hallucinations whereby two-dimensional images reappeared in 3D. Partly through these hallucinatory devices, Crary argues, the rational order of enlightenment vision was fragmented and deranged. Subjective vision 'effectively annihilate[d] a real world' (Crary 1992, 14).

The subjectivization of vision changed the way objectivity was understood. Reality could not be taken for granted, but had to be indicated and evaluated through 'reality effects' (Virilio 1994), including proliferation of exacting detail. The use of machines, such as cameras, became imperative (Daston & Galison 1992; 2010). Whereas enlightenment science saw the exercise of reasoned judgement as necessary to the production of 'representative' images, this was now considered dangerous interference. Unlike human vision, machine vision was not subjective. The very ignorance of the camera ensured that it was unfailingly objective. As visual culture was increasingly mechanized and industrialized, new regimes of attentiveness made the human propensity for inattention and distraction a concern (Crary 2001). Human attention was found lacking, but the attention of the machine never wavered. Machine vision embodied scientific virtue.

Aerial survey could not have appeared in the way it did without the fragmentation and individualization of 'subjective vision'. In order to substantiate this argument, we examine visualizing practices that predate and prefigure aerial survey. First, we look at the aerial visualizations of 'enlightenment vision'; then we explore some visual practices from the nineteenth century that, we suggest, helped to set the scene for, or shaped the emergence of, aerial survey. We do not want to overdraw this contrast. Visualities do not follow one another in precisely periodized blocks; the rotting edifices of previous theatres of vision persist alongside and within alternative models. However, we consider that the distinction helpfully illuminates what makes aerial survey different to previous ways of visualizing landscape.

Enlightenment vision: the imaginary and the earliest aerial drawings

The aerial view has been an aspect of the imaginary in many different times and places. Often imagined as the vision of gods or supernatural agencies, aerial views are a familiar feature of religious imagery.[2] It is impossible to do justice to every aerial tradition here. Instead we examine some eighteenth-century visualizations of aerial views, some of them projected from the ground, and others derived from the earliest human flights.

Imagined aerial perspectives

Before aerial photography came cartography. The two techniques are frequently elided — both practically, in aerial survey, and ideally, in histories that treat aerial photographs as part of the inevitable technological advance of mapping. We discuss the relationships between cartography and aerial photography at length elsewhere (Wickstead & Barber forthcoming). But it is worth repeating here that the equivalence of maps and photographs is by no means straightforward. Aerial viewing is not innately map-like (Barber & Wickstead 2010). Unlike photographs, maps are symbolic, and they often involve time-consuming procedures for projection from ground-based survey data. Although the prior existence of maps conditioned the possibilities which aerial photography afforded, historically both aerial photography and cartography had to be extensively re-configured before the radically different visualizing practices involved in each could be reconciled.

In the eighteenth century a different visualization lent three-dimensional verisimilitude to the map. The bird's-eye view hybridized perspective drawing and cartography, projecting an oblique view from an imaginary vantage point high in the sky. Bird's-eye plans of townscapes were increasingly common from the mid-sixteenth century. By the eighteenth century views of formal gardens, usually focused on the houses of the aristocracy, were popular subjects.[3] Figure 1 shows a depiction *c.* 1710 of London's Charter House, and offers a striking parallel with the kind of

Figure 1. *Charter House, London by Johannes Kip,* c. *1710. (© English Heritage Photo Library.)*

low-level oblique aerial photograph that might be used illustratively today (cf. Johnson 2006, 89–93).

At first glance, bird's-eye plans appear to be precursors of aerial-survey images. However, the prospects presented, although similar to certain carefully constructed aerial photographs, represent a very different set of visualizing practices. Bird's-eye plans framed complete objects, offering a reality that could be wholly assimilated, owned and displayed. They were not part of a sequence, in which reality spills out of the edges of the frame, as the aerial-survey image would be. The practices involved in producing bird's-eye views were close to those of linear perspective and cartographic projection and, as such, they were quite unlike those of aerial photography. Bird's-eye views possess vanishing points, which are often removed or dramatically displaced in aerial photographs, particularly in verticals. The bird's-eye view was projected through composition, a procedure which allowed Reason to fully apprehend reality. This is an enlightenment visuality, informing an encyclopaedic world view in which knowledge could be fully encompassed and possessed by a rational, ordered, optics.

Baldwin's balloon drawings

When Thomas Baldwin ascended over Chester in September 1785, flight was new. The maiden flight over Britain had occurred just the year before, while the Montgolfier Brothers' balloon had first risen over Paris only two years previously. Flight offered a novel visual experience, but it is impossible to generalize about its effects. Although aerial vision is often assumed to be inherently panoptic, surveillant, voyeuristic and map-like, accounts produced by aeronauts throughout the late eighteenth and nineteenth centuries suggest it could be apprehended in many ways (Barber & Wickstead 2010). In fact, differences in balloon-age aerial observation broadly follow the transformations in visuality set out by Crary and others. Reports from the late eighteenth and earlier nineteenth centuries emphasize the clarity of a Gods-Eye View in an ordered reality, in line with what Crary described as enlightenment vision. Texts from the later nineteenth century, however, describe obscured and fragmented visual experiences in line with subjective vision. These later aeronauts were to experience aerial vision as blurring distinctions (social as well as visual) and hiding the

Figure 2. *Thomas Baldwin's vertical representation of his flight from Chester. (Science Museum/SSPL.)*

detail that reveals truth, while for eighteenth-century aeronauts the balloon, like the telescope or microscope, offered a new way to find order in the universe.

The first images based on direct experience of actual flight illustrate how visualities were changing. Created and published by Baldwin in 1785, they do not in the least resemble perspective drawings like bird's-eye views, yet at the same time they are nothing like the aerial photographs that would follow. Baldwin offered something genuinely new and startling — the world's first vertical aerial image, containing a depiction of his flight path (Fig. 2). Baldwin intended this to be viewed in a special way:

> Whoever will be at the Trouble of viewing *distinct* Parts of *the Balloon-Prospect*, throu' a very small Opening, made by rolling a Sheet of Paper into the Form of a hollow Tube, and applying it close to either Eye, at the same Time shutting the other; or by looking throu' the Hand, held a little open, and close to the Eye, may form a very accurate Idea of the Manner, in which the *Prospect below* was represented *gradually in Succession*, to the Aironaut; whose Sight was bounded by a Circularity of Vapour… (Baldwin 1786, IV–V, his emphasis).

Baldwin's vertical drawings presented the experience of flight as a totality. The drawing that accompanied our Figure 2 in Baldwin's *Airopaidia* captured a single view as a high vertical framed by swirling clouds. Figure 2 unifies the balloon journey through the flight path, while allowing the viewer to re-experience flight, from the comfort of their own armchair, using an improvized 'telescope' or 'microscope'. Transporting the world into an interior where it can be contemplated outside the body is redolent of the *camera obscura* — an instrument that Baldwin suggested should be used for aerial drawing.

Baldwin's drawings were a one-off. Vertical aerial views were not to reappear until well after the advent of photography — and when they did they were nothing like Baldwin's drawings — while the mapping of flight traces did not become widespread until well into the twentieth century. They remain an extraordinary product of the collision between enlightenment visual culture and the experience of genuine flight.

Subjective vision: panoramas, stereoscopes and photography

Ballooning was not just a new visual experience for aeronauts, but also for the enormous crowds who made flight a massive public spectacle. The first ascent in Britain — by Vincent Lunardi in September 1784 — was witnessed by a crowd of 150,000. Balloons rapidly became attractions at fairs, exhibitions and other mass gatherings. In this section we show how the fascination with flight translated into modern visualities. We examine three visualizing practices that took hold in the nineteenth century, and which would contribute crucial elements to aerial survey — the Panorama, the aerial photograph and the stereoscope.

The Panorama

From the 1790s, the aerial view became a popular mass experience — but not through direct experience of flight. Instead, aerial views were experienced through Panoramas. The Panorama was more than an extensive prospect or 360° view — these panoramas occupied circular buildings specially designed to focus attention on an artificially-lit 360° painting suspended from its walls. Spectators entered the building from below and emerged onto a raised interior viewing platform that allowed them to look down towards the surrounding spectacle. From their first appearance in 1791, circular panoramas were wildly popular, going through a range of different incarnations and coming in and out of fashion throughout the nineteenth century. As well as contemporary cityscapes, popular subjects included battle scenes, historic and newsworthy events, and exotic ancient cities such as Constantinople, Athens and Jerusalem, all depicted in lavishly minute detail (Virilio 1994, 40). Panoramas were typically accompanied by printed diagrams and written explanations which often highlighted features of historic interest (Griffiths 2003).

Panoramas prefigured motion pictures (Clarke & Doel 2005). Moving Panoramas were quite literally moving pictures, comprising either painted screens revolving around the viewing platform, or a platform that rotated to reveal scenes. Screens were carefully lit, while a variant form — the Diorama — used projection to create the illusion of night and day in speeded-up time. They seldom presented uninterrupted, literal depiction, but were spliced to highlight entertaining features, and edited with close-ups or entirely different scenes inserted. The viewer was required to construct relations between these montage elements, often aided by supplementary hand-outs. Cinema inherited aspects of the Panorama, notably in 'panning' (Castro 2009). Panoramas thus educated observers in visual skills that would be important to both aerial survey and cinema.

Of particular relevance to aerial survey was the Balloon Panorama. These first appeared in the 1820s as a theatrical special effect but soon developed into a free-standing attraction, of which the most spectacular was Grieve's *Aeronautikon* of 1836. Itineraries for Balloon Panoramas claimed to be drawn from actual flights and to represent views experienced by real aeronauts, although in fact they offered heavily edited highlights not always consistent with the aeronauts' written testimony. According to Charles Dickens, who witnessed

the *Aeronautikon*, actors playing the aeronauts were placed in a large, fully practicable balloon surrounded by scenery representing a ground view of London's Vauxhall Gardens. The stage set was lowered, and reels unfurled from top to bottom. Lighting and translucent screens produced dioramatic effects: the journey began in daylight, continued in twilight and moonlight, and reached the Rhine 'in the morning, as the (gas powered) sun was rising' (Huhtamo 2009).

Both panoramas and ballooning share a connection with Romanticism and the sublime (Huhtamo 2009). 'With romanticism' Johnson argues 'we are seduced by the aesthetic appeal of the scene laid out before us in our elevated position, and turn it into a spectacle' (Johnson 2006, 93). While Wordsworth was critical of panoramas, they share aspects of his visual sensibility (Jones 2006). There is clearly, as Johnson (2006, 93) points out, an inheritance between this Romantic visuality and the low-level obliques that decorate archaeological publications. This same sense of 'visual mastery' and 'spectacularization of landscape' is also found in film, in the aerial panning shot (Castro 2009, 12).

Panoramas, like flight, are part of a transition from 'enlightenment' to 'subjective' visualities. Firstly, they did not present a totally consumable whole centred within a frame; Panoramas were 'endless' landscapes, whether static or revolving on reels. The viewer turned her head to experience a spectacle beyond apprehension as a single view. The Panorama was only consumable as parts which the viewer reassembled into an imagined whole. Second, as immersive environments, Panoramas broke with perspective, cancelling the vanishing point. Lastly, Panoramas overwhelmed the viewer with detail in the form of props, stage sets, imagery and so on.

The detail of the panorama has been linked to nineteenth-century senses of reality (Crary 2002). In the panorama, reality is 'real' because it 'always exceed[s] the capacity of a spectator to grasp it' (Crary 2002, 21). A parallel is provided by contemporary techniques of literary realism. In novels like *Madame Bovary*, the accumulation of detail in the text stands for a real world in which details proliferate endlessly. By noting the seemingly insignificant and inconsequential, Flaubert allowed detail to stand in for a limitless reality (cf. Virilio 1994, 35–7). Nineteenth-century critics observed parallels between realist literature and photography. Both provided means of documenting reality that depended on the mechanical, impersonal and seemingly objective capture of overwhelming detail (Kelly 1991). Whereas earlier visualizations allowed the observer to assume total possession of the perceived, now truth was signalled when images presented more detail than could possibly be assimilated. Reality was now based on the inadequacy of the human observer and the limitations of subjective vision (Crary 2002, 21).

The stereoscope

The stereoscope was the most significant visual invention of the nineteenth century after photography (Crary 1992, 118). Today, few people encounter a stereoscope professionally, unless employed in aerial survey.[4] However, from the mid nineteenth century the use of a stereoscope to view photographic images was common and widespread.

The stereoscope owes its origin to scientific experiments examining binocular vision. It works by separating the vision in each eye. When the eyes are focused separately on one of two near-identical two-dimensional images the brain is forced to fabricate a third image, which it perceives in three dimensions. What is actually perceived using the stereoscope is a hallucination; there is no external image that resembles what the viewer 'sees'.

Stereoscopic hallucination confers peculiar effects. With stereo-photography, the third dimension is proportionate not to the size of the object(s) photographed, but to the distance travelled by the camera between the two exposures. Furthermore, because of differences in the degree of spatial convergence between each eye, the hallucinated image is composed of a patchwork of intensities of relief. Its depth 'has no unifying logic or order' but contains a series of planes which exist in uncertain relation to one another (Crary 1992, 125). 'The hills zoom out as tactile objects ...' as Wilkinson expresses it; '... details come up and "pinch you"' (2008, 33). The stereoscopic image is thus fundamentally unlike perspective. Perspective relates objects within measured space, creating a unified field. The stereoscope fragments space into an aggregate of disunified elements. One senses things closer or further away, but it is not entirely clear how far things really are from each other.

Through the stereoscope, the nineteenth-century observer embarked on a voyage into photographic detail. Particularly prized was the capacity of stereoscopic vision to reveal detail not apprehended by unaided human vision; as Oliver Wendell Holmes put it:

> there is such a frightful amount of detail ... a perfect stereograph is absolutely inexhaustible. In a painting you can find nothing which the artist has not seen before you; but in a perfect photograph there will be as many beauties lurking unobserved as there are flowers that blush unseen in forest and meadow (Hamilton 1949).

Stereoscopy made photographic detail the focus of sustained attention. At the same time it revealed the

superiority of machine vision, its capacity to discover things hidden to the human eye.

While the *camera obscura* projected vision outside the body, the stereoscope buried it within each individual's subjective perception. Although the stereoscope pre-dated photography and does not depend upon it (stereoscopic images can be created from drawings or engravings, for example) stereoscopy and photographs rapidly intertwined. Photographs were widely circulated as stereo-cards, and twin-lensed stereo-cameras allowed photographers to take stereo-pairs in a single exposure (the lenses typically spaced 2½ inches apart, the distance of 'normal', regularized, binocularity). Perhaps more than any other nineteenth-century visual practice stereoscopy illustrates the transition from distanced enlightenment vision towards individualized subjective vision. Through the stereoscope the distance between subject and object, the foundation of rational enlightenment vision, imploded.

As well as providing popular entertainment, the stereoscope stimulated cartographic innovations that prefigured aerial survey. The most remarkable parallel is supplied by Stereoscopic Mapping. Invented by Francis Galton and first demonstrated by him in 1863, Stereoscopic Maps comprised a photomosaic of continuous overlapping verticals (Galton 1865; Wickstead & Barber forthcoming). Designed to be viewed in the field through a pocket stereoscope, the most commercially successful adaptation of the idea seems to have been based on the Royal Engineers' surveys of the Holy Land in 1864 and 1868. These led to the construction of some three-dimensional models of the Biblical landscapes, vertical photographs of which were sold commercially as stereo-pairs (Stewart Howe 2003). These images achieved wide circulation: 'found in a range of parlours, from the barely middle class to the royal household, and in Sunday schools and Bible study groups' (Stewart Howe 2003, 241). Galton's techniques of stereoscopic mapping anticipated those of aerial survey; a camera was held on a horizontal plane and calibrated to take continuous coverage of terrain in an overlapping sequence of vertical photographs. The principal difference between Galton's method and twentieth-century aerial survey is that Galton photographed a model of landscape from above, rather than actual terrain from an aeroplane, otherwise the principles of Stereoscopic Mapping are virtually indistinguishable from those of vertical aerial survey practised half a century later.

From the 1890s stereoscopy became important to the developing science of photogrammetry. Mapping from individual photographs was first attempted in the 1840s, by the French Army engineer Aimé Laussedat, who experimented with sequences of photographs taken from a series of precisely located camera stations. Towards the end of the nineteenth century the Surveyor-General of Canada, Edouard Deville, developed Laussedat's techniques further, experimenting with the use of stereoscopic pairs of photographs taken from either end of an extended baseline, something that exaggerated the relief visible in the resulting stereoscopic image. In the decade that followed, Deville and others independently developed stereo-plotting devices, allowing the observer to transcribe directly from the stereoscopic image to a topographic map. None of these early machines could be used on aerial photographs because they required each camera position itself to be precisely located in three dimensions, something that was not only impossible with balloons, but with the first aeroplanes as well. What these pioneering efforts at photogrammetry did do, however, was establish a connection between survey and the stereoscope decades before aerial survey emerged (see Wickstead & Barber forthcoming).

The aerial photograph

The first successful aerial photograph was taken in 1858, when the remarkable Gaspard-Félix Tournachon (a.k.a. Nadar) successfully exposed a glass plate from a balloon tethered a few hundred feet above a village on the Parisian outskirts. Although aerial photography had theoretically been achievable since the 1840s, ballooning presented considerable vicissitudes to the photographer. The shorter exposure times of the collodion or wet-plate process of 1851 made an airborne picture more achievable than with a daguerreotype camera, but Nadar still required several expensive and hazardous ascents before achieving a presentable image. Firstly, the balloon car had to be converted into a flying darkroom — the wet plates had to be prepared, exposed and developed within around twenty minutes. Once aloft, the constant movement of the balloon proved a problem for the capture of a satisfactory image. Lastly, gas escaping from the balloon reacted with the chemicals on the carefully prepared plates, ruining several attempts.

Nadar's brief career as an aerial photographer obtained meagre results, but stimulated noteworthy innovations. During the 1860s, for example, Nadar experimented with a multi-lens camera from a tethered balloon at the Paris Hippodrome (Fig 3). The camera held just a single plate, but possessed eight lenses. Each lens would be opened and then covered in sequence, as the balloon drifted or turned gently on its tethering rope. His intentions are unclear — it has been suggested that he was merely trying to increase his chances of getting a successful image — but the end result was a series of overlapping images that could be combined to create a panoramic view of Paris,

Figure 3. *Nadar — one of his sequences with multi-lens camera from balloon at Paris Hippodrome. (Agence Photographique de la Réunion des musées nationaux.)*

while each pair of successive images can be viewed stereoscopically.

Nadar's original patent had proposed fixing the camera to the outside of the balloon car, the lens pointing straight down. However, what is often regarded as the first true vertical aerial photograph was taken by Cecil Shadbolt in 1882. With his camera also fixed to the outside of the basket, Shadbolt captured what was described at the time as an 'instantaneous map photograph' of the area around Stamford Hill, London from around 2000 feet. With vertical photographs, a break had been made with the 'pictorial' tradition of photography, something later artists and photographers interpreted as radically new (Doty 1983). Vertical images did away with the vanishing point — photographs had been taken beyond the rules of perspective; they had become decisively modern.

By the end of the nineteenth century there was a well-developed popular appetite for aerial views, filling a distinct niche among the flood of landscape imagery found on postcards, stereo-cards, souvenir objects, and so on (della Dora 2009). Satisfying this demand became possible thanks to the mass marketing of simplified cameras, such as the Kodak box camera (first produced in 1888), which did not require that photographs be processed immediately; instead they were sent away to specialist photo-processing services. The development of the half-tone printing process allowed the mass reproduction of photographs in printed media and, during the 1890s, there was a growth in the number and popularity of photographically illustrated magazines. Aerial views featured as illustrations, usually accompanying articles describing balloon journeys. The contrast between these illustra-

tions and Baldwin's drawings (see Fig. 2) is marked. Rather than reproducing the aerial view as a totality, photography fragmented the flight into a sequence of instantaneous snapshots; a series of landmarks each captured, framed and described within a single photographic image (Barber & Wickstead 2010).

Photography mimicked the 'reality effect' of Panoramas. As with the Panorama, detail was the mark of photographic veracity. Commentators marvelled on the detail revealed by close scrutiny of photographs, detail not even apparent to the photographer. In aerial photography, this abundance of detail was particularly marked, balloon photographers being particularly drawn to urban areas where everything from the monumental to the minute could be captured in exquisite detail (Barber & Wickstead 2010). Rather like the panoramic view, aerial photography produced a reality that spilled out of the frame, its details beyond the grasp of the observer.

During the nineteenth century photography gradually came to be seen as the most realistic form of representation. However the source of photography's realism is not verisimilitude, but machine vision. Nineteenth-century photographs were often less true to life than other pictorial techniques.[5] As one commentator declared, 'the object which, photographically pictured, meets our eyes, we have indeed *seen*!' (Ellis 1847, cited in Schwartz & Ryan 2003, 7). As recent commentators on aerial photography have pointed out, photographs are *traces* (Baines 2005; Stepney 2005; Hauser 2007). They are indexical objects, seemingly made by nature; imprints on the retina of a machine. Photography provided a means to eliminate the flawed, subjective human observer, by obtaining an objective, supposedly unmediated, view. As vision was increasingly lodged within the bodies of individuals, photography reinscribed objectivity through the impartial eye of the machine. The very objectivity of photography, the core of its success, is founded on anxieties provoked by the subjectivization of vision.

We have argued that the three technologies considered here — panoramas, stereoscopes and aerial photographs, all, in different ways, embody the subjective vision described by visual historians. The ways in which they do so can be summarized into four related tendencies:

- *Fragmentation:* Panoramas, aerial photographs and stereoscopes all in some way fragmented visualization. Whereas bird's-eye plans and Baldwin's balloon drawings created completed aerial views within a single image, these later practices were partial, requiring totalization be re-imposed onto the scene.
- *Detail:* the 'reality effects' of the Panorama, aerial photograph and stereoscope rest on their inexhaustible, excessive detail. Reality is signalled when detail is so great that it spills out of the edge of the frame or proliferates within the image, almost beyond the bounds of human apprehension.
- *The break with linear perspective:* Panoramas and vertical aerial photography abolished the vanishing point; the sensation of stereoscopic viewing made it impossible to sense depth in the way it had been before, and the third dimension was now measured on another (machine based) metric.
- *Collapse of objective vision and its reinstatement in machines:* in stereoscopy, the image is a hallucination experienced within the body of the individual. The very origin of photography's supposed 'objectivity' rests with the idea that human vision is subjective while the camera never lies.

In the next section we consider how these tendencies contributed to the emergence of aerial survey. We organize our discussion around two impulses: fragmentation and detail.

Aerial survey

While previous histories of aerial survey have placed its origins firmly within the First World War, many of its practices have a much longer history. In this section we scrutinize aerial survey at closer range. Aerial survey can be distinguished from other forms of aerial visualization by the sequential fragmentation of imagery. The automation of this process joins the history of aerial survey with stop-motion photography and cinema, rather than perspective painting and cartography. The technology of the fragmentary image, however, was not in itself sufficient to produce aerial survey as a discipline. When aerial survey finally emerged it was as a regime of attentiveness as much as a technology of image production.

Fragmentation

Aerial survey belongs to what Virilio describes as the age of the 'solidary' image — the age of cinema. In motion pictures, as in aerial survey, the image is no longer 'solitary (subjective, elitist, artisanal)' but becomes 'solidary (objective, democratic, industrial)' (Virilio 1994, 52). Solidary images exist as sequences produced and displayed by machine. Verticals in particular were images without perspective. The primary relation set up within each image was not to a vanishing point, but to other verticals that preceded, followed, and overlapped in sequence. Aerial survey, as it would emerge in the First World War, was 'not a matter of images ... but of an uninterrupted stream of

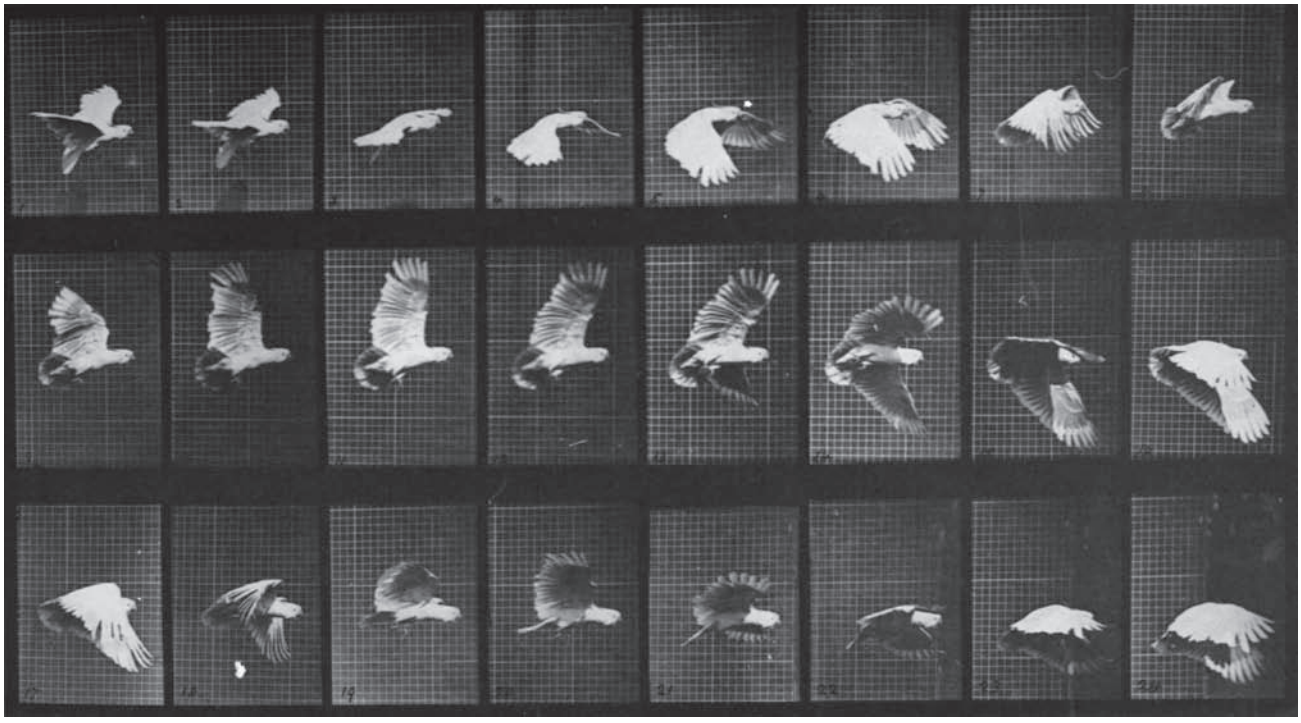

Figure 4. *Eadweard Muybridge's stop-motion photography of a cockatoo in flight. (Negative of image originally published as plate 758 in* Animal Locomotion *(1887). Neg 10a: By permission of Kingston Museum and Heritage Service.)*

images, millions of negatives madly trying to embrace on the daily basis the statistical trends of the first great military-industrial conflict' (Virilio 1994, 48).

Aerial survey required automated cameras that systematically fragmented aerial visualization to produce sequences of images. From the 1870s experiments with automated cameras were motivated by two impulses: on the one hand were those who sought to fragment *time* to investigate bodies in motion; on the other were those who sought to fragment *space* along the trajectory of a body in motion. Experimenters who fragmented time are now lauded as the fathers of cinema; those who fragmented space are mostly forgotten. Among experimenters with automated cameras who fragmented *time*, the best known are Eadweard Muybridge and Etienne-Jules Marey. Both were primarily interested in studying the motion of humans, animals and birds using split-second timing to create sequences of images (see Fig. 4). For both, automating cameras to produce sequences led onto the animation of those sequences; to moving pictures. Muybridge's experiments involved batteries of cameras, with shutters which opened automatically, triggered, for example, by a moving object breaking a thread. Muybridge claimed to be able to take photographs at less than 1/1000 of a second, although he did not usually find it informative to take sequences at that resolution (Muybridge 1887, 14). Muybridge's best-known discovery was proof that all four hooves of a galloping horse leave the ground simultaneously. For Muybridge this revealed the ultimate superiority of the machine eye, and the misleading nature of human vision. Muybridge's horse sequence was published as zoetrope strips allowing them to be inserted into a popular device for animating pictures. Muybridge also devised his own moving picture projector — the zoopraxiscope — using a circular wheel of painted slides based on his photographic sequences.

It is possible Muybridge was led to stop-motion sequences through shooting panoramas from high elevation. In 1877 Muybridge created a seventeen foot 360° mammoth plate panorama surveying San Francisco from a high-placed tower. Muybridge's technique compiled a sequence of exposures, moving the camera between each shot, at a fixed angle. This spatial sequence, it has been suggested, could have inspired Muybridge's temporal sequences, first produced only months later (Clegg 2007, 121).While Muybridge was working in the Americas, Marey was also automating cameras. Like Nadar, who in the 1860s had attempted multiple and successive exposures on a single plate (see Fig. 3), Marey initially created sequences through repeated, split-second, exposure, again on an individual plate. After seeing Muybridge present his work, however, Marey became interested in sequences of

successive images (Miller 2010). He built a 'rifle' camera which registered images on a light-sensitive wheel, an idea derived from an earlier photographic rifle (in turn inspired by the phenakistiscope) that had been designed to photograph the transit of Venus in 1874. In 1888 these experiments culminated in a motion picture camera shooting 20 frames per second (McMahan 2003, 24). By cutting each photograph out and pasting it into a zoetrope, Marey could watch his sequences move, but the device did not allow him to show them to an audience. Like Muybridge, he had to devise a machine for projecting his moving images.

While Muybridge and Marey automated cameras to fragment time, aerial photographers developed automated cameras to create sequences that fragmented *space*. Automatic cameras offered a simpler approach to airborne photography, by allowing photographs to be taken from unmanned balloons, kites, rockets and even pigeons (Barber 2011), and thereby removing the need for a human photographer. In 1877 Walter Woodbury patented an automatic aerial camera intended to take 'an absolutely vertical picture such as would be necessary to get a correct map of the earth' (Newhall 1969, 34–5).Woodbury's camera could use an automatic plate changer or, even more ahead of its time, film. From around 1880, Henry Elsdale of the Royal Engineers experimented with his own patented 'clockwork' (or electrically) operated camera also designed to take a sequence of verticals (Barber 2006). As with Muybridge's early work, which took sequences along a single plane (the horizontal), so early aerial cameras initially took sequences along a single (vertical) plane. During the 1890s however, new automated aerial cameras were specifically designed to take oblique aerial panoramas (Doty 1983, 13).

Motion pictures and aerial survey were linked by more than the automation of cameras and the sequencing of images; both shared an abiding preoccupation with flight. As Alison McMahan (2003, 20–28) has shown, the same individuals pioneered aerial photography, motion pictures and the emerging science of aerodynamics. By the late nineteenth century most of the mathematical theories necessary for heavier-than-air flight had already been developed, but there was still no clear idea of what a successful airplane might look like. After the frustrations suffered while taking aerial photographs from balloons, Nadar began to look for better ways to fly. He studied 'the motion of kites, birds, projectiles and, his favourite example, a worker who soaked his sponge in water before tossing it up to his colleague on a scaffold' (McMahan 2003, 21), concluding that controlled flight should be heavier than air. With a range of luminaries (including Jules Verne and George Sand) Nadar founded the Society for the Encouragement of Aerial Locomotion by Means of Machines Heavier than Air. An important direction in aerodynamics was the idea of the ornithopter — a flying device modelled on birds. Marey's earliest experiments were drawings traced from the movements of harnessed birds and, in 1872, he worked with an aerodynamist to build a mechanical bird. Muybridge's and Marey's automated images of bird flight (see Fig. 4) were contributions to the science of the aeroplane.

The visual parallels between proto-cinema and aerial survey are compelling. Muybridge and Marey fragmented the flight of moving entities (horses, humans, birds) by observing trajectories from the outside looking in. Aerial survey fragmented the flight of moving entities (balloons, kites, aeroplanes) by observing trajectories from the inside looking out (Fig. 5). Aerial film was among the earliest footage taken by movie cameras. The Lumière Brothers and Edison Motion Pictures both filmed from balloons at a very early date (1898 and 1900 respectively) (Castro 2009, 14). British aerial photographer John Bacon published a sequence of frames of aerial kinematograph film in 1898. In the 1900 Paris Exposition, one of the last Panoramas and first cinematographs was a simulated balloon ride. The *Cineorama* displayed film footage shot by ten movie cameras on an actual balloon ascent. The film was projected onto a wrap-around screen by ten projectors, viewed by an audience situated within a large balloon car (Clarke & Doel 2005, 55). Some of the earliest military aerial survey deployed cine-cameras alongside conventional cameras. In 1912, during the Turko-Italian War, the Italian army used aerial photographs to create photomosaics while using an aerial movie camera to film enemy encampments (Paris 1992, 108). The 1918 mapping of the former combat zones of World War I involved both aerial photography and footage shot by the French Service Cinématographique de l'Armée, combined within the same cartographic enterprise (Castro 2009, 13–14). Flight, photography and film were intimately related.

We have emphasized the importance of fragmentation to aerial survey, but it should not be forgotten that beyond the fragmentation that would produce aerial survey lay the unobtainable dream of totalization. This totalizing drive was illustrated, particularly from the First Word War, in the creation of photomosaics and transcriptions. In photomosaics, fragments of sequential images were montaged to form vastly intricate 'maps' (see Collier 2002). Compelling this form of totalization were values surrounding detail; the very excessiveness of detail, the fact that it is beyond the bounds of human capacity to assimilate, was taken as signalling the reality of the image (Crary 2002). The detail of photomosaics was often overwhelming, and

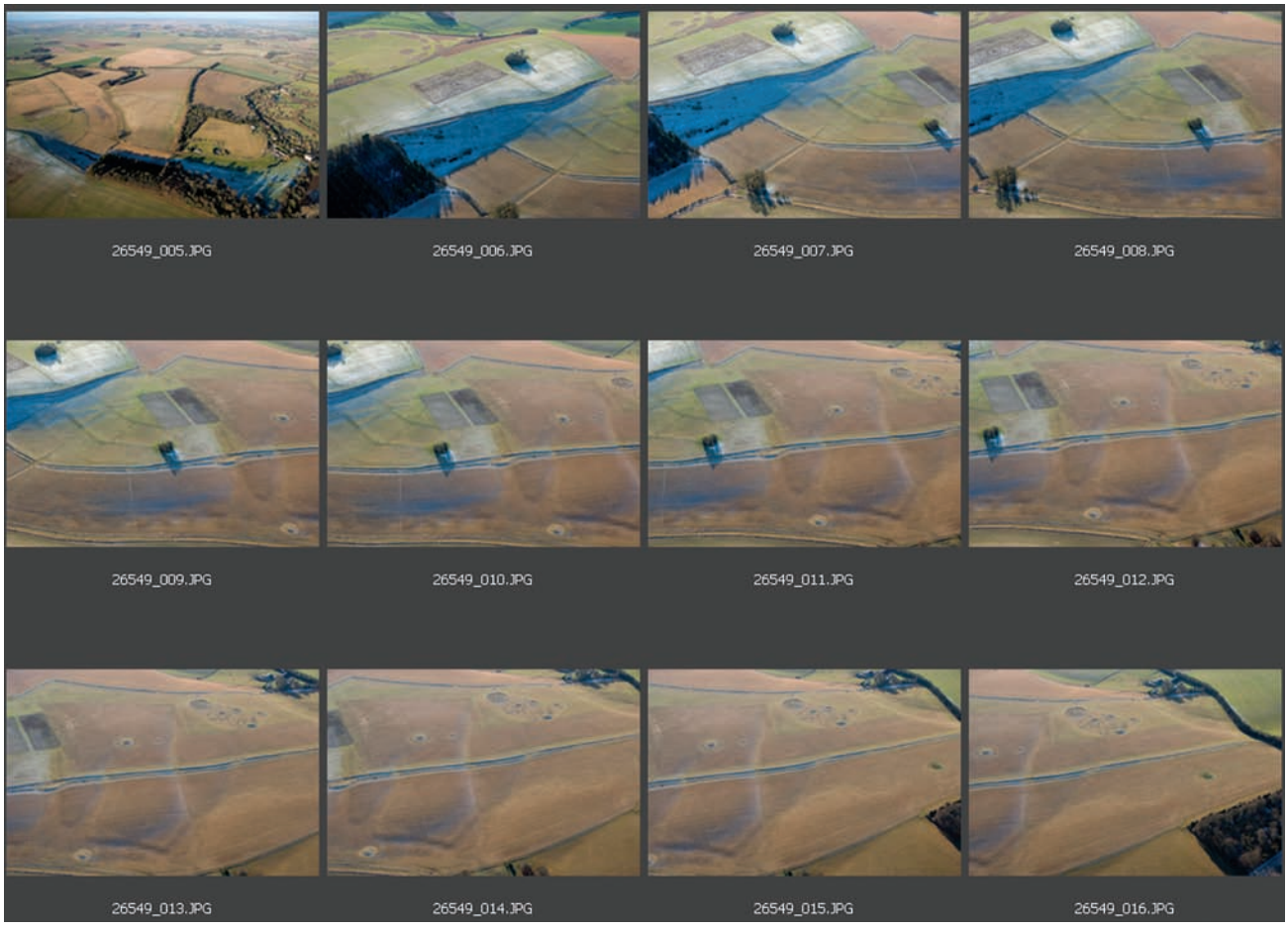

Figure 5. *This screen-grab depicts a sequence of oblique images taken over Salisbury Plain by Damian Grady of English Heritage on 30 January 2010 during a routine archaeological reconnaissance flight. Itself a fragment of a much longer sequence of images from the same flight, this is typically how digital aerial images are initially viewed and processed. (© English Heritage NMR.)*

this was the point — it was understood to be in the accumulation of tiny details that clues to the enemy's intentions could be deduced. It is this theme of detail to which we turn next.

Attention to detail

The unique, defining characteristic of aerial survey was not aerial photography, but the construction of a new regime of attentiveness. Aerial survey was, above all, about attending to detail. Kitty Hauser has written about attention to detail as a key nineteenth-century epistemological paradigm (Hauser 2007, 42–56). The decoding of minute traces became an especially prized scientific ability, celebrated in the new literary genre of detective fiction. The first modern detective story, Poe's *Murder in the Rue Morgue*, coincided with the beginnings of commercially available cameras, and by the time Sherlock Holmes appeared, so-called 'Detective Cameras' were mass-marketed. In the military, meanwhile, the colonial encounter led to fascination with the supposedly ancient skills of 'tracking' — Baden-Powell, exponent of military disguise and reconnaissance, exhorted officers to seek out the tiny traces that would reveal the enemy's hidden manoeuvres. Implicit within both fictional and real-life processes of accumulating detail was the creation of narratives — constructing stories from detail spread across time and space. Interpretation of detail was common to many disciplines emerging towards the end of the nineteenth century; among those Hauser notes are the historical sciences (including palaeontology, geology, archaeology) as well as psychoanalysis, art history, and forensic science (Hauser 2007, 44–8).

Crucially, military organization provided a pedagogical structure within which observers were tutored. This training configured aerial survey, and would go

on to shape the discipline of aerial archaeology. Historically, the military disciplining of vision is linked to the teaching of field drawing, which was an element of training for officers from the later eighteenth century (Gough 1995). Particularly important was the panorama sketch, an endless vista produced from an elevated observation point, and marked with degrees of the compass, for directing artillery fire. As balloons became a feature of warfare, panorama and reconnaissance sketching became an established aerial observation technique. Although histories of aerial archaeology seldom consider how the already established techniques of drawing shaped aerial survey, it seems likely that the influence was profound. During the First World War photographic panoramas (produced by ground-based reconnaissance photographers including O.G.S. Crawford) were the direct inheritors of the panorama sketch. Information from aerial survey also began to be used in field drawings (Gough 1995).

Military visual techniques configured the observer in important ways. In the eighteenth and nineteenth centuries observation was based on rank. Only officers were trained in observation (and, later, in balloon reconnaissance), and the skill was considered so important that famous artists were employed (e.g. Paul Sandby, David Cox, Alexander Cozens — although John Constable turned down the military's offer). During the First World War reconnaissance tasks were broadened to include the rank and file. The 'democratization' of observation, however, was accompanied by the reconfiguration of visualization along industrialized, Fordist, lines. At war's outbreak a number of reconnaissance and drawing manuals were hurriedly re-issued, followed by numerous new manuals during the conflict. The purpose of these guides was to configure the flawed, subjective vision of human interpreters so that it became more like an objective machine or scientific instrument. The first manual on air-photo interpretation was produced in the very earliest stages of the war by the French, with British and American guides following later (Barber 2011). For aerial survey hygienic attention to detail was key: 'Concentrate your whole mind on the particular objects you are seeking' the interpreter was told. 'Do not let your attention wander to subsidiary objectives. Follow every traverse and detail with a pointer in regular and logical order ...' (General Staff 1917). Above all, interpreters had to rise above the subjectivity that their flawed human frame made unavoidable. Like instruments, their vision was calibrated and normalized through tests (such as the stereoscope test). 'Avoid "special pleadings",they were commanded: "do not allow yourself to read in a photograph what you *want* to see"' (General Staff 1917, 5 original emphasis).

Within the new regime of aerial interpretation that emerged during the First World War, clues were not only located in space but traced in relation to one another through time. At the height of the war reconnaissance might cover the same ground several times a day seeking the tiny details which might indicate enemy intentions. Aerial survey made photographic coverage sequential not just in space but also in time, allowing the trained eye to build narratives from the shifting detail, narratives that not only combined past and present but also looked to the future (e.g. Hauser 2008, 36). This layered quality of aerial reconnaissance during the war prefigured the concept of palimpsest that later became so important in landscape archaeology (Stepney 2005; Hauser 2007).

Photographs are two-dimensional; vertical photographs remove vertical perspective, flattening the landscape. Stereoscopy reverses this process, allowing the viewer to sustain attention to a level of detail not accessible from the single image. Increased military stereoscopy in wartime highlighted further 'interpretative' issues. For example, difficulties were encountered in 'decid[ing] whether the point under observation is convex or concave, and ... get[ting] an idea of the depth or height of cuttings and embankments' (General Staff 1917). The latter was demonstrated during the Gallipoli campaign 'when troops were sent to occupy positions identified monoscopically as trenches or ditches, but which turned out to be shallow scrapes that afforded no shelter from enemy fire' (Collier 2002, 162). The convex–concave issue was one that had been recognized long before stereoscopy and photography. It illustrates once more the inadequacies of human vision, yet the response of the military (and, later, aerial archaeology) was to explain it as a technical or procedural error, the result of a failure to arrange photographs and stereoscope correctly (e.g. Bradford 1957).

Ways of thinking were embodied in the visual techniques archaeology acquired from the military (see Stepney 2005). In the military, 'Interpretation' was a specially defined function, with separate staff, equipment and locations. The special training of 'Interpreters' supposedly gave them the ability, through standardized procedure, to transcend the inherently subjective nature of human vision. It was in 'Interpretation' that subjectivity lay, while data (e.g. photographs) were inherently objective. The history of archaeological empiricism emerged from the history of a subjective model of vision. This subjective model can, in turn, be related to the emergence of modern industrial capitalism, which required flexible, mobile, individualized visualities: consumers revelling in the flickering spectacle of mechanized visualizations, and labourers disciplined in the correct way of paying attention (Crary 2001).

Conclusion

The histories we tell ourselves about what we do shape the future of our practice. Today aerial archaeology is being transformed through the effects of shifts in visuality at least as profound as those of the 1820s and 1830s. With screen-based viewing, airborne laser scanning (Lidar) and digital mapping, aerial archaeology is moving from the cinematic era into the simulation age. Historicizing this shift is beyond our remit here; nonetheless, the dramatic changes in archaeological visualization of the last fifteen years add urgency to the question of how we should tell our histories. Modernist histories focused on individual pioneers and technological advances (the 'men in the air' tradition) perch Lidar on the crest of a wave-of-advance propelling archaeology ever forward, meanwhile letting much of Lidar's significance wash by, unanalysed. At the same time, theoretically informed approaches need to find ways of tackling the specificities of archaeology's specialist practices. For all it partakes of a 'Western' masculine way of looking, aerial survey is different from perspective painting and classical cartography. While insights from the history we have developed might prove useful to accounts of Geographical Information Systems, Lidar or Geophysical Survey, the practices of each differ, and they each require their own a detailed genealogies (see Wickstead 2009).

Modernist history perpetuates the empiricist fantasy, long dismissed in archaeology generally, that knowledge consists in accumulating facts about the past: new technologies allow us to map more sites and therefore, supposedly, to know more about the past. Our history offers an alternative standpoint, though hardly a novel one (Thomas 2004; 2008): that the way in which knowledge is built is linked to changing ways of seeing. The empirical tradition in archaeological prospection means that debates around 'objectivity' continue to shape new approaches (see Brophy 2005). We have argued that aerial survey has always been linked to a profoundly subjective, interiorized, model of visuality located within the individual body. This shift, which smashed perspective and fragmented the relationship between observer and observed, led to neurotic attempts to fix reality through endlessly proliferating detail and by re-inscribing objectivity within the vision of machines. When objectivity is based around the impartiality of machine vision, subjectivity is relegated to 'bias' — concerns about where and how the camera is directed, and the individual flaws or personal experiences of those involved. Much debate within aerial archaeology continues to revolve, in circular fashion, around a subjective-human and objective-machine circuit.[6]

Our 'spectacular history' has not absolved aerial archaeology from charges of surveillance and totalization. Instead we have traced the specific ways in which aerial survey's totalizations and subjectifications might operate. We have argued that aerial archaeology emerges less from the objective vision associated with the *camera obscura*, and more from the deranged and disorientating subjective vision associated with stereoscopes and moving pictures. Modern totalization paradoxically requires this creative destruction, fragmenting time-space into smaller and smaller pieces that demand reassembly. However, by linking aerial survey to the history of spectacle, we suggest that it has never been a purely disenchanted science of surveillance and control. Aerial archaeology in particular has always also involved curiosity, pleasure and the re-enchantment of the seemingly mundane (see Hauser 2007; Wilkinson 2008).

At the beginning of this article we observed how the distance between aeroplane and earth, embodied in the aerial photograph, provides a metaphor for the distanced perspective of science. In this metaphor, objectivity is based on the observer standing outside the object, just as the user of the *camera obscura* stands outside a vision projected outside her body. Both critics and practitioners of aerial archaeology make use of the distance metaphor, yet aerial survey has never been a simple matter of getting airborne with cameras. Our history has tried to sever aerial survey from the burden of this metaphor, suggesting aerial survey involves visual practices that entangle observer and observed, creating intimacy rather than distance. The elision between the distance of the aerial view and the distanced gaze is created by selectively preferring one moment in aerial survey's practice over all others. Rather than appreciating the whole chaotic stream of visualization that is aerial survey, this metaphor selects the isolated photograph, the illustration frozen on paper, to stand for the whole. We have attempted to broaden critical reflection away from photography and the singular aerial photograph, towards the visual practices within which multiple, sequenced images are deployed. Hallucinatory techniques like stereoscopy are profoundly intimate and interiorizing, while aerial survey's broader range of visualizing methods are as capable of evoking emotional and aesthetic responses as they are of providing mathematical precision. Restoring the history of devices like the stereoscope, and re-situating aerial survey alongside contemporary developments in stop-motion photography and cinema, we find a history that belies the dreams of empiricism so often invested in this field.

Notes

1. 'The air photo, the satellite image and the Geographical Information System', Thomas argues, are 'tainted with surveillance and voyeurism' (1993, 25, 27).
2. For example, in the bible, the temptation of Christ sees the Devil transport Jesus to a high place from which 'all the kingdoms of the world' are visible 'in an instant' (Luke 4, 5–7).
3. Models — including models of ancient monuments — also embodied many of the properties of the bird's-eye view. Indeed, Evans (2000; 2007) has argued that some nineteenth-century depictions of archaeological sites such as Stonehenge were drawn from models rather than the real thing (see also Chippindale 1985).
4. English Heritage, for example, requires all prospective Air-photo Interpreters pass a stereoscope test.
5. For example, they were not in colour, yet were still considered more 'realistic' than paintings or engravings (Daston & Galison 1992).
6. 'Phenomenological' approaches posited on the rediscovery of individual subjectivity within existing practice (e.g. Brophy 2005) uncover little more than the reproduction of a nineteenth-century model of vision already located within aerial survey. The model of vision from which aerial archaeology emerges has always depended on an individualized notion of subjective experience.

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