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$GPGSV: SATELLITES IN VIEW

Introduction

Contemporary tourism is a product of the nineteenth century. The solitary traveler who finds himself in an encounter with nature is a central image of Romanticism – a trend that came into existence at the same time as tourism. This image is still active today – in the notion that a successful education must include a period of study abroad as part of the characterforming role of the comprehensive backpacker's journey or in "the connection of learning and roaming"[1] in the MigAA project. Furthermore the emergence of both Romanticism and tourism took place in the same historical context in which the construction of global space was completed. A primary consequence of this construction is a global grid upon which the whole surface of the earth may be locally pinpointed: its origin is an activity which today carries specifically romantic connotations: the observation of stars.

1. As Laura Popplow formulates in her contribution to this book: "Clearing and Locating."

2. Jacques Lacan: "Psychoanalysis and Cybernetics," in *The Seminar of Jacques Lacan, Book II (1954-1955): The ego in Freud's theory and in the technique of psychoanalysis*, Cambridge University Press 1988, p. 294

Places and Positions

"It's not for nothing that I choose the heavenly orientation instead of the earthly, the map of the heavens was completed before the map of the globe was compiled."[2] Whereas the Earth's surface was, first of all, a net of connected local *landmarks*, which already found a place in local maps and navigational

Figure 1: *Satellite Spotting* in Motovun, Croatia, 2009. Photo: Anselm Bauer

methods – the celestial map formed the basis for the construction of a global map. Only the celestial map furnishes the foothold on which the grid of a global map may be suspended – not so much because the celestial bodies mark earthly positions as heavenly *landmarks*, but because the Earth rotates.

The central observation of astronomy, and the exact sciences in general,[3] is that of repetition – day, night, moon phases, seasons, and tides. Indirectly, important events such as the flooding of arable land all depend on cyclical celestial events that make them predictable and therefore controllable. Many of these events have a frequency of one day. They are the direct result of the Earth's rotation motion that is, first and foremost, a clock. The sun comes up in the morning and goes down in the evening. The high point of this movement, the zenith, defines astronomical noon. The stars trace, in the course of a night, a circular motion across the firmament. As these movements are the result of Earth's rotation, they are designated as *apparent*. That is, although the location of the stars relative to the Earth barely change, they seem, from the perspective of an observer, to move in a circular paths across the sky. Because this apparent motion of celestial bodies at each point on Earth's surface is different from any other point, the time frame that it produces is local and it can be used to define this point. The system of coordinates that defines this point is spanned by longitude and latitude. Whereas the angle of the solar altitude at the midday zenith is the basis of a terrestrial point's latitude, the difference between local time and the time of any other point on the Earth provides the longitude.[4]

3. Ibid., p. 376

4. Compare this to the tenth Astronomer Royal, Sir Harold Spencer Jones: "The Measurement ofTime" in: *Reports on Progress in Physics*, Volume 4, 1937, pp. 1–26.

The coordinate system of the Earth's surface is thus anchored in the sky above. Geodetic astronomy measures the Earth by observing celestial bodies. It is not interested in the stars themselves, but only in the trajectory of their apparent motion. These directional vectors are the coordinates of celestial

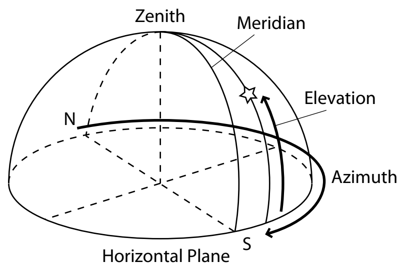


Figure 2: Horizontal equatorial and geographic coordinate systems.

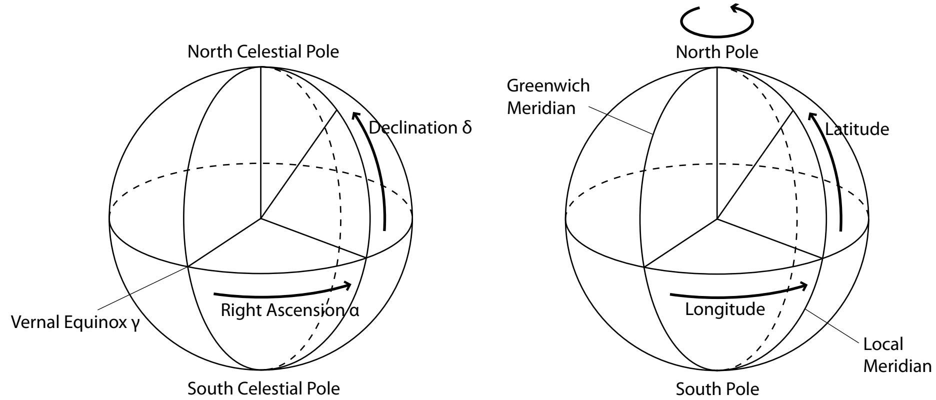
bodies, they are called 'star positions'. These positions, once projected upon the earth's surface, are the age-old basis for all locations. The longitude and latitude of the earthly coordinate system hence correspond to right ascension and declination measured on the celestial sphere.

As European imperialism extended to the entire world and began to solidify that global reach, the Royal Greenwich Observatory formed one of its cornerstones. The production of place and time through the observation of stars constituted part of the control system of the British Empire and was anything but romantic. The assistants to the *Astronomer Royal* spent the majority of their time operating this system. For fifteen hours a day they had to be available for observations and running calculations.[5]

5. Mary Croarken: "Astronomical Labourers: Maskelyne's Assistants at the Royal Observatory", Greenwich, 1765-1811, in: *Notes and Records of the Royal Society of London*, Volume 57, Number 3, 2003, p. 288.

At first, the coordinate system for the observation of stars was still geared towards the observer. The horizontal coordinate system was oriented towards the horizon of the observer and indicated the direction of a star from his point of view. The azimuth of the star designated the deviation from the local meridian to the north, the elevation its elevation angle above the horizon (fig. 2).

To get from this system to the equatorial coordinate system of the celestial sphere and the geographical coordinates of the Earth, local time and location must be generated by themselves from the earth's rotation. This type of observational practice continually put location and time in relation with one another. Geodetic astronomy observed when a star (apparently) happened to cross a certain line of reference. The telescope became an 'instrument of passage' (a transit telescope) through which the apparent motion was observed. Local time was not only determined but also set in relation to such 'transits'. Therefore one had to be able to record the time once it was determined. This first became possible in 1657, when Christiaan Huygens



implemented Galileo's law of the pendulum in a pendulum clock.[6] Localization thus became a recursive procedure: observations of celestial bodies provided the local time, which was recorded by a pendulum clock, so that time could support further astronomical observations.

6. Albert Schödlbauer: *Geodätische Astronomie*, Berlin (Walter de Gruyter) 2000, p. 302.

7. Compare to Jones: "The Measurement of Time" or Croaken: "Astronomical Labourers."

The pendulum clock and telescope were linked in practice – James Bradley, the third *Astronomer Royal* at Greenwich, developed the eye-and-ear method, that distributed movement and time to the eye and ear of an astronomer. A telescope was focused on the local meridian to the north. In its eyepiece a crosshair grid allowed the observer to fix a selected star on one horizontal thread. Through the Earth's rotation the star would appear to pass through one vertical thread after another. While the eye followed this movement, the ear heard the pendulum clock that ticked every second. Noting the distances between threads and star at each tick of the clock, a trained observer could determine the time of transit, referred to as the 'bisection', to a tenth of a second.[7]

The observations were recorded and published by a standardized global network of observers, methods, apparatuses, and almanacs and it was only then could the global *grid* of today's maps and the ensuing production of locality come into being.

Ground Truth

The projection of the celestial sphere onto the earth stands in contrast to a confusing ground truth. The Earth is not a sphere, not even an ellipsoid, but an irregular geoid. Gravity and the Earth's magnetic field are subject to local variations which may affect the northward alignment of monitoring instruments and cause clocks to beat more slowly on one side of a moun-

Figure 3: The Mason-Dixon-Line. Map: The Slave Heritage Resource Center, www.sonofthesouth.net/slavery/slave-maps/mason-dixon-line.htm [13-09-2010]

tain than on the other. In addition to all this is a landscape that is made up of anything but straight lines.

Since the ultimate submission of the old and new world depended substantially on the ideal arcs of astronomy, it is not surprising that these arcs are found today in the political boundaries of former colonies and even in the subdued landscape itself. Charles Mason, a former assistant to James Bradley, together with Jeremiah Dixon, in a famous expedition from 1763-1767 cut the border between Pennsylvania and Maryland as a straight line through the landscape of America.[8] Their positioning was linked by chained lines, demarcated by logged forests, and engraved on stones. As a *very bad feng shui*,[9] astronomy became landscape. The Mason-Dixon Line is still the symbolic boundary between the northern and southern United States, just as *Dixieland* is a namesake form of music from the South. (Fig. 3).

8. Thomas D. Cope and H. W. Robinson: "Charles Mason, Jeremiah Dixon and the Royal Society" in: *Notes and Records of the Royal Society of London*, Volume 9, Number 1, 1951, pp. 55–78.

9. Compare to Thomas Pynchon: *Mason & Dixon*, London (Vintage) 1998.

For astronomers, the *ground truth* long played a crucial role. Measurements were repeated, clocks were compared, and the gravitational field of the Earth measured in detail. It was considered impossible that astronomers could make mistakes which could effect space and time. This was partly because the response time for the eye-and-ear method could only be noticed when there was a source for this time independent of the observer – and not when the time at which a delayed transit was observed, has been determined by observation and with the same response time before. Systematic errors could only be noticed when different observers referred to the same synchronized local time. But for a long time the scientific world-view did not allow for a flawed observer. In Greenwich, where the *Astronomer Royal* and his assistant worked, divergent observations could theoretically occur. When this event actually did occur in 1796, the astronomer Nevil Maskelyne summarily fired his assistant David Kinnebrook. The difference in their observations was

ascribed to Kinnebrook using the wrong methods.[10] Perhaps this error came at the right time for Maskelyne, however, as coincidently, he had wanted Kinnebrook to marry the niece of a friend and Kinnebrook had refused.[11]

Only when Carl Friedrich Gauss introduced statistical calculations with errors into physics, was the 'Kinnebrook case' rediscovered. Now the time was ripe to add the errors of observation to the errors of instruments. As these were still errors that could only be discovered by comparing different observers they were designated as 'constant differences' by Friedrich Wilhem Bassel. Astronomy now included such differences for subsequent error calculations in their records. The constant differences between observers became known as the 'personal equation'.[12]

Up to the nineteenth century astronomy sought to minimize the personal equation, first by training and later with new monitoring tools. In 1889, the personal equation was finally dealt with by the *impersonal micrometer* – a semi-automated instrument on which an observer recreated the apparent motion of a star and the time of the transit was recorded electro-mechanically.[13] Subsequently, the observer was finally eliminated – zenith cameras recorded the apparent motion of celestial bodies fully automatically, and later electronic CCD systems took over this task completely.

Today the history of the depersonalized observation of stars has been radicalized: the *Global Positioning System* has replaced the global network of instruments and observations through machinery. Not only has the observer been replaced by fully automated radio receivers, even the heavenly bodies have been replaced by artificial satellites and the locations of apparent motion by actual orbits. This artificial positioning system is still dependent on time, only now it is the delay differential of radio signals that is the critical factor – and their references are created by atomic clocks in the satellites. This has led to technologies such as GPS satellites, but not to a revolutionary rupture. Rather, they show how "historical and social structural principles" such as the positioning practices extant since ancient times have been objectified into "machinery and organisational structure."[14] Observing the stars and astro-navigation, in light of this layered technological genealogy, remains a particularly romantic hobby.

10. Christoph Hoffmann: "Constant Differences: Friedrich Wilhelm Bessel, the Concept of the Observer in Early Nineteenth-century Practical Astronomy and the History of the Personal Equation" in: *The British Journal for the History of Science*, Volume 40, Issue p, p. 339.

11. For this and other possible reasons for Kinnebrook's termination as well as his differing observations see J. D. Mollon und A. J. Perkins: "Errors of Judgement at Greenwich in 1796" in: *Nature*, Volume 380, 1996, pp. 101–102.

12. Christoph Hoffmann: *Constant differences.*

13. Jones: *The Measurement of Time*, p. 6.

14. Compare to Arno Bammé, Günter Feuerstein, Renate Genth, Eggert Holling, Renate Kahle, Peter Kempin: *Maschinen-Menschen, Mensch-Maschinen.* Grundrisse sozialer Beziehungen, Reinbek (Rohwolt) 1983, pp. 109–112.

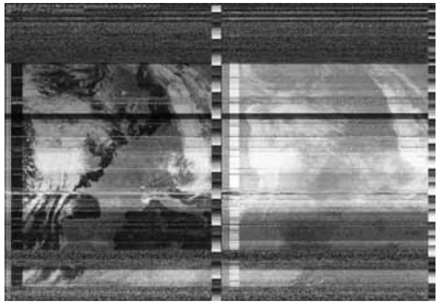


Figure 4: Improvised *Satellite Can* in MigAA Laboratory III, Ars Electronica 2009, Linz. Photo: Lasse Scherffig
Figure 5: Satellite image of NOAA17. Image: received by the Office for Uncertainties (Büro für Unabwägbarkeiten) on 23-08-2009 in Oldenburg

Global Positioning and Locative Arts

A look at the NMEA 0183 data format[15] that is used primarily for communication between GPS receivers and their applications, will quickly demonstrate how astronomical practice has left its mark on satellite navigation. The data sets of the type $GPGGA encode a point on the global grid in the geographic coordinate system – and thus the image that we find in each navigational device. In contrast we find encoded in the $GPGSV-dataset the satellites-in-view – that is those satellites above the local horizon and indicated as celestial bodies with azimuth and elevation in observer based horizontal coordinate system. GPS receivers are literally mechanized observers of geodetic astronomy.

15. *National Marine Electronics Association 0183 Standard*: www.nmea.org/content/nmea_standards/nmea_083_v_400.asp [23-06-2010]

Against this background it is no wonder that a series of artistic strategies dealing with positioning technologies take the lost observer as a theme. An obvious strategy is to reproduce the role of the astronomer and to direct attention to the cyclically emerging artificial celestial bodies in this system. This requires that the angles describing the relative position of the satellites be translated into action. The *Satellite Can* (fig. 4) uses an orientation sensor that detects the vector of the viewing direction. A sensor attached to a cardboard tube, through which a viewer looks, steers and measures his glance. The difference of the viewing angle and the position of a satellite is sonified, so that the ear hears if the eye is looking in the direction of a satellite. *Satellite spotting*, actually a purposeless hobby activity which is very close to romantic star gazing, thus becomes an experiment which takes as its theme the technical foundations of global positioning, as well as their historical origins in the observation of stars with the eye-and-ear method.

But the tracking of GPS satellites will never reveal more than their mere direction. The orbits of GPS satellites, at 20,200 km above the surface of the

earth, are too high to be visible to the naked eye. But the world of amateur *satellite spotters* already offers websites, software, and data sets to predict the emergence of many other satellites[16] – predictions which can in turn be fed into the *Satellite Can*. The most famous of the visible phenomena are the *Iridium flares*: extremely bright reflections of sunlight on the reflecting antenna of *Iridium* satellites (whose orbit is at an altitude of 780 km) which are sometimes even visible during the day.[17]

In her project *Sun Run Sun* and the emerging work *Satellite Sounders* the artist Yolande Harris works explicitly with the lack of visibility of GPS satellites. Portable devices assess data from GPS receivers and sonify the position of the observer, as well as the relative position of the 'satellites-in-view' making an abstract soundscape. The project refers also to the historical roots of satellite navigation systems: "Sun Run Sun investigates contemporary, historical, and animal techniques of navigation through the use of sound."[18]

Members of *The Office of Uncertainties* (German: *Büro für Unabwägbarkeiten*) go one step further in the research performance *satellite sailors*. "Anselm Bauer, David Hahlbrock, and Franziska Windisch move through urban space on spontaneous walks. In their bags they carry modular research stations. Together these laboratory modules form a system with which the image data received from weather satellites, can be received, presented, and processed."[19] An ordinary alarm clock goes off whenever a NOAA weather satellite rises above the horizon. The Office members then stop and build up their mobile laboratory. While the satellite crosses the sky, the laboratory receives its radio signals and decodes them. The result is the image that the satellite has just taken. Since this can only be accomplished when the satellite is 'in view' and the satellite sends what is just then directly in its view, The Office crew receives a image of their own location. The image is then printed at the receiving point and pasted onto the road with gelatine. With chalk more information is added to this fleeting archive. Because the horizon determines the duration of the transmission, The Office crew supplement the satellite image with an additional panorama image of the surrounding horizon. Finally this fleeting archive within the urban space is integrated into an installation in the context of the exhibition *Landschaft 2.0.* "The Meta-archiv consists of photographic documentation of the street archives and an arrangement of the recorded data in an audio installation and a video projection, which are linked with a spatial drawing."[20]

While their arbitrary movement through urban space, their improvised laboratory, and their use of everyday objects in the *research performance* may seem absurd and pseudoscientific, the performances do more than

16. For example heavens-above.com or www.n2yo.com [23-06-2010].

17. heavens-above.com/iridium.asp [23-06-2010].

18. www.yolandeharris.net/?p=177 [23-06-2010].

19. The project *satellite sailors* was realised in 2009 in cooperation with the Edith-Ruß-House for Media Arts as part of the exhibition Landschaft 2.0. Compare to Büro für Unabwägbarkeiten: "satellite sailors" in: *off topic*, Number 1, 2009, pp. 68–71.

20. Ibid., p. 69.

Figure 6: *Satellite sailors*, 23.08.2009, 21:32 MEZ, Donnerschweerstr. 336, NOAA 17, FM 137,62 Mhz
Photo: Niels Mlynek

materialize actual images received from space. Above all this *poetic process of experience and production of landscape*[21] confronts the conventions and technologies of navigation and its historical roots. The mathematically-predicted appearance of certain celestial bodies structures the *research performance*, just as the 15-hour day structured the Royal Greenwich Observatories daily tasks. The alarm clock, as an instrument of this structuring, is not just an everyday object, it also recalls the temporal organisation of observation by pendulum clocks. And while the horizon is, in astronomy, the basis of the observer-based horizontal coordinate system, it is here depicted as the perimeter of reception. The reference to marine travel in the title of the performance is a clear reference to the origins of satellite navigation in nautical navigation techniques based on the observation of celestial bodies and the use of clocks.

Since the US military ceased its 'selective availability' of GPS satellites in May 2000, finally opening up the system for non-military purposes, GPS has become a normal part of our world. Modern technologies of navigation and positioning have driven the construction of local places on the global grid and have resulted in a transformation of motion and location, which has been primarily a technical one. So-called *Locative (Media) Arts* introduce a new terminology because they are not simply 'site specific'. Despite what the name suggests, they work not only with places, but primarily with positioning technology. Laura Popplow introduces the genre elsewhere in this book with the words: *Besides its commercial and military uses, a group of artists, designers and researchers have emerged in recent years who are concerned with the technology of localized media.*[22]

21. Ibid., p. 69.

22. Laura Popplow: "Clearing and Locating", emphasis are mine.

There is no question that *Locative Media Arts* have technology as their theme. This is true even when these technologies are in the service of spatialized stories or when mapping projects create an imaging of space. The projects described here make explicit that positioning technologies and their foundations, historical origins, and usages are at the center of their work. It is no coincidence that the word *satellite* is prominent in the title of the work. In this context the projects are part of a tradition of an archaeology of media and media art that is above all media-reflexive.