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Early Digital Images. A Praxeology of the Display

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Early Digital Images

A Praxeology of the Display

The digital image is non-existent. If anything is responsible for missing the point here, then it is inappropriate essentialism. What there are, are innumerable analog images that illustrate the data that are present in a digital form: on monitors, televisions or paper, on movie screens, displays and so on.[1]

Shedding Light

Media studies have postulated consistently that digital images do not exist.[2] This has not prevented the visual studies and arts from continuing with the attempt at proclaiming a phenomenology of images that refuses to negate their digital transformation or even origin.[3] The fact that we perceive images on digital displays has led to an analytical imprecision in the development of theory in the visual studies, in that the technical conditions underlying displays are referred to the materiality of images. This contribution attempts to re-introduce the separation between image and image carrier, in order to make a statement on the specific properties of digitally generated pictorial worlds. By shedding light on the historical and, simultaneously, the practice-theoretical contribution of the display in the discourse on digital imagery, we can show that the scientific reflection on images in general has been unfoundedly loaded with meaning in the truest sense of the word.

The "material turn"[4] that is currently being diagnosed in the analysis of digital media practices as well as the discourse on "soft images"[5] reveals that we are increasingly dealing with dynamic, transparent and malleable displays adapting themselves to the individual user, context and situation. This raises the question as to what contribution a practice theory can make toward conclusive media esthetics, media history and a media theory of the display.

Such a practice theory must be assessed on the basis of "the practical procedures being given precedence over all other explanatory parameters".[6] Under reference to Harold

1 Claus Pias, Das digitale Bild gibt es nicht. Über das (Nicht-)Wissen der Bilder und die informatische Illusion, in: *Zeitenblicke* 2.1 (2003), http://zeitenblicke.de/2003/01/pias/ (accessed November 1, 2017).
2 See ibid.; Wolfgang Hagen, Es gibt kein digitales Bild. Eine medienepistemologische Anmerkung, in: Lorenz Engell, Bernhard Siegert, Joseph Vogl (eds.), *Archiv für Mediengeschichte. Licht und Leitung*, Weimar: Bauhaus-Universität Weimar, 2002, pp. 103–110.
3 See Gundolf S. Freyermuth, Lisa Gotto (eds.), *Bildwerte. Visualität in der digitalen Medienkultur*, Bielefeld: transcript Verlag, 2013.
4 Bill Brown, Materiality, in: W. J. T. Mitchell, Mark B. N. Hansen (eds.), *Critical Terms for Media Studies*, Chicago: The University of Chicago Press, 2010, pp. 49–63; Sarah Pink et al. (eds.), *Digital Materialities. Design and Anthropology*, London/New York: Bloomsbury, 2016.
5 Ingrid Hoelzel, Rémi Marie, *Softimage. Towards a New Theory of the Digital Image*, Bristol/Chicago: The University of Chicago Press, 2015.
6 Erhard Schüttpelz, Skill, Deixis, Medien, in: Christiane Voss, Lorenz Engell (eds.), *Mediale Anthropologie*, Paderborn: Wilhelm Fink, 2015, pp. 153–182.

Garfinkel, we could also formulate this as follows: "Praxeology seeks to formulate statements of method, and to extend their generality, seeking as wide a domain of applicability as possible."[7]

The aim of a media practice theory of the display must be to unveil the methods of the medium.[8] Given the diversity and multiplicity of displays, this essay therefore pursues the question of what sociotechnical properties are exhibited phenomenologically by digital displays. What constitutes their specific media characteristics that distinguish them from all other forms of electronic monitors and screens? We initially need to take a step back to help us to better estimate the scope of the current development. How long have we actually been in a position of referring to the *display* as an independent medium?

The Top View of the Display

In 2003 for the first time, more LC displays were sold in Germany than conventional monitors with cathode ray tubes (CRT).[9] Since then, a fundamental change in screens can be diagnosed: from the stable, fixed CRT monitor to the flexible, mobile LC display;[10] from the heavy, furniture-like, three-dimensional object that reveals an image on its *open* side to the thin and fluid two-dimensional digital surface that appears to be one with what it depicts.

While the term monitor (Latin: an overseer, instructor or guide) still expresses specifications of an observing subject, at first sight, the display shifts what is being presented and exhibited into the center. The term "screen", which primarily emphasizes protection from electronic radiation (electronic images), already points to this fundamental difference between it and the display.[11] The type of visibility appears to be the key to understanding the display culture.[12] The materiality of the display will therefore be at the focus of a historical genealogy in the following, which reveals a series of media practice-theoretical determinants.

When contemplated from a technical and historical perspective, the term display does not originate from the medium of the television or computer but rather from the military medium of the radar: the radar display refers to the radar screen. The first field experiment using radar was conducted in Great Britain as early as February 26, 1935, during which a test airplane produced an additional illuminated dot on the screen of a cathode ray oscilloscope through the radio waves emitted by the BBC transmitter in Daventry being reflected off the body of the plane.[13]

7 Harold Garfinkel, Some Sociological Concepts and Methods for Psychiatrists, in: *Psychiatric Research Reports* 6 (1956), pp. 181–198, p. 191.

8 For visual media methodologies see: Gillian Rose, *Visual Methodologies*, London: Sage Publications, 2001.

9 See Andreas Wilkens, Erstmals mehr LC-Displays verkauft als Röhrengeräte, in: *heise.de*, 16.03.2004, http://heise.de/newsticker/meldung/45600 (accessed November 1, 2017).

10 Liquid crystal display (LCD) is an umbrella term for liquid crystal screens. The thin film transistor (TFT) refers to specific LCD technology that is used to created large-scale electronic circuits. TFT technology is currently the dominant flat screen technology, which is why LCD and TFT are used almost synonymously. More modern LCDs are also called LEDs as they use light-emitting diodes for background lighting. This allows a more compact construction and thus thinner displays. LED technology is currently becoming more and more prevalent, also in the form of its organic variant (OLED) that possesses a lower luminance density and therefore no longer relies on the use of monocrystalline materials.

11 The French écran also originally means visual protection. The term screen that is generally used in English refers to the projection surface in movies and to television, video and computers. Gunther Kress, "Screen": Metaphors of Display, Partition, Concealment and Defence, in: *Visual Communication* 5.2 (2006), pp. 199–204.

12 See Sean Cubitt, *The Practice of Light. A Genealogy of Visual Technologies from Prints to Pixels*, Cambridge, MA, 2014.

13 An oscilloscope detects changes in voltage in an electric circuit using a light trace. This becomes visible on an analog computer based on the same

During this experiment, the radar display was already calibrated so that distances were on a linear scale and it was thus easy to take a reading.[14] A ruler was depicted on the oscilloscope, from which the distance of a flying object could be read off, based on where the pulse of the echo signal amplitude was produced. However, in spite of their scaling, the distances that were measured were not yet georeferenced. Cartographic projections were not yet possible with the oscilloscope. The first radar displays simulated the practice of reading a ruler (fig. 1).[15]

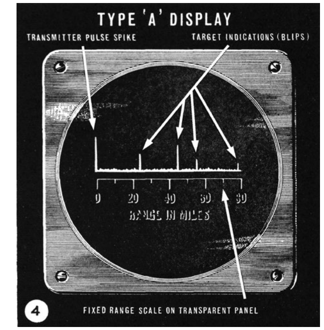
This changed with the plan position indicator (PPI), proposed in 1935 and used for the first time in 1940, that allowed a top-down view of events.[16] This is the classical form of the radarscope with a panoramic display (fig. 2).[17]

"Such a system with a rotating, or sweeping, line is what most people continue to associate with a radar display."[18] The PPI display indicates the distance and direction for all altitudes through a *sweep* (a scan line that corresponds to the position of the radar antenna in a given moment) that rotates around the center of the cathode ray tube and depicts the echo blips as bright dots: "With this form of display, the airplanes were represented as dots in a two-dimensional representation of the actual airspace. Here, for the first time perhaps, a bridge is constructed between the representation of technoscientific data, such as offered by the oscilloscope, and the mimetic representation made possible by the television."[19]

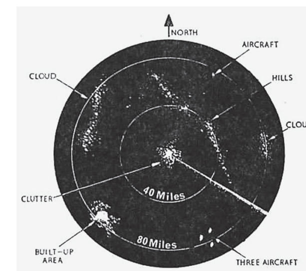
In Germany, the viewing tube of the all-round sensing system was called a "*Sternschreiber*".[20] The first decades of displays are not characterized by a (4:3 or 16:9) rectangular section of *reality*, but by circular screens. Using radar systems ("*Rundsuchanlagen*", lit. "circular search apparatus") required panoramic viewing instruments.

All-round sensing with a panoramic display only became available in Germany in 1944. A distance indicator, EAG 62 "Emil", was used to locate enemy bombers and to guide the German fighter jets.[21] However, joint depiction of the fighter jets and enemy bombers was required to guide the fighter jets, leading to the development of the "*Himmelbett*" method in 1941, led by Josef Kammhuber, to project the measurements for distance, azimuth and flight altitude as spots of light onto the glass disc of the "Seeburg plotting table".[22]

In this case, the display is a window onto the turntables behind it that combine the different representations produced by the pixel projector ("*Bildpunktwerfer*") into an indexed picture (fig. 3). The foundations for the display as an independent playback medium were thus laid, and the term display was transformed from the *indicated* to the *indicator*,



1 Radar oscilloscope before 1940.



2 Schematic illustration of a classical displays on a plan position indicator.

principle as the Braun tube, as is also still the case for the image signal in current televisions. Robert Watson-Watt was already using an oscilloscope as a display for locating storms in 1923.

14 See Robert Watson-Watt, *Three Steps of Victory*, London, 1957, p. 471.

15 The History of Flight Radar, http://planefinder.net/about/the-history-of-flight-radar/ (accessed November 1, 2017).

16 Robert Watson-Watt, The Evolution of Radiolocation, in: *Journal of the Institution of Electrical Engineers* 93 (1946), pp. 374–382, p. 379.

17 Manfred von Ardenne had already developed a precursor to the panoramic display tube in the mid-1930s. See Manfred von Ardenne, Ein neuer Polarkoordinaten-Elektronenstrahl-Oszillograph mit linearem Zeitmaßstab, in: *Zeitschrift für technische Physik* 17 (1936), pp. 660–666. However, Göring rejected further development after looking at the drafts and photos of "figures on a fluorescent screen". Manfred von Ardenne, *Ein glückliches Leben für Technik und Forschung*, Munich, 1976, p. 131.

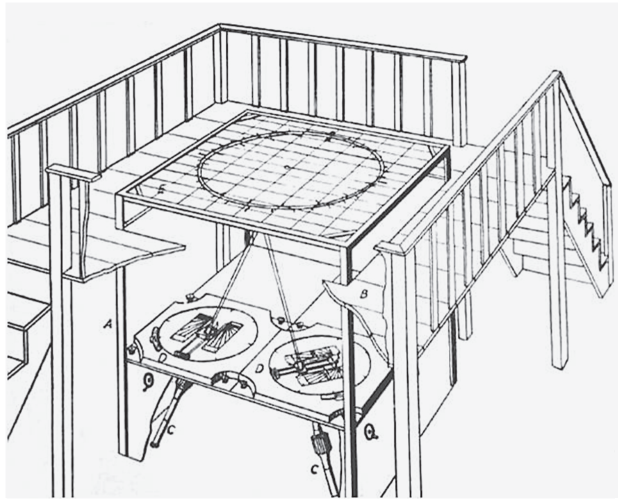
18 Wikipedia, Radar in World War II, http://en.wikipedia.org/wiki/Radar_in_World_War_II (accessed November 1, 2017).

19 Charlie Gere, Genealogy of the Computer Screen, in: *Visual Communication* 5.2 (2006), pp. 141–152, p. 146.

20 Fritz Trenkle, *Die deutschen Funkführungsverfahren bis 1945*, Heidelberg: Hüthig, 1987, p. 200.

21 David Pritchard, *Durch Raum und Zeit. Radarentwicklung und -einsatz 1904–1945*, Stuttgart, 1992, p. 63.

22 Trenkle 1987 (as fn. 20), pp. 193–194.



3 Sketch of the *Seeburg plotting table*.

from the *(re)presented* to the *(re)presenter*, from the image to the medium.

Instead of the now common sight of vertical screens, the dispositif of one of the first displays was determined by people moving around a table in the *Himmelbett* method. The compact all-round viewing instrument (“*Rundsichtgerät*”) in the “*Jagdschloß*” system also required observation from above.[23] Even the frontally attached panoramic display in the 1944 mobile “*Rundsuchanlage*”, “*Jagdwagen*” or “*Panotwiel*”, still makes reference to this: it was called “*Drauf*” (from above).[24] It is this special dispositive structure, in particular, that characterizes the *point of departure* for the display and its history (fig. 3).

There were also enormous map tables in the English command centers of the pre-display era, on which, however, bits of cardboard cut into the shape of airplanes were still being used to indicate their current position (fig. 4). While the male officers studied the map, female soldiers continually changed the position of the miniature airplanes based on the incoming radar information, by moving them with long sticks.[25] The human actors were also moved about in the same way as the model airplanes. The display of the *Seeburg plotting table* has this in common with map tables and paper maps (fig. 4).

The methods that are used to process and depict the information collected from the radar have not changed the *puppet strings* guiding the supposed beneficiaries. The movement of distant objects determines the motion of the person in front of the display. The display renders the location of a distant object into externally guided movement and location of the person, as the position of the person in front of the display is determined by the position of the objects detected by radar. The display creates a uniform interaction space in which distant objects that are out of view are aligned with a subject making the observation. Coordination thus occurs without (visual) contact.

Radar technology creates semipermeable spaces in which object coordinates from an external space penetrate into an internal space, and resultant actions in the internal space have effects on the external space. A sociospatial duplicity of vehicular coordinates is produced by the simultaneity of movement in geographical space and in the map room.

23 Ibid., pp. 106–107.
24 Ibid., p. 112.
25 Lev Manovich, *The Language of New Media*, Cambridge, MA/London: MIT Press, 2001, p. 100.

4 Plotting Room, Uxbridge, GB (1939).

The *Himmelbett* method renders the display dispositif evident. It opens up three spaces to us that can be subjected to a comparative investigation within the meaning of media praxeology. (1.) Firstly, we are dealing with objects that are out of sight, that are also moving rapidly and over great distances, and thus are scattered over a correspondingly large external space. (2.) The internal space of the display is also not visible to the observer. In this respect, it represents a miniaturized model of the external space, in that different actors (fighter jets and bombers) are being represented 1:1 here by their own medium (a ray of light). (3.) Finally, there is also the space in front of the display. This is where the actors behind and outside the display are transformed into objects that are represented together on one area. In this interaction space, alliances are formed between different observable objects and the different observers.

What is depicted, how it is depicted and the dispositive position of the subject are all still contingent here. The view from above results in a unification that documents both the dispositive structure of human and display, the relationship between significats in the external space and signifiers in the internal space, as well as all intermediaries,[26] bringing about the translation from things to signs. The *how* of the unification remains hidden, even though it takes place neither electronically, nor algorithmically, but optically and electromechanically.

If we understand technology to be a distributed action,[27] then this opens up a space that separates the space in front and below the display from each other; but the causal relationship between significat and signifier still remains preserved. The external and internal worlds of the display behave in a homomorphic fashion in relation to each other.

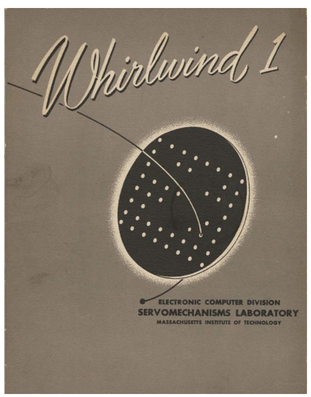
In the case of the Seeburg plotting table, we are still primarily dealing with interface agents who are standing around a display. In contrast, in the case of the first digital displays, we start to talk about the particular importance of coordination agents, the active, no longer passive, movement in space that was central to the functionality of the first computer and its display.[28]

26 The actor-network theory defines an intermediate link or binding agent in a sociotechnical translation chain as an intermediary, which simply transports meaning, while a mediator, or go-between, simultaneously also transforms a meaning that is to be transported. See Bruno Latour, *Reassembling the Social. An Introduction to Actor-Network-Theory*, Oxford: Oxford University Press, 2005; Ann-Sophie Lehmann, Das Medium als Mediator. Eine Materialtheorie für (Öl-)Bilder, in: *Zeitschrift für Ästhetik und Allgemeine Kunstwissenschaft* 57.1 (2012), pp. 69–88. A media practice theory that places digital displays in its center no longer needs to differentiate between *intermediaries* and *mediators*.

27 See Werner Rammert, *Technik – Handeln – Wissen. Zu einer pragmatistischen Technik- und Sozialtheorie*, Wiesbaden: Springer, 2007, pp. 79–81.

28 See Ibid., p. 83.

5 The Manchester Mark 1 Williams tube with the pickup plate.



6 Cover of the Whirlwind I brochure with a schematic illustration of a Williams tube.

The Discrete Nature of the Display

For the first time in the history of computing and optical media, the radar screen allows for directly addressing an individual pixel on an illuminated area without having to pass through "precursors" and "successors".[29] This is of relevance to the optical media, as follows: In contrast to the dispositif of the television, it is not only the rows but also the columns of an image that are decomposed into single elements. In terms of the computing media, this means: a number is broken down into its decimals and is no longer depicted in its semantic unity, but instead distributed across the area of a decimal digit(al) display.

This discrete nature of the geometric location and chromatic value distinguishes the radar display from the movie/television picture and, long before the computer was to conquer media, already pointed toward our current media era in which displays have become the signature of (full) digitality. While calculating with decimal digits was still associated with the analog world, this now changes for the computer-illiterate observer, through the use of binary digits.

The 1948 Manchester Mark 1 is regarded as the first binary digital computer. Computer CRTs in this computer also acted as an accumulator, as well as control and arithmetic registers. The computer pioneers Tom Kilburn and Frederick Williams used modified cathode ray tubes, called "Williams tubes", as random access memory (RAM) for the 1948 Manchester Mark 1 (fig. 5).[30] Such vacuum tubes were widely used as RAM up until the 1950s, for example, in the mainframe computers ERA 1103 (with a Williams tube memory of 1024 words) and IBM 701 and 702[31] (fig. 5–6).

What is decisive in relation to the Williams tube is that, with it, a new form of visibility or image processing appears in the true sense of the word. However, the data that are to be processed are not simply intended for the visualization of the invisible or the absent during completion of their processing, but the dot images themselves *are* the data in the RAM. They do not represent, but instead index. They are images that are not intended for the eyes of the users, but are observed by the computer itself.[32]

The Whirlwind computer was one computer that worked with Williams tubes, the first computer that processed data in real time and was simultaneously capable of depicting anumeric data on a display.

An early computer advertisement for the Whirlwind computer shows how a cathode beam hits the phosphor layer in a cathode ray tube and produces an illuminated dot (fig. 6). An illuminated point (digit) represents a 1 and a non-illuminated point a 0 in this rectangular grid in the Williams tube. In practice, however, as a pickup plate was fixed opposite the data screen to protect the data storage tubes from electromagnetic radiation, the data storage contents could not be read off directly during normal operation. People in media studies therefore reached the conclusion that the digital *per se* is withdrawn from perception and that the hidden nature forms the condition of possibility for

29 Friedrich Kittler, Computergrafik. Eine halbtechnische Einführung, in: Herta Wolf (ed.), *Paradigma Fotografie. Fotokritik am Ende des fotografischen Zeitalters*, Vol. 1, Frankfurt/M.: Suhrkamp Verlag, 2002, pp. 178–194, p. 179.

30 Simon H. Lavington, Computer Development at Manchester University, in: Nicholas Metropolis et al. (eds.), *A History of Computing in the Twentieth Century*, New York/London: Acdemic Press, 1980, pp. 433–443, p. 433.

31 The Airspace Company Convair later developed a 7 inch tube monitor for the ERA 1103 which could display 6 × 6 characters. See Paul E. Ceruzzi, *Eine kleine Geschichte der EDV*, Bonn: mitp-Verlag, 2003, pp. 63–66.

32 Claus Pias, *Computer-Spiel-Welten*, Munich: Sequenzia Verlag, 2002, p. 75.

the function of digital data storage.[33] Full separation of data and display, which can be regarded as the central adage of digitality, was only achieved with Whirlwind I.

In 1945, project leader Jay Forrester started with the development of the Whirlwind computer at the Massachusetts Institute of Technology (MIT) with the words: "We are no longer building an analog computer; we are building a digital computer."[34] "One of the things that I think we did first was to connect a visual display to a computer",[35] reports Robert R. Everett, the engineer on the Whirlwind project at that time.

In this case, displays also initially served the purpose of checking for errors and carrying out tests, not for complex data output or input.[36] For example, in 1949, only one *ball* (dot) jumps across the 5" Tektronix oscilloscope of the Whirlwind computers to demonstrate the speed and graphics capabilities of the computer (fig. 5–6). When the Bouncing Ball Program is referred to as the first demo program in the history of software,[37] "the first display program ever written"[38] and "the first significant use of the computer display screen",[39] this is due to a perspective that attributes far greater importance to the media specifics of moving characters than the (admittedly abstract) illustration of a trajectory. Otherwise, the ENIAC demo program would have to have been ranked first in a media history of the display – especially if we consider the fact that the mediality of the ENIAC targets the contingent visualization and calculation of trajectories, just like the Whirlwind. These displays reveal an immediate continuity in computing practices – at least when Whirlwind I is considered in the context of the development of the Semi-Automatic Ground Environment (SAGE).

> *The obvious updating of SAGE related to [...] the status of the picture. The radar systems that were connected supplied the position of an object with the aid of angular coordinates that were converted into Cartesian coordinates based on the location of the radar and were indicated on the screen. The separation of data and display creates an arbitrariness of the depiction, such that it is no longer the screens doing the work (as is the case for the* Williams tube*) but users working on them.*[40]

During the Bedford Tests in 1950, the Whirlwind computer was used as the central control station for the Cape Cod Experimental Air Defense System, a prototype for the aerial defense and early warning system, SAGE. An additional "computer-generated visual display"[41] not only depicted

33 See Wolfgang Ernst, Den A/D-Umbruch aktiv denken – medienarchäologisch, kulturtechnisch, in: Jens Schröter, Alexander Böhnke (eds.), *Analog/Digital – Opposition oder Kontinuum? Zur Theorie und Geschichte einer Unterscheidung*, Bielefeld: transcript-Verlag, 2004, pp. 49–65; Pias 2002 (as fn. 32), p. 75.

34 Robert R. Everett, Whirlwind, in: N. Metropolis et al. (eds.), *A History of Computing in the Twentieth Century*, New York/London: Acdemic Press, 1980, pp. 365–384, p. 365.

35 Ibid., p. 375.

36 "All we used the displays for was testing the various parts of the system so displays were ancillary completely to the main event." Norman Taylor, as cited in Jan Hurst et al., Retrospectives I. The Early Years in Computer Graphics at MIT, Lincoln Lab and Harvard (Panel Proceedings of SIGGRAPH '89), in: *Computer Graphics* 23.5 (1989), pp. 19–38, p. 22.

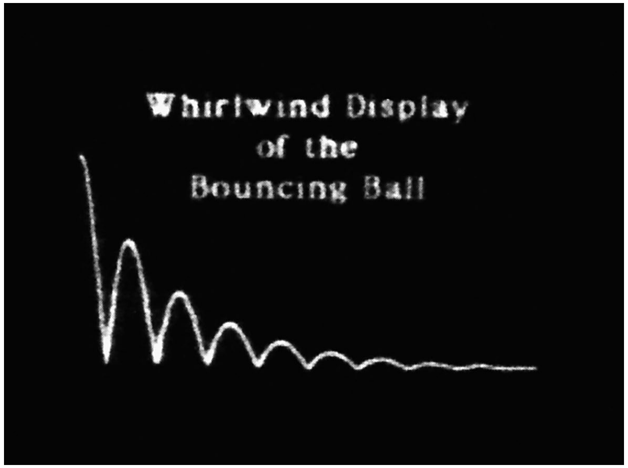
37 Claus Pias, Die Pflichten des Spielers. Der User als Gestalt der Anschlüsse, in: Martin Warnke et al. (eds.), *Hyperkult II*, Bielefeld, 2004, pp. 313–341, p. 321.

38 Jan Hurst et al., Retrospectives I. The Early Years in Computer Graphics at MIT, Lincoln Lab and Harvard(Panel Proceedings of SIGGRAPH '89), in: Computer Graphics 23.5 (1989), pp. 19–38, p. 21.

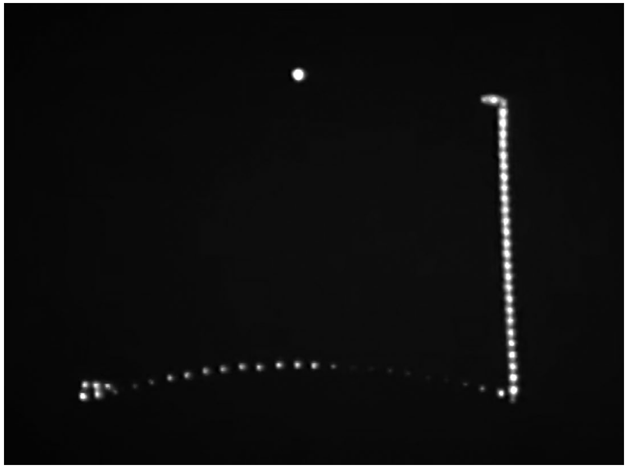
39 Jan Hurst et al., Retrospectives II. The Early Years in Computer Graphics at MIT, Lincoln Lab and Harvard (Panel Proceedings of SIGGRAPH '89), in: *Computer Graphics* 23.5 (1989), pp. 39–74, p. 40.

40 Pias 2002 (as fn. 32), p. 77.

41 IBM Corporation – Military Products Division, On Guard! The Story of SAGE, https://archive.org/details/OnGuard1956 (accessed November 1, 2017).



7 Trajectory of a bouncing ball and a rocket on the Whirlwind I 5" Tektronix oscilloscope.



8 Trajectory of a rocket (without afterglow). The x-axis of the coordinate system is slightly curved on the right display. The dot of light (the rocket) is located at the highest point, the apex of the trajectory. The right bar indicates the velocity of the rocket.

dots but also depicted and georeferenced lines and text as Cartesian target coordinates in the visualization of airplane movements (fig. 7–8):

> *Such screens, referred to as 'vector screens' […] had no filled areas, but potentially only lines, such as those indicating borders and travel routes. The alphanumeric text of coordinates also had the status of a map. Letters and numbers were composed of dots in the blackness of the monitor that were connected by lines like an astronomical constellation.*[42]

Even so, practices relating to the display still had a long way to go before it could be used like a map. The initial difficulties in depicting flying objects on electronic maps included the fact that the radar system at Bedford airport that was used to carry out the first Cape Cod tests allowed two different modi of data representation.[43] The radar antennae rotated four times a minute without suppression of interference, while the radar only achieved two rotations when suppression of *clutter* was switched on – the deletion of undesirable data was required for improved legibility of the display (fig. 7–8).

42 Claus Pias, Punkt und Linie zum Raster, in: Markus Brüderlin (eds.), *Ornament und Abstraktion*, Cologne: Dumont, 2001, pp. 64–69, p. 66.

43 Kent Redmond, Thomas M. Smith, *From Whirlwind to MITRE. The R&D Story of the SAGE Air Defense Computer*, Cambridge, MA: MIT Press, 2000, pp. 81–82.

In practice, the airplanes thus easily disappeared from the perceptual horizon as their blips only lit up twice a minute. Continuous *tracking* was therefore almost impossible.[44]

The determination of the location of mobile airborne objects and the depiction of their location on the display were strictly coupled to each other. Even though the digital PPI screen therefore primarily visualizes the function of the rotating radar antenna itself and thus renders apparent the media methodology of the display, all practical steps that are taken are tied to it as if the basis of the display image was formed by a continuous "track-while-scan ability"[45].

On March 13, 1953, Robert Wieser explained in a lecture to visitors to the Cape Cod Experimental Air Defense System what the different data processing steps were in order for the Whirlwind computer processes to make a *special display* available that monitors and controls the paths, path guidance and path guidance aids:

> *The radar data is fed into the Whirlwind I computer at the Barta Building in Cambridge, which processes the data to provide 1) vectoring instructions for mid-course guidance of manned interceptors and 2) special displays for people who monitor and direct the operation of the system.*
> *In processing data, the computer automatically performs the track-while-scan function, which consists of l) taking in radar data in polar coordinates, 2) converting it to rectangular coordinates referred to a common origin, 3) correlating or associating each piece of data with existing tracks to find out which pieces of data belong to which aircraft, and 4) using the data to bring each track up-to-date with a new smoothed velocity and position, and 5) predicting track positions in the future for the next correlation or for dead reckoning if data is missed. Once smoothed tracks have been calculated, the computer then solves the equations of collision-course interception and generates and displays the proper vectoring instructions to guide an interceptor to a target.*[46]

Even though the entire process was predetermined, such that the operators are denied independent coordinating practices on the displays in the literature, the interpretation that is required in relation to the displays must not be forgotten in a sociotechnical consideration of the issue.[47]

The radar screen shows radial snapshots in time, at regular intervals, of the continuous movement of an object in real space. The conditions underlying the visualization are clear and apparent to the participating actors; they require no justification. Nobody would assume that the airplane that is being tracked in this way was moving discontinuously, as depicted on the display. A significant praxeology of the display has developed based on the presentation of incomplete path information and its completion by the actors, as practices relating to interpretation and actions have arisen due to this medium that require no further justification, given the strict adherence to instructions and incorporation into the rules of the system.

44 See Servomechanism Laboratory, Air Traffic Control Summary Report 7, July 25, 1950 – October 25, 1950, Massachusetts Institute of Technology, Cambridge, MA, 1950.

45 Redmond, Smith 2000 (as fn. 43), p. 77.

46 C. Robert Wieser, Cape Cod System and Demonstration. Memorandum VI – L-86, MIT Lincoln Laboratory, Division 6, Cambridge, MA, March 13, 1953, p. 2, http://dome.mit.edu/bitstream/handle/1721.3/41510/MC665_r28_L-86.pdf (accessed November 1, 2017).

47 See Kjeld Schmidt, *Cooperative Work and Coordinative Practices. Contributions to the Conceptual Foundations of Computer-Supported Cooperative Work (CSCW)*, London et al.: Springer, 2011, p. 318.

Precisely because the computer users sitting in front of the displays were not in a position to change the situation or the program,[48] practices relating to displays require a not entirely insignificant ability to normalize, as is also demonstrated in studies on current GPS navigation practices.[49]

Lev Manovich's reference to "visual nominalism", the automated "use of vision to capture the identity of individual objects and spaces by recording distances and shapes",[50] must therefore be contrasted with an equivalent *visual norminalism*. Manovich reduces the radar to "seeing without eyes",[51] whereby the praxeological changes that arise from the radar display are overlooked: a modified *seeing with eyes* under the conditions of *remote sensing*.

In addition, the central change that is associated with the digital radar display occurs at the interactional level: in mid-1950, a joystick was initially used to pursue a target object, with which a mobile dot of light was moved until it covered the radar blip of the target object. The target thus selected could then be pursued automatically.[52]

In addition to this manual targeting, simultaneous work was being carried out on a) how targeting can be carried out automatically within a selected corridor, b) how target objects can be separated from each other, even if they are close together, and c) how data can be smoothed – something that was required due to the inaccuracy of the positional data obtained by radar.[53] The unified planimetric depiction on the display required "rationalization of sight"[54] – a modification to adapt the technically perceived reality to the conditions of the display.

Robert Everett, who had already made a significant contribution with Jay Forrester toward driving forward the construction of the Whirlwind computer, developed a light gun as a computer interface – "a photoelectric device which is placed over the desired spot on a display scope" – as the joystick had proven too slow and cumbersome to operate.[55] The joystick was then discarded at the end of 1950. The medium of the light gun corresponded to the planned media practice of the Air Defense computer "to zero in on a selected target",[56] not only on a screen but also in the air with the help of fighter jet interceptors.

The programing foundations for the interception tests were laid in the second half of 1950. The criteria for a successful computer test were a) the simultaneous tracking of the target of the attack and the interceptor on the display, b) the calculation of the target guidance data, and c) the transmission of the control command to the fighter jet interceptor or rocket interceptor.[57] However, one problem in relation to tracking flying objects was that stationary targets were not yet suppressed on radar displays until mid-1950.[58] This only changed in October 1950, with the patenting of the "Moving

48 Judy E. O'Neill, *The Evolution of Interactive Computing Through Time-sharing and Networking*, University of Minnesota, 1992, p. 21.

49 See Barry Brown, Eric Laurier, The Normal Natural Troubles of Driving with GPS, in: *Proceedings of the ACM CHI 2012. Conference on Human Factors in Computing Systems*, Austin (2012), pp. 1621–1630.

50 Lev Manovich, The Mapping of Space: Perspective, Radar, and 3-D Computer Graphics, in: Thomas Linehan (ed.) *Computer Graphics Visual Proceedings, Annual Conference Series, ACM SIGGRAPH '93*, New York, 1993, pp. 143–147, http://manovich.net/content/04-projects/003-article-1993/01-article-1993.pdf (accessed November 1, 2017), p. 2.

51 Ibid., p. 4.

52 See Servomechanism Laboratory, Air Traffic Control Summary Report 6, April 25, 1950 – July 25, 1950, Massachusetts Institute of Technology, Cambridge, MA, 1950, p. 4, p. 8.

53 See Redmond, Smith 2000 (as fn. 43), p. 80.

54 William M. Ivins, *On the Rationalization of Sight. With an Examination of Three Renaissance Texts on Perspective*, New York, 1973 [Original published as *Metropolitan Museum of Art Papers* 8 (1938)].

55 Servomechanism Laboratory 1950 (as fn. 52), p. 1.

56 Redmond, Smith 2000 (as fn. 43), p. 81.

57 See Ibid., pp. 83–84.

58 See Ibid., p. 79.

Target Indicator", a module for the suppression of stationary targets.[59]

Before radar targeting of mobile objects turned into the suppression of stationary targets, two 5" oscilloscopes were used to separate mobile from stationary objects. A 12" PPI screen only became available to the MIT Digital Computer Laboratory toward the end of 1950.[60] One display was used to select objects with a light gun and a second display for the presentation of the marked objects. Input and output screens were still separated from each other.

> *Tracking would be initiated manually by applying the light gun to a selected target on the main scope. So far, use of the test patterns indicated that the light-gun technique should work. Holding the light gun on the location of the target long enough to detect the computer's next scanned display would transfer the target's display to the second scope. Doing the same to the interceptor's spot on the first scope would select it too for display on the second scope. From that time on, the two selected blips would be tracked in isolation on the second scope, without further need for the light gun. Their courses would be predicted on the basis of the history of preceding sightings. A collision course would be computed, proper heading instructions for the interceptor would be displayed, and the scope operator would pass on the information by voice to the pilot in the interceptor.*[61]

The scope operator's task was thus reduced to the selection and passing on of information. The operator fulfilled a relay function[62] that also could have been automated.

In this sense, selection was part of a "distributed cognition" process,[63] because the power behind the action of selecting the target with the *light gun* is limited to the separation of a mobile object from the stationary objects, to extracting it and transferring it to a second display using copy/paste. This second display is based on a different construction of reality: on a world that only knows vehicles.

The production of coordinates that had been conducted previously outside the display was shifted to translation steps between two displays. With reference to the narrative and visual complexity of the overall context that is being depicted, this therefore threw the development of displays back to before the Seeburg plotting table, which was oriented to an even greater extent based on mimetic procedures. The *Himmelbett* method required a consensual interpretation by the actors standing around the display. From an action-theoretical perspective, the development of the radar display that occurred in 1950 simultaneously constituted a step in sociotechnical innovation: Through the separation into a data input and a data output display, "cooperation

59 Charles T. Baker Jr., Moving Target Indicator Radar, Patent-No. US 2811715 A, October 2, 1950.

60 See Redmond, Smith 2000 (as fn. 43), p. 83.

61 Ibid., p. 84.

62 See Antoine Hennion, Cécile Méadel, In the Laboratories of Desire. Advertising as an Intermediary between Products and Consumer, in: *Reseaux. The French Journal of Communication* 1.2 (1993), pp. 169–192. Within the scope of the actor-network theory, a relay can also be understood as a team that takes over and triggers a relay race of further actions. See Tristan Thielmann, Digitale Rechenschaft. Die Netzwerkbedingungen der Akteur-Medien-Theorie seit Amtieren des Computers, in: Tristan Thielmann, Erhard Schüttpelz (eds.), *Akteur-Medien-Theorie*, Bielefeld: transcript-Verlag, 2013, pp. 377–424, p. 382.

63 Edwin Hutchins, *Cognition in the Wild*, Cambridge, MA: MIT Press, 1995.

without consensus"[64] became possible for the first time in graphic human-computer interaction, in that targeting (enemy flying objects) and target guidance (of the fighter jet interceptors) were separated media-praxeologically and became an action distributed across displays.

At this point, it is interesting to note the use of the term *scope*, used colloquially to refer to a) an oscilloscope and b) a viewfinder or a telescopic sight in military terms, and c) the word more generally refers to a frame for movement and latitude.

These three different levels of meaning also actually emerge in the SAGE Air Defense Computer and its prototypes. On the one hand, this display is a converted measuring instrument – an oscillograph that reduces waveform graphs to the depiction of dots. The *scope* is one such measuring instrument and indicates that it once simply served to control the computer, as was the case for the ENIAC. On the other hand, it also served as an instrument to search for enemy objects. At the same time, the only demand that could be made was the displaying of a section of reality: a reality that is solely determined by the movement of the objects that have been reduced to a dot.

Equally, the *scope* no longer serves the sole purpose of monitoring the internal and external world of the computer. With the advent of digitality, the internal world increasingly closes up; additional translation steps are incorporated by new interfaces; the external world is simultaneously represented in a more media-differentiated way – limited to a circular excerpt, to mobile objects and discrete characters.

The display reveals its media methodology in the first computer applications, as demonstrated by these elaborations. This shows that a technical component (an oscilloscope) is used in a different way from what was originally intended – as an optical snapshot in time of the location of dots, instead of one or more courses of waveforms. Put in graphical terms, a loophole is left that must be closed by the user through the determination of a mobile final destination. Both at the technical and at the practical levels, this display is all about producing an endpoint coordinate. Furthermore, a *scope* is not only etymologically linked to the media practice of searching, from a genealogical perspective, a *scope* is also focused on applications that try to fix movement.

The different Whirlwind computer displays thus have a media-technical, practical, normalizing and nominalist dimension, all of which are also of importance for our current understanding of displays. This section has demonstrated that the separability and addressability of the individual pixel is a variable that takes precedence over the question of whether data are used for display or storage. The procedure of discretization must therefore be considered as an essential component of a praxeology of the display.[65] The reason this is so important is that the discretization comprises both the fabrication of image and location dots. This step in the development in display media praxeology is therefore characterized by a sociotechnical duplicity of endpoint coordinates.

64 Susan Leigh Star, Cooperation Without Consensus in Scientific Problem Solving. Dynamics of Closure in Open Systems, in: Steve M. Easterbrook (ed.), *CSCW. Cooperation or Conflict?*, London: Springer, 1993, pp. 93–106.

65 On understanding media praxeology, see special issue of *Digital Culture & Society* 2 (2017) on *Mobile Digital Practices*; Erhard Schüttpelz, Epilogue. Media Theory Before and after the Practice Turn, in: Ulrike Bergermann et al. (eds.), *Connect and Divide: The Practice Turn in Media Studies. The 3rd DFG conference of Media Studies*, Zürich/Berlin: diaphanes (forthcoming).

Flood Lights

The current analysis demonstrates that representations and their arbitrary dimension can only form part of a media-esthetic investigation. The decisive media-methodological occurrence does not take place on the display, but behind it from a technical perspective and in front of the display from a practical perspective. A combined technical and practice theory is therefore required to understand the specific mediality of the display.

This kind of approach shows how the practice of coordination and the materiality of coordinates each determine the media-specific nature of the display through their duplicity. This socio-technology of the duplicity of image-space coordinates has the capacity to more closely define the dispositive structure of digital displays and to present them in their different variants. In this process, the innovative steps that emerge in the media history of the display are characterized by the elimination and inclusion of mediators, through which the perceptibility of co-coordination is newly materialized in each case.

Up to now, the duplication of spatial and image-related coordinates was simply declared to be a cultural-geographic characteristic of *augmented reality* applications.[66] This essay shows that this scope of analysis that is driven by intervention is not far-reaching enough. Spatial co-coding not only characterizes the layering technologies through which the location-relevant internet information is merged with the live camera image on mobile consumer devices. Co-coding of online and offline spaces already occurred with radars. In this respect, a far more comprehensive heuristic continuum can be described based on the "duplicity of code",[67] through which image and spatial production are constituted interactively and are reified in displays.

In addition, the praxeology of the display shows how historical media methods reach into the present and are still having a formative effect on current manifestations of displays. The display not only harbors within it the intrinsic persistence of guidance and bearings, it cannot deny its genealogy, which stems from the medium of the radar. The media methodology of the display aims at a mediated seeing over distance and the depiction of discrete and addressable pictorial symbols in the form of co-existing light and location dots. Even when considered in light, the dispositif of the display remains seeing in the dark, inherent in surroundings and in proximity. Displays show the immediate mediate. That is its media practice-theoretical dimension.

Displays can therefore by all means be called visible objects as per the meaning of Thomas Elsaesser, giving light a spatial form and materiality that goes beyond the artist's flat and framed canvas.[68] They represent an a-modern return in the cloak of the digital modern, "that returns the fixed spectator facing the fixed rectangular screen to being a historically contingent actor"[69] and thereby also allocates spatio-temporally limited valence to the dispositif of the movie.[70]

66 See Mark Graham et al., Augmented Reality in Urban Places. Contested Content and the Duplicity of Code, in: *Transactions of the Institute of British Geographers* 38.3 (2013), pp. 464–479.

67 Ibid.

68 Thomas Elsaesser, The 'Return' of 3-D. On Some of the Logics and Genealogies of the Image in the Twenty-First Century, in: *Critical Inquiry* 39.2 (2013), pp. 217–246.

69 Ibid., p. 244.

70 See Hermann Kappelhoff, Der Bildraum des Kinos. Modulationen einer ästhetischen Erfahrungsform, in: Gertrud Koch (ed.), *Umwidmungen. Architektonische und kinematographische Räume*, Berlin Vorwerk 8, 2005, pp. 138–149.

The rectangular viewing window has been a "medium of visibility"[71] since Roman antiquity, which opens up elementary practical functions, such as illumination and views. The display is the first medium that opposes this image-generating dispositif in its mediality, materiality and media practice. Based on the variability and adaptability of its shape and its co-coordinating function, it represents a disillusioning feast for the eyes. Unlike the rectangular window or screen that is not subdivided, it no longer provides a view in or out – is thus no longer constrained by architecture – but represents a socially canonized practice[72] of telemetry and remote sensing.

When we take a look at the media history of the display, it becomes clear that the discourse in the pictorial sciences on the discrete nature, operationality and spatial control of images precedes the methodology of displays outlined here. Stiegler has recognized this:

> *[I]t will not be much longer before we can view images analytically: screens* [l'écran] *and what is written* [l'écrit] *are not simply opposed to each other.*[73]

Both are increasingly becoming one from a phenomenological perspective. This increases the lack of conceptual clarity in relation to what we understand an image to be and simultaneously moves into the foreground implicit knowledge and media methods that are solely based on displays.

In point of fact, it will indeed not be much longer, as it has always taken place and is always occurring anew: Displays allow us to view images analytically.

71 Gerd Blum, Epikureische Aufmerksamkeit und euklidische Abstraktion. Alberti, Lukrez und das Fenster als Bild gebendes Dispositiv, in: Horst Bredekamp, Christiane Kruse, Pablo Schneider (eds.), *Imagination und Repräsentation. Zwei Bildsphären der frühen Neuzeit*, Paderborn: Wilhelm Fink Verlag, 2010, pp. 79–118, p. 80.

72 See Hans-Jürgen Horn, Fenster (kulturgeschichtlich), in: *Reallexikon für Antike und Christentum*, Vol. 7. Stuttgart: Anton Hiersemann, 1970, pp. 732–737; Achatz von Müller, Der Politiker am Fenster. Zur historischen Ikonographie eines „lebenden Bildes", in: Gottfried Boehm (ed.), *Homo Pictor*, München/Leipzig: De Gruyter, 2001, pp. 323–338.

73 Bernard Stiegler, Das diskrete Bild, in: Jacques Derrida, Bernard Stiegler (eds.), *Echographien. Fernsehgespräche*, Vienna: Passagen, 2006, pp. 162–188, p. 180.

Figures

1–2 Royal Air Force, Standard Technical Training Notes, Part 3: Elementary Radar, Great Britain, Air Ministry, London, 1965, p. 37, p. 87.

3 Gyges Publishing Company, http://gyges.dk/Seeburg%20(Small).jpg (accessed November 1, 2017).

4 Danielstirland, https://en.wikipedia.org/wiki/Battle_of_Britain_Bunker (accessed November 1, 2017).

5 http://virtualtravelog.net/images/2003-08-Williams-Kilburn-tube.jpg (accessed November 1, 2017).

6 Curtesy MIT Museum, image curtesy Computer History Museum.

7 Claus Pias, Die Pflichten des Spielers. Der User als Gestalt der Anschlüsse, in: Martin Warnke et al. (eds.), Hyperkult II, Bielefeld: transcript-Verlag, 2004, pp. 313-341, p. 321.

8 Diego Hernan Sanhueza Martínez, See It Now: Jay W. Forrester and the WHIRLWIND Computer - (1951), https://youtube.com/watch?v=5ZQP4G3Qwb4 (accessed November 1, 2017).