The Case of the Missing Overlays:

A Strategy for
The History of
The Digital Transition in Cartography

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Abstract: Almost all treatments of the digital transition begin with realized systems or experimental projects that have been identified as important. Analysis then proceeds *backwards* tracing antecedents. This approach is standard—if not ubiquitous—but that cannot rescue it from failure. The messy contingencies, dead-ends, and serendipitous convergences of human science and technology are displaced by a spurious and relentless inevitability. A better model begins with the identification of an array of key pre-digital cartographic systems and methodologies and then proceeds *forward* in time, through the digital transition, examining how these elements change, adapt, and/or disappear.

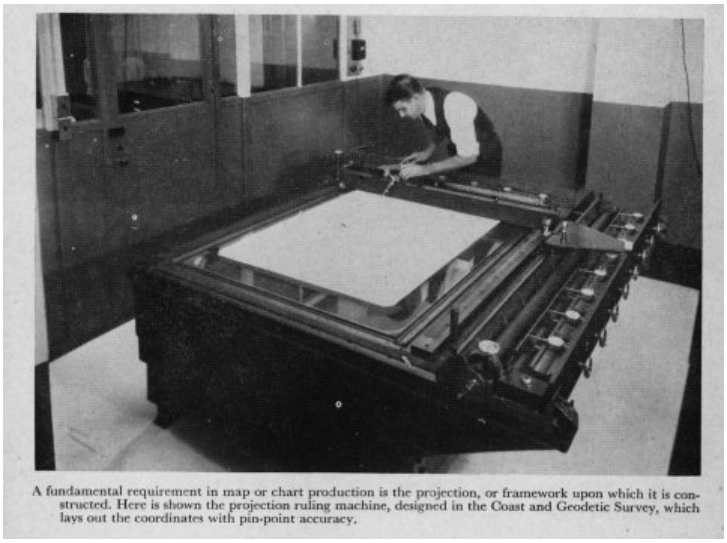
I identify three major suites of technologies and methodologies to trace forward: (1) the postwar evolution of map projections and their computational intensities, (2) advances in photogrammetric rectification of reconnaissance imagery and data, and, most importantly, (3) the evolution and uses of thematic map overlays and their transition from analog to digital forms. These three suites, developed in very disparate realms, over the course of more than one human generation, eventually converged in Military Geographic Information Systems (MGIS), from which developed those civilian-accessible technologies now known as GIS. I discuss recent discoveries in map overlay history involving pre-war German and American applications.

1.1 Introduction

The digital transition in cartography spans topics ranging from the evolution of digital computers to numerical processing in general, to the appearance of geographic information systems, and prepress processing in cartographic publishing. Most extant histories on these and allied matters are based on an approach that begins firmly on the *digital* side of the particular transition in question, working backwards. (Foresman, 1998) The relentless inevitability of "the path to the present" renders this approach problematic. All transitions, digital or otherwise, involved dead-ends, missed opportunities, minor and major influences from related or quite different fields—the interesting quotidian of human life, in fact. These are erased or diminished by such a backwards-directed approach; extant scholarship on the digital transition reflects that. I propose another model, based on historical research beginning at a point in pre-digital time and proceeding *forward* and *through* the digital transition.

There are a number of disparate technological suites and themes that converged in the digital transition in cartography. In fact, one's choice of technological suites to trace largely constitutes one's definition of what matters most in digital cartography. That noted, it should be emphasized that the most important event in cartography of the 20th century was the Second World War. The technological and political transformations that the war created are the foundation for analysis of all else. In my own assessment of postwar cartography and the digital transition, three suites of technologies and cartographic applications are paramount: (1) the evolution of postwar map series and their projection systems, particularly in reference to increasingly large demands on computational systems to support their effective uses; (2) the postwar explosion in classified reconnaissance systems of many kinds and the demands these systems made on photogrammetric rectification technologies and data storage and access systems; and, most importantly, yet somehow little discussed, (3) the development of systems of thematic map overlays and their uses.

Because of the Second World War, nationally-scaled mapping programs became global in scope. The combination of globally-scaled battle theatres and new geo-positioning and weapons systems created demands for novel map projection systems and computational capabilities. A critical artifact of the national response to these demands was the US Coast & Geodetic Survey's great projection ruling machine [Figure 1]. This machine, designed and built in the Survey's Instrument Shop, was the finest instrument of its type in the possession of the United States, and in fact also the finest in the entire western hemisphere. It was used constantly, throughout the war effort, by all relevant American services with cartographic projects. (Department of Commerce, 1951, 35) The projection ruling machine was an entirely analog device, requiring highly skilled hand labor, linked to demanding computational constraints. Cold War-era cartographic developments eventually made the machine "obsolete," but what that really meant was that successor systems, and eventually digital ones, had to meet and then exceed the capabilities of the projection ruling machine in order to prevail.



A fundamental requirement in map or chart production is the projection, or framework upon which it is constructed. Here is shown the projection ruling machine, designed in the Coast and Geodetic Survey, which lays out the coordinates with pin-point accuracy.

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During the American Cold War, overhead and space-based reconnaissance systems were developed that privileged geopolitical advantage over dimensional stability of the reconnaissance systems themselves. These privileged systems, primarily based on scanning panoramic camera systems like those of the CORONA Program, strained associated data reduction and processing capabilities almost to the breaking point. In response, a cascade of new geospatial data processing technologies and methodologies were developed, closely connected to related and parallel breakthroughs in computing capabilities in other areas. Specifically, an array of technologies were developed to rectify and geo-position top-secret panoramic photography and later imagery into standard and novel map making and geographic analysis systems. A major part of the analog-to-digital transition in the American military and intelligence communities was precisely the development of these capabilities, transitioning from photo-mechanical and electro-optical rectification systems to computationally intensive image rectification systems connected to semi- or fully automatic mapping systems. . (Cloud, 2003, in Cloud & Reppy, 2003; Cloud, 2002; Cloud 2001A, 2001B, 2001C; Cloud 2000; Clarke & Cloud, 2000)

Many stages of this transition are listed and illustrated in *Cartographic Production Equipment*, one of the most important—and least well known—documents from the digital transition as it was in progress. (Data Corporation, 1968 and 1970) Once digital geo-positioned data handling systems were developed, originally for panoramic photography, then they were applied to many other traditional analog imagery suites and applications. These included systems of sophisticated analog map overlays, which had been developed completely independently, by other people and institutions, in the decades that preceded the Second World War. This convergence of map overlay systems, classified reconnaissance acquisition programs and largely unclassified data reduction and mapping programs then yielded Military Geographic Information Systems (MGIS). The “M” was soon erased as the complex was delivered to civilian, unclassified applications, and eventually was characterized as “GIS”, particularly so by those who did not know or did not want to know about the military/intelligence origins of the systems.

1.2 **The Problematic Origins of Map Overlay**

All treatments of geographic information systems (GIS), whether they address GIS history or its uses, include some variant of a graphic of at least four co-registered thematic map layers hovering in space. These graphics, although ubiquitous, are almost never examined critically or even described in great detail. It is assumed, or inferred, if not specifically disclosed, that digital overlay and much of the actual functionality of GIS systems descends from pre-digital, analog map overlay applications, and the ubiquitous graphic represents essentially a vestigial organ of that history. But where did analog map overlay come from? And how did analog map overlay and its techniques elide into their digital equivalents in GIS? There is, in contemporary scholarship, a rather myopic understanding of the history of map overlay techniques themselves, and the evolution of these systems.

In keeping with my technique of moving from the past *forward*, tracing the evolution of map overlay systems, I will devote the rest of this paper to a report on extant comparative research of two pre-war nationally-scaled mapping and analysis programs, in the United States and German. These overlay systems must be considered in two respects: as the visible tips of icebergs of increasingly large and complex data sets and allied numerical processing systems, and as major conceptual breakthroughs in the evolution of analytical cartography, even though these systems were invented and flowered a human generation before Waldo Tobler coined the term analytical cartography. The highest development of analog map overlay systems occurred in nationally-scaled American and European programs addressing urban crises of the Depression and regionally-scaled land use and development. Their stories are little known because the fullest elaborations of these systems were *secret*. The route from these secret analog map overlay systems to MGIS was circuitous, like many Cold War technologies. The designers of these new MGIS systems adapted the suite of overlay cartographic and analytical practices, but they did not invent them—the practices were developed before most of them were born. This, in part, accounts for the limitations of extant histories of the transition, as most were written by people who had no direct knowledge of prewar analog map overlay systems.

To the extent that there is any discussion of the history of analog map overlay techniques, it generally revolves around the claims and counter-claims of Ian McHarg. The Scottish-borne American immigrant McHarg, a celebrated landscape architect and founder of the Department of Landscape Planning at the University of Pennsylvania, claimed to have devised the overlay technique in the early 1960s as a device to optimize the locations of roadways by a method that paired engineering efficiencies with social and environmental justice protections for surrounding neighborhoods. As will soon become apparent, his claim has always been contentious. Apart from my own publications, the other published sources on this subject converge to one desultory article, published almost 30 years ago, which was intended to counter Ian McHarg's claims of paternity of the overlay technique. (Steinitz, et al, 1976) Nevertheless, to the extent that

there has been any consideration of the history of analog map overlay and its relationship to GIS, that consideration has revolved around McHarg's claim. A concise and incisive contemporary exemplar of that is provided by Canadian geographer Nadine Schuurman (2004).

"Where Does GIS Come From? A Technical History: The roots of GIS' identity problem date back to the 1960s when the technology and epistemology that underlie it were first being developed. Methods of computerizing cartographic procedures were coincident with the realization that mapping could segue neatly into analysis. In 1962, Ian McHarg, a landscape architect introduced the method of "overlay" that was later to become the *sine qua non* methodology of GIS. He was searching for the optimum route for a new highway that would be associated with suburban development. His goal was to route the highway such that its path would involve the least disruption with other "layers" of the landscape including forest cover, pastoral valleys, and existing semi-rural housing. He took multiple pieces of tracing paper, one representing each layer, and laid them over each other on a light table. By visually examining their intersections, he was able to "see" the only logical route. The process of overlaying map layers is depicted in Figure 1.1. Ironically, none of McHarg's initial analysis was done using a computer. Indeed, computers of the day were very primitive, and required massive physical and human resources to run. It is the metaphor of overlay, however, that was integrated into early GIS, and became the basis for a range of analytical techniques broadly known as "spatial analysis"."

Schuurman's epistemology of overlay is correct and insightful, and Ian McHarg did exist, and 1962 occurred. Beyond that, the rest of the passage is almost entirely wrong. Analog map overlays were developed and elaborated—but a full human generation earlier. My exploration of the paths of innovation that led to GIS is, hence, complicated. On the one hand, it is universally acknowledged by all concerned with GIS that there must be a connection between physical analog map overlay systems and their equivalent in digital map overlays in the GIS. But what were the specific pathways, and who were the specific participants, and how was the suite of overlay technique and epistemology actually transcribed between the very different environments of translucent maps on a light table to datasets in a digital computer? On the other hand, if Ian McHarg didn't invent the practice of overlay in 1962, and I will demonstrate this easily in a moment, then I am faced with another and more baffling question. How and why were the original developers of overlay forgotten or expurged? In which case, just what is the pathway, linear or not, between analog map overlays and GIS?

My approach to this research is consistent with that of Philip Scranton in his analysis of several "back-ward glancing" analyses of historic technologies. Innovation is better discerned by starting at a point in time and proceeding forward, rather than starting from a realized technology in time and proceeding backwards looking for the elements that contributed to it in the path-to-the-present. (Scranton, 2004)

1.3 **Pre-war German and American Development of Analog Map Overlay Systems**

I have been exploring the pre-computer, pre-war histories of analog map overlay systems, the foundational technologies and allied social practices that led to GIS as we know it. The comparison between two major applications, one German and the other American, is fascinating and instructive. My two cases are roughly contemporary, both occurring in the last decade before World War II. My selection process was as follows. In recent years, I have been scouring archives wherever I can looking for exemplars of analog map overlay *systems*. This means that simply finding specific maps that overlay is insufficient, as is also finding maps that *might* overlay. The extant scholarship on overlay history is not rigorous—in Steinitz, et al (1976) separate maps co-registered to the same projection and with the same map extent are *inferred* to have been overlaid, without any other evidence to support this. The only overlay map data acceptable in my research consists of maps that do physically overlay, accompanied by specific and explicit text describing the overlay practices in question, how they work, and what they are for.

The "metaphor of overlay" itself is insufficient to trace the pathways of innovation that led from analog map overlays to GIS. Rather, it was the specific realization of specific overlay applications embedded in specific social and political milieus, and their impacts on their participants and those who followed them, that account for the line of transmission, and also that which is transmitted. But the most elaborate applications of analog map overlay set a historical ceiling, if not a floor, with which to evaluate the subsequent development of digital GIS systems and their applications. The two applications, German and American, were, simply put, the two most elaborate and sophisticated systems of overlay maps I've yet found. The pathways of specific linkages, and also missed connections, and influences large and small, must wait until after much further research. But I believe that my research thus far discloses, for both the American and German cases, some hints about why the disjunction between historic analog map overlay systems and GIS exists.

In the American case, I will examine the evolution and uses of innovative systems of analog map overlays devised by a set of inter-connected agencies of the US government under the Roosevelt Administration as part of a coordinated response to the urban housing crisis triggered by the Great Depression. These map overlay suites spanned the period of 1934 to approximately 1940. In the German case, I will examine innovative analog map overlay systems applied to regional-scaled industrial and agricultural land use planning, as these were presented and analyzed in *Raumforshung und Raumordnung*, (henceforth *R und R*) at the time the premier spatial theory and regional and city planning journal in Germany. Specifically, I will examine the larger context of the single paper (by Morgen & Sievers, 1941) that contained the greatest number of map overlays and the most elaborated and sophisticated analysis of their uses and limitations. This was an exercise on agricultural land-use potential compared to historic farmland size and ownership, for an area of what in English is called Lower Silesia, which was then part of the German Prussia (Niederschlesien in Prüssen), now part of the Lower Silesian Voivodship of Poland. Both applications are quite disparate,

in terms of themes, personnel, degree of success at the time, and ultimate fate. Yet both are oddly closely related and uncannily parallel. Systems of map overlay are based on technologies and allied practices that combine distinctly different themes of data in order to *reveal* relationships otherwise obscured or disguised. Yet in both very different cases, nothing is quite what it seems, in large part because the visible data layers serve to *conceal* other data.

The key to both applications is the ways that publicly accessible maps were used to hide secret ones. In the American case, the publicly disclosed data layers described and analyzed the conditions of urban housing, but the final decision-making layers were secret—with far-reaching consequences. In the German case, the paper was a nuanced academic contribution to regional agricultural land-use planning, presenting and analyzing an application of thematic map overlays in great detail. It was published in *Raumforshung und Raumordnung*, considered one of the leading international journals on spatial theory and regional land-use planning in the world. The journal's founding editor, Doktor Konrad Meyer, was considered one of the leading soil scientists in Germany, and was director of the Institut für Agrarwesen und Agrarpolitik der Universität Berlin [the Institute for Agricultural Science and Agricultural Politics of the University of Berlin]. He was also, simultaneously SS Oberfuehrer Meyer, the director of the Stabshauptamt für Planung und Boden ([the High office for Planning and Soil], as well as the planning division of the Reichskommissariat für die Festigung deutschen Volkstums [the Reichscommission for the Strengthening of Germandom] in Hitler's SS, directly under Heinrich Himmler.

1.4 **Nazi Spatial Theory: The Natural Foundation of Size Classes of Farms**

The paper and overlay map set presented in *R und R* in 1941 were created by the sociologist Herbert Morgen and the geographer Angelica Sievers. At the time, these two were, along with the geographer and spatial theorist Walter Christaller, the primary social scientists Konrad Meyer had hired to develop innovative methods and theories for both Meyer's university research institute (Institut für Agrarwesen und Agrarpolitik der Universität Berlin) and his planning and soil science office (the Stabshauptamt für Planung und Boden) in the SS Reichkommisariat. (Rössler, 9189A, 1989B, 1993) In their paper the authors explore the relationships and correspondences between the size classes of farms (Besitzverfassung) and the characteristics and optimum agricultural potential of the lands of the farms (die natürlichen Grundlagen) for a diverse region, spanning six counties (Kreise) in Lower Silesia. The paper presents analysis based on voluminous data sets on regional characteristics from various German government ministries and initiatives in regional planning in Prussia (Prüssen) dating back to the establishment of the Hamburg-Prussian Regional Planning Committee ((Landesplanung im hamburgisch-prüssischen Landesplanungsgebiet). (Rössler, 1993, 127

Morgen and Sievers present the thesis that there is or should be an optimum correlation between the distribution of farms ordered by their size classes and the characteristics of the lands the farms occupy. They proposed to explore the thesis cartographically by abstracting several salient characteristics and presenting them as

specific translucent map layers (Deckblatten) which are designed to overlay on one opaque base map (Grundblatt). The base map is a vivid grey-scale depiction of altitude of the lands in question (Höhenschichtenkarte). There are three overlays—dwei Deckblatten. One, which is essentially a map of political infrastructure for the region (Gemaindeschlüsselkarte) folding in from the right, provides the county and sub-county boundaries of the area and displays the areas of forest (Wald) as well, printed in black on translucent vegetable vellum paper. Folding in from the left are two thematic overlays, the soil quality ranked in five classes (Karte der Bodengüten) printed in blue on translucent vegetable vellum paper, and the constitution of the property evaluated in seven classes (Karte der Besitzverfassung), printed in red. The two tinted thematic overlay maps utilize different cross-hatching patterns of varying print-density to represent their different information classes. The physical ordering of the overlay set allows individual thematic of infrastructure overlays to be compared to the base altitude map, or one or both thematic overlays compared to infrastructure, etc. The authors analyze the potentials and limitations of the approach in great detail—the major limitations stem from the fact that, in order to analyze an area sufficiently large and diverse to make the analysis meaningful, they must use maps of a small enough scale that it becomes cartographically difficult to portray the farms appropriately, particularly for the smaller size classes of farms. Nevertheless, they suggest that the methodology and approach are very promising and could be quite useful as a regional planning tool. The overlay technique itself, embedded in cartographic and social practices, is the ultimate objective of the paper. "Their value appears to us to be above all a methodical art". ["Ihr Wert scheint uns in erster Linie methodischer Art zu sein".] (Morgen und Sievers, 1941, 375) They also note, with regards to their specific study in Lower Silesia, that their analysis indicates that the historical development of the farmsteads works against the natural optimum potential of the dimension of space ("dass zwar der historische Werdegang oft den natürlichen Gegebenheiten eines Raumes entgegengewicht hat"). (Ibid, 374) I shall return to this observation later.

1.5 **The New Deal in Old Cities: The Real Property Inventories and Surveys**

When Franklin Delano Roosevelt took office in 1933, the US was then several years into the global Great Depression that Germany had entered much earlier. The writing and underwriting of mortgages had essentially ceased, which brought new construction to a halt, precipitating a crisis in which the highest levels of unemployment in the nation were in the skilled building trades. Therefore the FDR administration regarded the urban housing crisis as both a crisis of housing needs and an unemployment crisis as well. Both were addressed by one of the administration's first major initiatives, the Real Property Inventories of national urban housing needs, conducted by unemployed members of the building trades hired to conduct the surveys. (Stapp, 1938) The nationally standardized surveys noted eight fields of data from all individual dwelling units surveyed, including, significantly, item no. 8: "number of members of the dwelling unit of races other than white". Data was summarized nationally using the city block as the basic mapping unit, so data from all dwelling units on the block were averaged or summed as needed. Significantly as well, extensive use of the now standard 80 column

IBM Hollerith cards were made in the tabulations and calculations of the data. (see NARA II, RG 207) And the data was mapped, city by city, utilizing the best available and contemporary city maps as a basemap template, upon which various thematic maps based on the Real Property surveys—and other data—were drawn. Versions of the maps drawn or printed on translucent vegetable vellum paper or transparent cellulose acetate sheets were then overlaid.

The troubled city of Richmond, Virginia was used as a test case for every new phase of the administration's unified response to the national housing crisis, which was coordinated through an inter-agency task force called the Central Housing Committee. (see NARA II, RG 195) In an early phase of this, federally produced data and overlay maps were combined with data and maps prepared by the Department of Public Works Bureau of Survey and Design of the city of Richmond. These maps, presented in a pamphlet, represent the single most elaborated set of map overlays I have yet found in my research. (see NARA II, RG 31) As in the German case, the overlays were designed to fold in from the left or the right. Those folding from the right are primarily "infrastructure" related, including one map titled "Areas Inhabited by Negroes" which was a depiction of the legally-designated "black blocks" of what was called "Jim Crow" segregation at the time. Folding in from the left are primarily dot-density maps (meaning the data is presented as tiny dots, the density of which correlates with the number or percentage or quality of the theme in question). Most of the maps are indices of social pathology, such as "Cases of Adult Delinquency". These are firmly within the cartographic and sociological tradition that cartographic historian Arthur H. Robinson has called "the mapping of moral statistics". (Robinson, 1982, 41) The system did not use a fixed base map (the equivalent of the German grundblatt). Instead, there was a separate colored map on cardstock, which carried the notation "NOTE: This map is left unbound so that it may be readily used in connection with any of the transparent maps". The colored map was a color-coded map of five housing rental rate classes, which the accompanying pamphlet text noted to be the single most important indicator of the status of housing among the eight data fields of Real Property Survey data averaged for each block. Hence, both the German and American cases use topography for the base map, but in the American case it is urban socio-economic topography rather than physical elevation.

The city of Richmond was used repeatedly as a test case for innovative statistical and cartographically analytical tools developed for the housing program. The greatest elaboration of these exercises was conducted by Homer Hoyt, who was, at the time, the chief research economist of the Federal Housing Administration and the chair of the Research and Statistics Sub-Committee of the Central Housing Committee. In 1939, he published a landmark book on the dynamic organization of residential neighborhoods in American cities. (Hoyt, 1939) The volume contains dozens of grey-scale and dot density maps of thematic data for Richmond. It also includes a set of four small transparent celluloid acetate overlay maps based on the data from the Real Property Surveys. Three of the maps depict poor quality housing, in specific attributes of low rental rates, high percentage of structures on the block in need of major repair, and high percentage of buildings over 25 years old. Hoyt then notes the relative correlations between the sum of

these thematic maps and the fourth thematic layer, “50% and over race other than white” meaning the distribution of the black blocks, the areas inhabited by Negroes from the previous map set. Hoyt presents the overlay set, but draws no conclusions at all. In fact, he describes the exercise as primarily important for the presentation of the overlay technique itself. “In order to bring out at a glance the areas in which a concentration of the desired housing facilities exists, a technique has been devised for superimposing a series of patterns on each other…This procedure is easily flexible—the area finally delineated will depend on the factors and the limits chosen by the investigator. In other cities, a different choice of factors might be advisable—other than white occupancy, for example, is a characteristic which may be used with justification only in southern cities as a measure of the poorest housing conditions. In northern cities, the worst slums are occupied by whites, and some cities have a relatively small Negro population”. (Hoyt, 1939, 48)

The Morgen and Sievers paper and the Hoyt book are roughly contemporary (respectively, 1941 and 1939) and both represent possibly the highest level of analytical cartographic techniques then extant in their respective milieus, which is to say they are the most sophisticated examples I have yet found. In both cases, the authors present map overlay and analysis techniques based on extremely specific datasets and applications, based on a surfeit of data of many kinds. Yet in both cases the authors present their case studies to be, above all, important insofar as they illustrate the techniques themselves, as it may be transferred forward to other applications.

The two applications are quite disparate, in that one addresses the cartography of urban housing, and the other regional-scaled agricultural land use potential. Yet they feature a remarkable degree of convergence. Both applications use base maps which represent data fields acknowledged to be of primary importance, and the base maps are graphically differentiated from the other maps by vivid color or high print density. The overlay data maps are, in both cases, divided thematically, with data layers of lines and polygons representing “infrastructure” folding in from one side, while overlays representing thematic variables defined by color tinting or dot-density fold in from the other side. The combination of the maps left and right then allows thematic data to be geo-positioned readily in reference to boundaries and important features like roads and intersections. The fact that the two applications represent very different data at very different scales, yet they resemble each other in many respects, possibly reflects some cross-contact between the teams of researchers and cartographers responsible for the two applications. Or the fact that the applications are quite different may provide some evidence of independent invention. Clearly, it is difficult to justify any conclusions about the two applications without significantly more information. Even so, it is possible to detect an additional major similarity between these applications.

Nothing is entirely as it seems here. What we have seen thus far are merely the publicly disclosed overlays and analysis of them. In both cases, there were other, later overlays—with truly dreadful consequences. In both cases the overlays continued to pile up on the extant stacks, as it were, but they changed from public to secret. These processes continued until they were curtailed and interrupted by the Second World War.

The exigencies of that conflict are such that far more of the overlays from the American case survived to the present era, so a portion of the story for the German case must be supplied by inference, with the hazards attendant on that.

1.6 **The Overlays Go Secret and Turn Red**

The Real Property Surveys were at best a snapshot of urban housing conditions city by city as the investigators found them in 1934-1936. But cities change over time, and neighborhoods flourish and decay. Homer Hoyt headed research initiatives to discern the structural patterns of American cities over time, to seek out what he called the "dynamic factors" that governed city growth and decay. He was candid about how they were to be created. "The use of dynamic factor maps, however, indicates the changes in the location of residential neighborhoods more exactly. These are constructed from evidence gleaned from old inhabitants. Those who have spent their lives in a city are often the only source of information on neighborhood changes. They have been eyewitnesses of the shifting character of neighborhoods. If a number of these residents are consulted independently and if they corroborate each other, much confidence may be placed in their evidence". (Hoyt, 1936, 112-114 in NARA II, RG 207, Entry 30))

As the agencies organized in the Central Housing Committee proceeded in their evaluations of American cities, their housing situations became much more detailed and sophisticated—and they went secret. Homer Hoyt organized a corps of FHA investigators to try pioneering techniques to grade the financial health of cities based on the status of their extant local loan and mortgage-writing companies. The exercises required a descent into subterfuge. "The next step will be to visit the Secretary of the Chamber of Commerce, or, in its absence, the leading local bankers. In these interviews, the investigator must never mention the fact that he is in any way rating or grading the city, but he should state he is merely collecting data to determine the need for housing". (Ibid, 47) Later on, Hoyt formalized the procedures necessary to create the dynamic factor maps, which were also integral to the grading of neighborhoods and cities. Hoyt ordered that, city by city, the FHA researchers should find elder but cogent members of the local elite with thorough knowledge of the city and its history. Each was to be kept entirely separate from the others, and all were to create the very same sets of thematic maps, which would later be compared by the investigators. In Hoyt's public writings, overlay applications were open-ended and malleable to any purpose. In his confidential instructions, he was far more specific. "On the same map, each man should draw a line with a red pencil around all the blocks or parts of blocks occupied today (1935) by any distinct racial, national, or income group that would be considered an undesirable element if introduced into other parts of the city" (Ibid, 57) It was for that reason that the subsequent confidential national map series known as the Home Owners' Loan Corporation Residential Security Area maps were finally revealed decades later by the historian Kenneth Jackson to be, in fact, the infamous "red-lining maps". (Jackson, 1985) The red-lining maps were confidential documents—and very controversial—and all but a few archival copies were ordered to be destroyed when the New Deal's infrastructure was being shut down as the US joined the Second World War. As a result, in the absence of

public perception of the maps themselves, the cartographic practice of overlay at their heart was abstracted to the status of a verb in American English: to "red-line" is to discriminate unfairly against others based on race. The post-war history of American urban areas is the story of that verb in action.

1.7 **In the Greater Reich, Historical Development Works against the Natural Potential**

Morgen and Sievers' 1941 Grundlagen paper appeared in the largest yearly volume of *R und R* ever to appear. As the war progressed, the journal published less frequently, finally ending in 1944. Given the exigencies of publishing, their research and writing probably occurred a year or so before publication. That would place their efforts in line with the great shift in German regionally-scaled land-use planning (Raumordnung) that occurred, as planning efforts originally directed to regions of German proper (Altreich) where re-directed progressively farther and farther away, to the Greater Reich (Grossdeutchen Reich). In Lower Silesia, Morgen and Sievers identified historical patterns of farm sizes and locations that did not correlate well, in their analysis, with the natural potential of the land. Their analysis may be seen as a training exercise for applications elsewhere. The progression might be characterized thusly: first Lower Silesia, and then the world.

An enormous literature on the Nazi conceit of "lebensraum" [living space] exists. Most of that addresses the concept on a rhetorical level, as in the semiotics and graphic designs of Nazi geo-politik. More important to my research is analysis of the brilliant techniques and methodologies of innovative cartography and spatial theory that were the tangible engines of lebensraum in action. These include, in addition to Morgen and Sievers' analytical uses of overlay, the work of Walter Christaller, their colleague in both the Institut für Agrarwesen und Agrarpolitik der Universität Berlin and also the Stabshauptamt für Planung und Boden in the SS Reichkommisariat. Walter Christaller is known as the developer of central place theory [Die zentralen Orte] which became a fundamental tool of empirical research and planning in the actual and optimized uses of space considered on a regional level. In post-war American geography, central place theory assumed a critical role as a powerful modeling and planning tool, quite amenable to the "quantitative revolution" in data and data processing that characterized the era. American geographers celebrated Christaller's presentation of the theory in his 1933 dissertation examining the distribution of medieval market towns in Bavaria. They did not discuss, and did not want to hear, that his dissertation expenses had been financed by Heinrich Himmler of the SS. (Rössler, 1990) The real point of central place theory, in this context, was essentially to address, systematically and in a rational Aryan manner, the great objective of the establishment of the Greater Reich. This was to correct the problem of "historical developments that work against the natural potential," as Morgen and Sievers put it, on a global scale. The work of all three—Morgen, Sievers, and Christaller—was subsumed in the final projects of their leader, Konrad Meyer, the author of the General Plan for the East (GeneralPlan Öst). The General Plan for the East was proposal for vast resettlement of Germanic populations and industrial development to be

worked by slave laborers. The General Plan was related to the Morgen & Sievers' paper in that they were both examples of a schema to address the historical developments that impeded the natural potential, as the Nazis saw it.

1.8 **From Red-Lining and the Reich to GIS**

Geographic information systems (GIS) may be seen as specific technological ensembles based on digital computers, along with their accompanying socio-technical ensembles and suites of geographic and social and political practices. With more investigation, the history of the implementation of GIS *sensu strictu* becomes more convoluted and complex, with a larger arena of development, many more players, and an emerging story that is both related to, yet quite distinct from, most of the key technologies of the Cold War. GIS is related to ICBMs and top secret reconnaissance systems, and in fact was developed by the very same ensembles in the Military-Industrial-Academic-Complex. (Leslie, 1993) Yet early generation ICBMs and early satellite reconnaissance systems, designed about the same time as GIS, were once top secret but now are known in some great detail, or at least in declassified detail. GIS was never quite so secret—in part, because the unclassified data reduction and mapping components of the system were used to hide the secret data acquisition systems "in plain sight". (Cloud, 2002) Yet, surprisingly, declassification and disclosure of early MGIS/GIS programs has not yielded comparable insight into the history of GIS development. The story of GIS alternates between that of a mature technology that simply appears, and an origin myth that begins with post-war 1960s analog map overlay applications invented by Ian McHarg and somehow, by processes unknown, rather speedily translated to the domain of early and problematic digital computers and their associated data management and mapping systems.

Demonstrating that internationally distinct sophisticated analog map overlay applications existed before McHarg entered puberty is straightforward. So what was the connection(s) between GIS and American overlay systems, German overlay systems, and those of other nations? (There were, for example, comparable explorations of overlay applications by Jaqueline Tyrwhitt, Max Lock and others in city and regional planning in Great Britain at the same time as the American and German cases presented here, although those projects are outside the scope of this paper). What were the links and connections of innovation in these technologies and their practitioners? Further, what were the linkages between sophisticated analog map overlay systems from the pre-war world, and post-war systems configured around digital computers a human generation later?

I haven't an answer that would even begin to suffice. But there is one bit of evidence, although absolutely anecdotal (like most of life). It explains why I went looking for German spatial planning maps and their makers in the first place. Back in 1998, when I was researching my dissertation on the geographic applications of the then-recently declassified CORONA reconnaissance satellite system, I interviewed a major participant in the geodetic sciences applications of the enterprise, Lawrence (Larry)

Ayers. Ayers was, at the height of his government career, the highest ranking civilian in the Defense Mapping Agency, now re-named the National Geo-Spatial Intelligence Agency. He retired to become executive vice-president of Intergraph Federal Systems, the second largest developer of GIS software applications. Ayers wanted to talk about CORONA, but he also wanted to talk about GIS, and about MGIS, from which it sprang. He said that MGIS had evolved from pre-computer map overlay applications directed to terrain modeling, mobility studies, and trafficability maps for use in ground-based warfare. But, he said, the inspiration for the map applications came from slightly different map overlay applications sets. These were extremely sophisticated translucent thematic overlay sets (as many as 20 co-registered overlays per set). They had been captured by Allied Intelligence at the end of the Second World War. The overlay sets were not broadly distributed at all—they were found in the possession of several elite planning units of the SS. (Ayers, 1998, pers. comm.)

Given the waves of destruction of German materials in the war and afterwards, the complex fates of captured German materials than fell into Allied hands, which in some cases were repatriated decades later, and the redistribution of extant German war-related archives following reunification (Der Wende), it is highly unlikely that I, or anyone, could either prove or disprove Ayers' account. Nevertheless, precisely because of that, I find it a very important part of the "historical" narrative of GIS, particularly considering that various GIS textbooks continue to state that Ian McHarg invented the analog overlay technique in the early 1960s. And pursuit of Ayers' story did lead me, eventually, to Morgen and Sievers, and Christaller, and Meyer—all of whom happened to be members of the leadership of small elite planning units of the SS.

Given the evidence trail thus far encountered, another important question is why American MGIS/GIS technologies developed in the post-war era apparently had little or no connection to the nationally-scaled cartographic enterprises from the Great Depression. I say this because no one, in the disparate historical materials on GIS history extant, has ever connected GIS to Homer Hoyt, except me, although his uses and analysis of overlay technique are clearly quite sophisticated.. So why did a nationally-scaled innovative program apparently disappear without leaving a conceptual or technological trace?

It is perhaps entirely fitting that the pathways and traces of innovation in the history of GIS are both ambiguous and contradictory. Is such a truncated and contested history not apt, given the full history of the analytical practices of map overlay that constitute the very conceptual engine of GIS. These first flowered in applications in which their use was absolutely integral to both *revealing* and *concealing* what the real story was.

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