Visualizing a History of What Might Have Been: Exploring the Potential of Geographic Information Systems in Mapping Past Mass Transit Plans for Metro Manila

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Abstract
The daily predicament of heavy traffic in Metro Manila has resulted in the notion that the region's mass transit system is poorly planned. However, transport documents from the 1970's reveal that this is not entirely true. Numerous plans for the railway system - which are notably different from the rail transit lines that we have today - were drafted in anticipation of the Metro's ballooning population, economic advancement, and traffic demand but these were not carried out. The question that remains to be addressed is whether these aborted plans could have serviced the commuters more effectively than the existing infrastructure.

This preliminary study explores the potential of using Geographic Information Systems (GIS) in reconstructing the unimplemented mass transit plans for Metro Manila through maps. The generated maps are intended to aid in and provide insight for policy-making and transport planning. A digital geo-database is created by compiling and processing information from historical maps and text in transportation plans and documents for the 1970s. Thus, the discontinued plans and the actual transit system can be analyzed side-by-side, and be overlaid with the environment and demography of Metro Manila from the 1970's to present. The study seeks to enrich the discourse on urban transport planning by using historical GIS to posit ideas and considerations for future mass transit projects in the country.

Keywords: Historical GIS, HGIS, Metro Manila, Railway, Mass Transit, Georeferencing

I. Introduction

The present burden of traffic congestion in Metro Manila has resulted in the notion that the area's mass transit system is poorly planned. However, historical documents dating back to the Hispanic occupation down to the post World War II period reveal that this is not entirely true. Late 19th century documents such as bundles 5287 and 5291 from the National Archives of the Philippines (NAP) reveal the meticulous planning, construction and management history of rails and *tranvias* by the *La Compania de Tranvias de Filipinas*. In the 1970s – several decades later – and still in the attempt to keep mass transportation efficient, numerous plans for the railway system were drafted in anticipation of the region's ballooning population, economic development and travel demand. Among these plans and feasibility studies, three were chosen as examples for this study's methodological discussion since they contain various maps and spatial information in their text. Namely they are (1) the railways and stations proposed in the *Transportation Systems Metropolitan Manila Assignment Report* by Sigurd Grava (1972), (2) the five rail lines in the *Urban Transportation Study in the Manila Metropolitan Area* (UTSMMA 1973) which is the result of the study by the Overseas Technical Cooperation Agency (OTCA) from Japan, and (3) the road construction and development plans in *MMETROPLAN: Metro Manila Transport, Land Use and Development Planning Project* by the Department of Public Works, Transportation and Communications with Freeman Fox and Associates (1977).

It can be observed that these transport plans have notable differences from the rail transit lines that we have today, indicating that not all of them were carried out. How are these unimplemented plans different from the current configuration of the Metro's mass transit system in terms of location and density? Were certain localities or municipalities in NCR prioritized in these plans? Another curious question that remains to be addressed is whether these aborted plans could have serviced the commuters more effectively than the existing infrastructure. This preliminary study seeks to build a spatially-nuanced foundation for answering these problems. Specifically, this explores the potential of Geographic Information Systems (GIS) and its hybridized field of Historical GIS (HGIS) in reconstructing these discontinued visions for the mass transit system. This paper also seeks to develop a cartographic strategy that integrates current and past transport infrastructure configurations, discontinued transport plans, and spatial-demographic information about Metro Manila. This task involves citing practices on HGIS and techniques that are applicable to the study area. The outputs include process models for future similar research, so as to spark interest into this interdisciplinary approach to transport history. Possible sources of historical maps and data, as well as potential applications of the process models have been identified towards the end of this paper.

II. Historical GIS: Where Geography, History, and Information Technology Meet

GIS has a wide definition. Herculano Felias, in his Master's thesis *A Study on the GIS-Based Transportation Planning System for the City of Metro Manila* (1988) defined GIS as a collection of data, software, tools and users that allow the capture, storage, processing and display of spatial knowledge. Felias created a catalog of datasets that are needed for effective urban transport management and modelling. The catalog includes information on the number of vehicles, urban district populations, and location of road facilities such as flyovers and U-turns, and time-dependency of the number of trips. Upon integrating the spatial data with tabular qualitative and quantitative information, different types of analysis can be performed and specialized maps can be generated. In the book *Geographic Information Science* (2004), Wolfgang Kainz broadly defined GIS as a scientific and interdisciplinary tool for understanding the world. Kainz added that GIS provides applications to archaeology, architecture, urban and regional planning, and surveying by building up on the foundations of mathematics, statistics and computer sciences. I-Chun Fan *et al.* in the paper "Past, Present and Future of Historical GIS in Academia Sinica" (2013) noted that GIS, with its ability and potential for spatial data integration and analysis as its most distinguishing feature, has developed rapidly in various fields and as a discipline on its own.

Historical GIS (HGIS), on the other hand, is defined as the application of GIS to historical studies by combining the three geographic axes of latitude, longitude, and altitude with time as the fourth axis (Kawaguchi 2013). HGIS involves the digitization of spatial knowledge from historical maps and text such that it can be presented in maps or a collection of them in a time-series, which enables multiple comparisons across different time periods. Kawaguchi (2013), in the paper "Progress in Historical GIS in Japan" identified three key benefits of the methods, namely (1) reduction of time and effort in data processing, (2) preservation of fragile historical documents in digital form, and (3) ease of sharing data and processes among researchers. HGIS and the discipline of cartography, which is "the art and science of mapmaking and map use" (Roth 2011, 11), are often side-lined in addressing the daily predicament of traffic congestion. Historical-spatial knowledge and maps, however, should be considered as central tools in addressing such issues. Wood (2010) argues that the growth of nation-states can be partly attributed to the increasing importance, creation and use of maps by political and governance institutions. Maps also serve as indispensable media for communicating and educating people (Robinson 1981). In Thailand, mapping is taught as subject in primary and secondary levels of education to foster understanding of the country's form and borders, as well as promoting a holistic approach in addressing various planning issues (Winichakul 1994).

Anthropologist and geographer Jay T. Johnson et. al. (2006), in their paper "Facing the Future: Encouraging Critical Cartographic Literacies in Indigenous Communities", posits the Hawaiian philosophy of "facing the future by facing the past" as the epistemological backbone of GIS and indigenous cartographies:

> The concepts of 'past' and 'future' are explained by Hawaiians using bodily directions, the front of the body faces the 'past' while the back faces 'future'. Hawaiians 'face' their 'future' with their backs because the future is an unknown. On the other hand, 'past' is knowable; it can be 'seen' in front of each of us, shaping our character and consciousness. (Johnson 2006, 10)

This paper argues that *facing the future* of transport in Metro Manila requires a close examination of its past – more specifically, its geographic past. Nathaniel C. Bantayan of the Institute of Renewable Natural Resources, estimated that eighty percent (80%) of all environmental problems and issues are geographical. As such, the development of a GIS infrastructure which involves a series of non-mutually exclusive steps from "(1) data encoding and processing, (2) GIS analysis and modelling, and (3) GIS display and output" is essential in addressing these environmental issues (Bantayan 2002,1).

In this regard, understanding and managing transportation and traffic issues in Metropolitan Manila as geographic issues, i.e. environmental, temporal and spatial in nature, require the implementation of HGIS-aided mapping and visualization. Moreover, in addition to HGIS's feature of preserving maps (Roth 2011), the editable feature of the geodatabase allows it to become a repository of historical data which can be collected and accumulated through the year. This functionality will be illustrated in the succeeding sections. The geodatabase can be made publicly accessible through the cloud, and spark interdisciplinary interest among transport researchers.

III. Process Models: HGIS Techniques for Metro Manila's Past Transport Plans

Tackled in this paper are techniques in handling historical maps and data in an HGIS environment. The first one is georeferencing, which broadly refers to the process of transforming physical maps, photos and other printed documents so that they can be accommodated in GIS (Hackeloeer 2013). Second is a set of strategies in order to address issues of missing or incompatible historical maps and documents. This section briefly discussed the use of Google Earth and geometry calculating tools in GIS to verify congruence between the historical plans and the GIS-rendered maps. Finally, this section also covers the preparation of historical data for analysis, integration with other mappable variables, and for visualization.

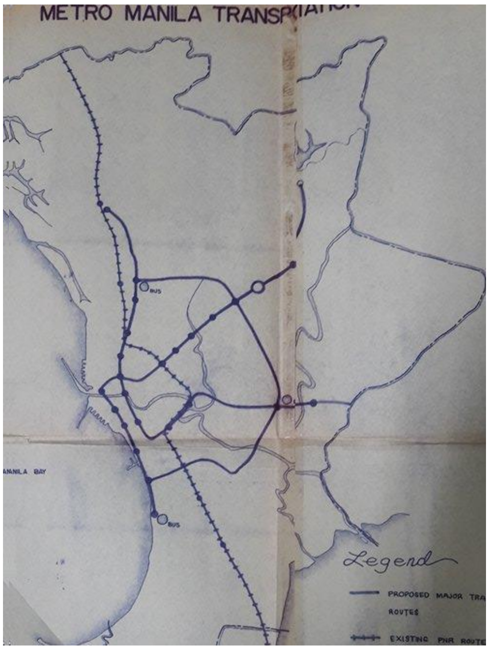
III.1 Georeferencing

Peter K. Bol (2012, 1) argued that GIS-based analysis "links Geography and History". The evolution and growth of the mass transit system of Metro Manila, the transport plans, and the rationale for each of them can be observed as not exclusive functions of time alone. They are equally functions of space and therefore they are features which can be mapped. This process model follows the trail of spatial data from the historical documents to the computer-rendered maps.

Specific techniques must be applied to convert historical maps into forms that can be accommodated by the GIS environment. The first step is to create digital copies i.e. JPEG, BMP or PNG file formats of old maps. However, these cannot be directly added to the geodatabase due to (1) the lack of spatial referencing i.e. latitudinal and longitudinal information, and (2) distortions of spatial reality due to the projection systems used in the old maps, error of scale and representation, cartographer's interpretation and angle of capture for aerial photographs (Felis-Rota 2012). Spatial referencing is given to the digitized images through *georeferencing* in GIS. Georeferencing, otherwise known as *rubbersheeting*, is the process of systematically stretching and warping the image files of historical maps or photographs to match the dimensions in the GIS environment with minimal residual error (Rumsey 2002, Hackelooer 2013). Rubbersheeting is applied to the map of three railway lines proposed by Sigurd Grava (1972).

The original illustration (Figure 1) is scanned from an old copy of Grava's *Metropolitan Manila Assignment Report* which is available from the School of Urban and Regional Planning Library in the University of the Philippines Diliman. The report proposed three rail lines, with the priority line running from Quezon City's government area, traversing España Avenue, then extending southwards to Intramuros. The first line was intended to reach Makati or the airport via the corridor between Taft and Mabini St. The second line would start from Malinta, Valenzuela in the north, running generally southward toward the Pasig River and in close proximity with a section of the first line. Finally, the third line would have a circumferential layout around Manila — transecting the other lines and forming a loop for efficiency. Grava (1972) also raised that his proposed lines should be located up to two kilometers from the mapped configuration, so that congestion along the main roads could be avoided.

The map from the 40-year old book in the School of Urban and Regional Planning has irreparable folds and cuts, which proved challenging to address in the digitization process. The present-day digital map of Metro Manila (Figure 2), on the other hand, is constructed using the shape file from the PhilGIS data clearing house (2011), which provides a more updated base map of the Philippines. This shape file of the Metro Manila is already georeferenced with respect to the global coordinate system. Note that NCR's western edge with Manila Bay appears differently across the two documents.



Left: **Figure 1.** Map of rail lines and stations proposed by Sigurd Grava
Source: Appendix A, *Transportation Systems Metropolitan Manila Assignment Report* (Grava 1972)
Right: **Figure 2.** Current appearance of the western edge of Metro Manila
Source: PhilGIS.org GIS database clearing house (2011)

The screen-capture on Figure 3 shows a part of the georeferencing process where the image is being overlaid on a GIS environment. The software used in these examples is ArcMap 10.2, a dedicated GIS application developed by the Environmental Sciences Research Institute (ESRI). In ArcMap, georeferencing is performed by selecting "control points", which are prominent locations easily identifiable on both the historical map and the GIS screen. The control points are likely to be matched congruently with the locations' coordinates on the georeferenced shapefiles. It is easier to rubbersheet old maps with borders equipped with gridlines or tick-marks which indicate latitude-longitude ordered pairs, since these are direct references to a geographic coordinate system. As for the maps in Grava's document, a different strategy is applied due to absence of such marks. A point on a meander of the Pasig River in Manila and the Quezon City Memorial Circle were chosen as control points, which were represented as red crosshairs on Figure 3. Each is then linked to its counterpart on the digital shapefile of Manila, which is another active layer in the

ArcGIS workspace. Choosing these two points prompted ArcMap to systematically warp the scanned image and transform its shape, orientation and scale to match the correct georeferencing. After rubbersheeting, the railway lines and stations were carefully traced with a digitizing pad, and then saved as polyline and point-type GIS data respectively. The resulting digitized proposed rail system of Sigurd Grava is illustrated on Figure 4.

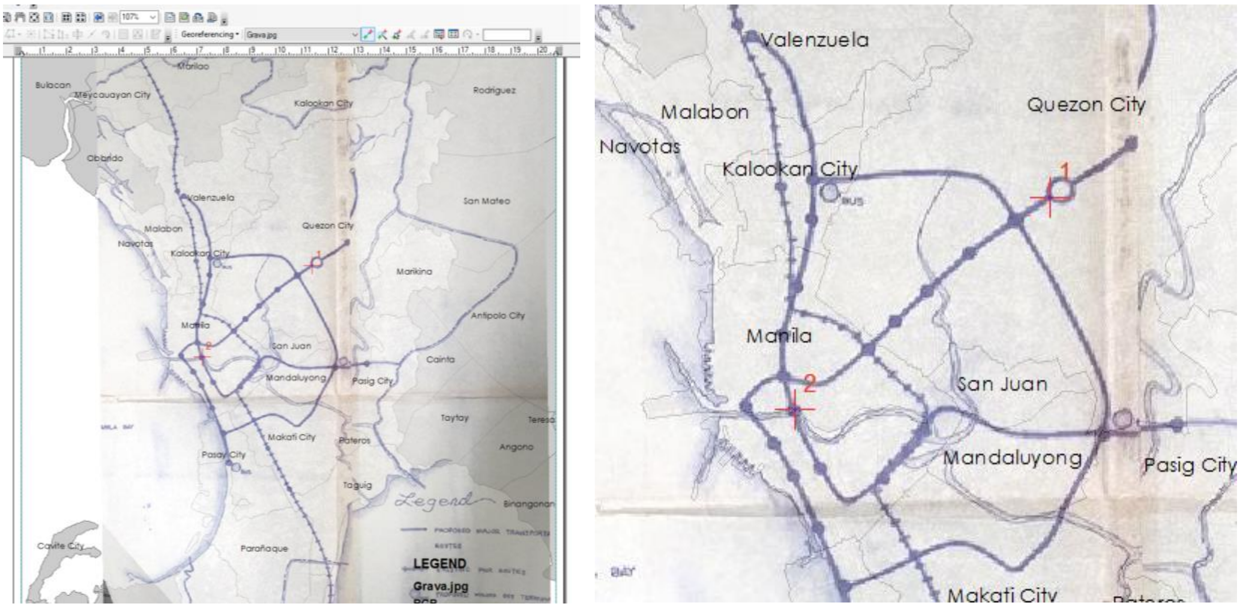


Figure 3. Georeferencing in ArcMap. At least two control points (crosshairs 1 and 2) were chosen to rubbersheet Grava's map (1972) across the georeferenced shapefile of Metro Manila.

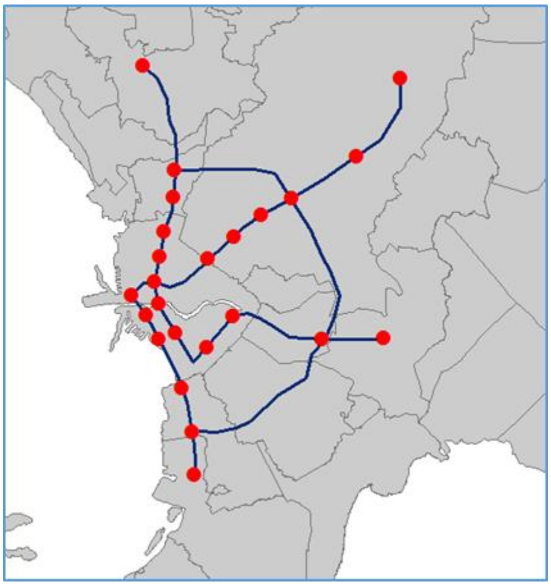
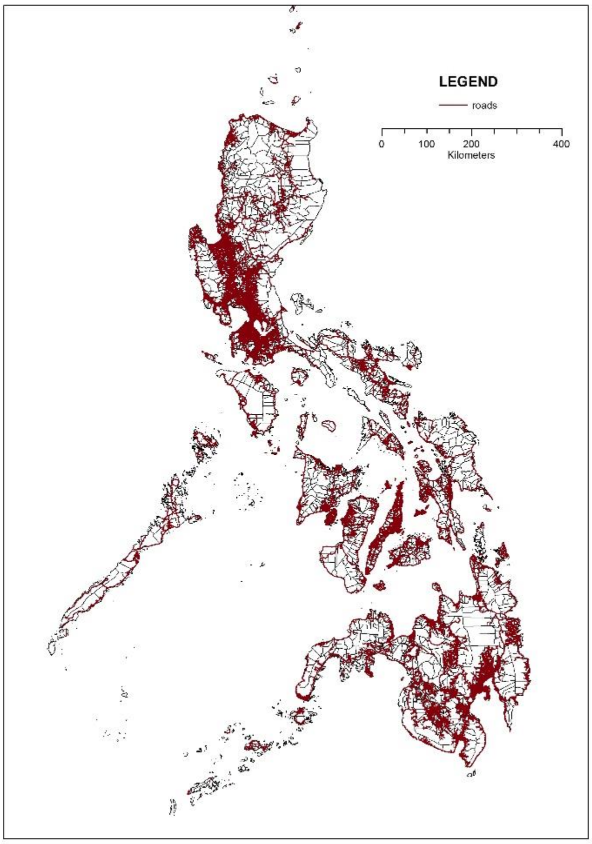


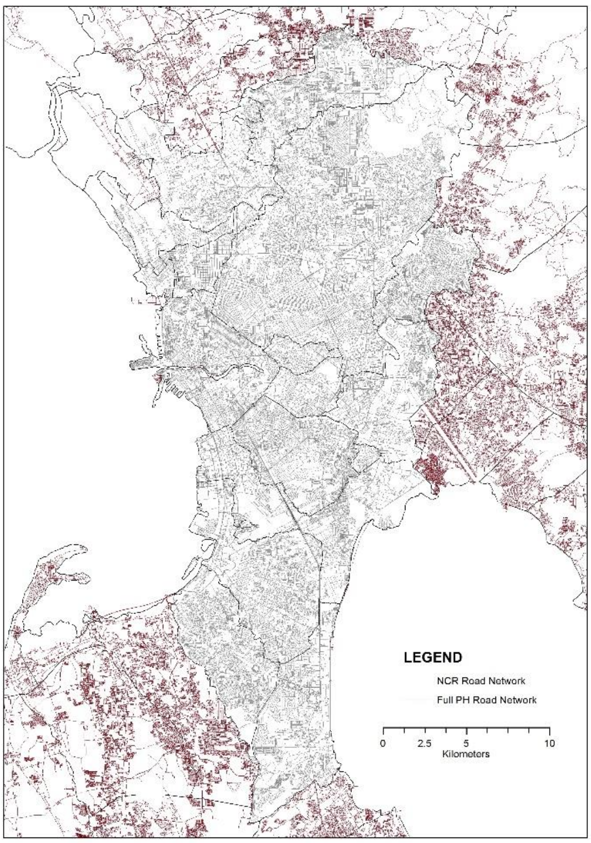
Figure 4. Digitized proposed railway lines and stations across Metro Manila

The geometry of the original historical map may be distorted due to georeferencing (Monmonier 1996), and it may take some trial and error to achieve the best fit with the original and the GIS environment. The distortions are caused by warping the image to fit with the projection of other georeferenced layer. In the paper "Old Maps and its Usage with Contemporary Map in Environment of Geographic Information Systems", Mirko Husak (2010) notes the effects of rubbersheeting to old maps:

> "It is almost impossible to perfectly align an old map to modern coordinate systems because mapping methods before the age of aerial photography often only very imprecisely represent scale, angle, distance, and direction... What one should keep in mind is that georeferencing does not necessarily improve a historical map or make it more accurate. In the course of changing the original map to make it amenable to digital integration, geo-referencing changes lines and shapes, the distance between objects, the map's aesthetics, and its value as a cultural artifact... Ideally, researchers should include both the warped map and the scanned image of the original map in a GIS project or publication." (Husak 2010, 10)

For the digitized unimplemented transport plan to be of any use in modelling or comparison, it was intended to be overlaid with other georeferenced information. For this example, a modern road network of the Philippines obtained from PhilGIS (2016), based on Open Street Maps (OSM 2011) and verified using Google Maps (2016) was selected for overlaying (Figure 5). The dataset is for the entire archipelago, and it can be observed that there are distinct concentrations of the network in certain areas of the country. Extraction tools in ArcMap enables the isolation or clipping of geographic features based on another layer – in this case, the boundaries of the Metropolitan region (Figure 6).





Left: **Figure 5.** The road network of the Philippine Archipelago (PhilGIS 2016)
Right: **Figure 6.** The road network clipped to the extent of Metro Manila using ArcMap

With Grava's proposed rail system and the road network having the same georeferencing, the two were placed in an overlay map (Figure 7). This configuration allows verification and correction of Grava's data, which probably carries some errors due to its age and distortions caused by rubbersheeting. Moreover, the overlay allows for advanced GIS methods such as network analysis (ESRI 2010) investigating the relationship of transportation modes which use the road network and the hypothetical railway, which is a mass transit mode. Akkarapol Tangphaisankun (2010), in his doctoral dissertation *A Study in Integrating Paratransit as a Feeder into Mass Transit Systems in Developing Countries: A Study in Bangkok*, among other techniques mathematically modelled the role of the motorcycle-taxi and the route-based paratransit *Songtaew* as feeder modes to Bangkok's railways and bus lines. Such study provides alternative perspectives on how to improve the efficiency of linkages between rail and road-based transport modes which, in the case of the Metro Manila may be the metro rail and jeepneys respectively.

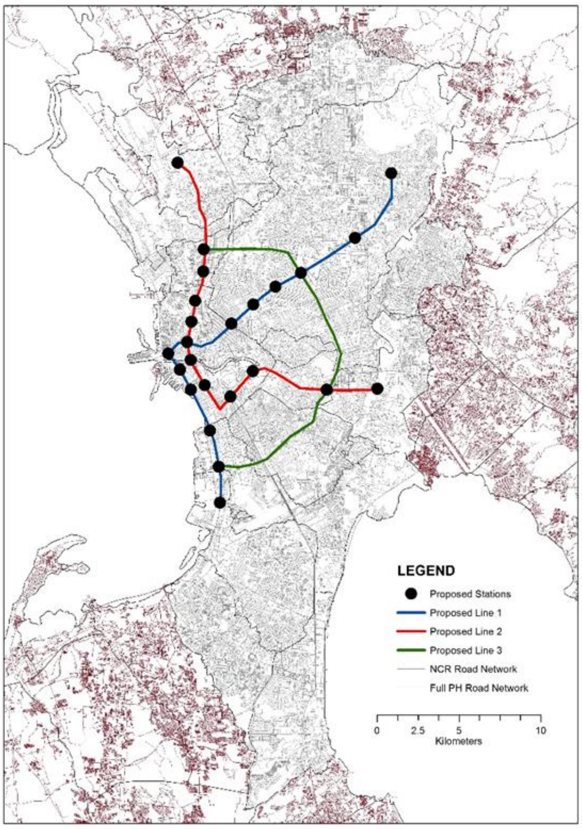


Figure 7. Overlay map of the road network and Sigurd Grava's Lines

III.2 Addressing the Issue of Missing Information

In addition to lack of georeferencing, another challenge in mapping historical data is the lack of information on the historical maps. David Rumsey (2002), argued that such situations entail the cartographer to cross-reference historical maps with several documents and, at times inevitable, employ cartographic imagination. In some cases, the historical maps of the plans are inexistent themselves. Mateu Morillas-Torne (2012) in another HGIS study, "*Creation of a Geo-Spatial Database to Analyse Railways in Europe (1830-2010)*, noted that there is usually no single homogenous set of documents that contains all the information about the evolution of a railway system. In Torne's case, he had to search and integrate various sources such as transport reports, news clippings and photographs around Europe to construct a geodatabase as comprehensive as possible. Another good example would be Wakako Kumakura's research "To Where have the Sultan's Banks Gone? An Attempt to Reconstruct the Irrigation System of Medieval Egypt" (2014). Kumakura, due to the incompleteness of historical maps on the study area, used Google Earth in mapping the irrigation infrastructure in the Nile Delta from 1382-1517. The visual traces from satellite imagery enabled pinpointing of the irrigation structures from as early as the 15th century.

As for this study, a combination of 1970s transport documents, maps in textbooks, and Google Earth were used to construct an HGIS-version of the five lines proposed in UTSMMA (1973) (See Figure 8). As described in the original plan, a total of 135.1 kilometers length of railways, excluding the 56.4-km proposed improvement of the Philippine National Railways (PNR), would be constructed to connect the following pairs of terminal stations: (1) Constitution Hill via Quezon Boulevard to the International Airport, (2) Novaliches via Manila to Cainta, (3) Along Circumferential Road 4 or C-4, (4) Marikina to Zapote via the Manila Bay Area, and (5) Bocaue to Muntinlupa via Tutuban Station. Even before rubbersheeting maps from UTSMMA documents, Line 3 proved to be the easiest to digitize since it runs a long C-4. The circumferential road is a geographic feature with a well-defined location and geometry. In fact, locations along C-4 were used as control points in georeferencing the UTSMMA map with the Metro Manila shapefile. However, digitization is different when it comes to the four other lines. Unlike Sigurd Grava's 1972 document where the individual stations are explicitly mapped, UTSMMA documents mostly mentioned the terminal stations and the general description of the path of each line.

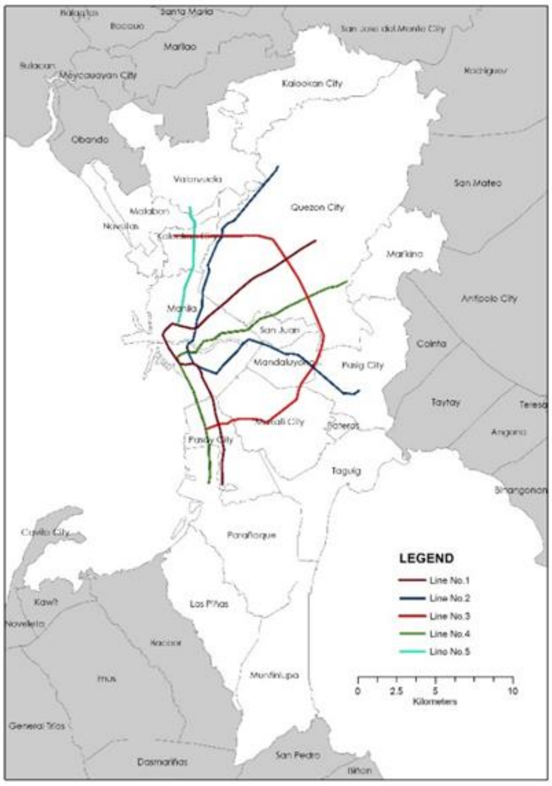
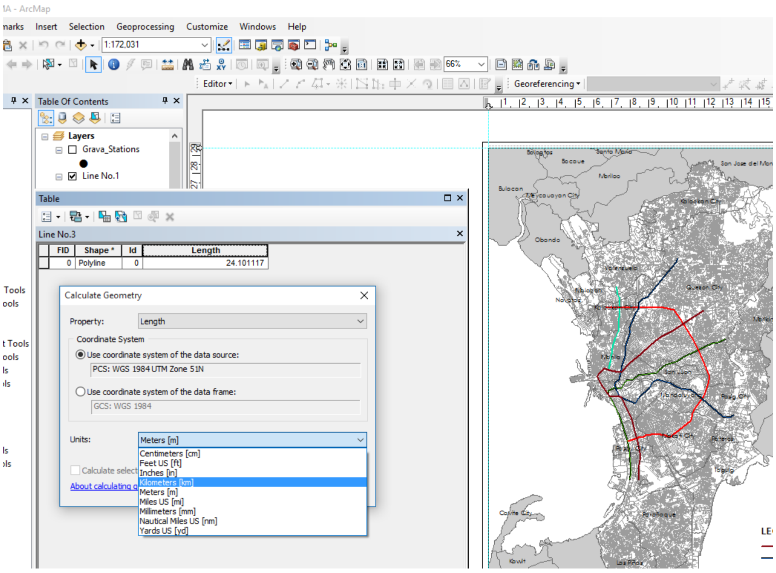


Figure 8. The HGIS version of the five railway lines proposed in UTSMMA (1973)

Completely mapping the railways proposed in UTSMMA required the use of Google Earth since no further details on the stations and turns of each line were provided. The satellite imagery provided by Google was used to trace and digitize the profile of the four remaining lines, and this process necessitated the approximation of best fit by the cartographer. However, using tools in ArcMap such as the feature Geometry Calculator, the length of the digitized lines in kilometers were determined and verified to closely match the specifications drafted in UTSMMA (See Figure 9).



9. Calculating Geometry in ArcMap: Determining the length of each feature in GIS allowed verification against the rails' lengths in UTSMMA

III.3 Analysis by Overlaying and Temporal Data Visualization

Ian Gregory and Richard Healy, in their paper "Historical GIS: structuring, mapping and analysing geographies of the past" (2007), argued that "Although creating and disseminating GIS databases are important, the real test for historical GIS as a discipline is to create new insights into the geographies of the past". Fan (2013) describes the digitization of historical maps and imagery as setting up new platforms for diversified analysis. Furthermore, Fan claimed that it is vital to map other environmental data which can be correlated with the actual feature of interest which, in this study, are railways. Case in point, Wen Zeng in her paper "Design of Data Model for Urban Transport GIS" (2010), in addition to old railway maps, included area demand, location of economic activities, and land use for her geodatabases. In another historical transport study "A GIS analysis of the evolution of the railway network and population densities in England and Wales 1851-2000", researcher Marta Felis-Rota (2012) tested the correlation between railways and population by mapping human settlements. This third set of methods in this preliminary study is dedicated to the preparation of historical data for analysis and visualization. This section also demonstrates overlaying the maps of proposed railways and road against other environmental variables.

The digitized version of transport plans in GIS are features that are given correct locational and geometric characteristics. However, additional information can be assigned to each of them through the attribute table. The attribute table in ArcMap is a "tabular file containing information about a set of geographic features, usually arranged so that each row represents a feature and each column represents one feature attribute" (ESRI 2016). In other words, an attribute table is a link between tabular entries and their corresponding geographic features such as municipal delineations, or the road and rail shape files themselves. Qualitative and quantitative characteristics such as temporal information can be inputted to the attribute table and these attributes, in turn, can be visually represented on the digital map.

For this section, the selected plan from the 1970s is the *Metro Manila Transport, Land Use and Development* or MMETROPLAN (1977). MMETROPLAN acknowledged that rail-based transportation is indispensable, but it emphasized more on road construction and improvement, and the cheaper road-based transport to help decongest Metro Manila. The phases of infrastructure construction in the plan were segmented according to this timeline: Phase 1 from 1977 to 1980, Phase 2 from 1981 to 1985, and Phase 3 from 1986 to 1990. In the example in Figure 10, the attribute table of the proposed road constructions is edited to reflect the target year of construction as stated in the MMETROPLAN.

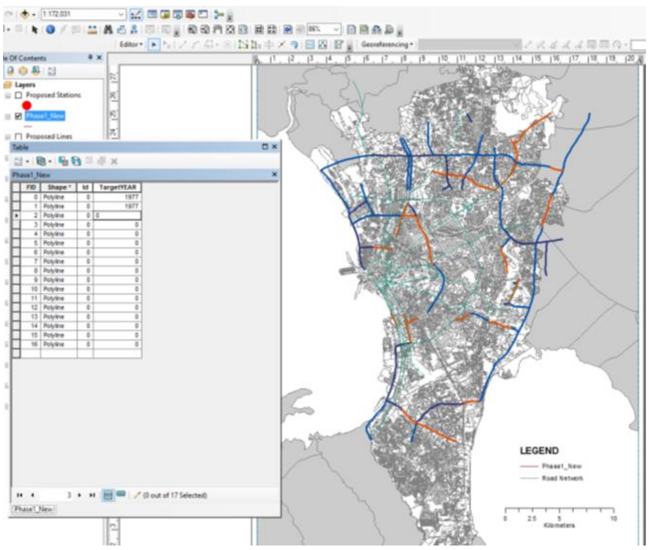


Figure 10. The Attribute Table links each road to the target year of construction as stated in MMETROPLAN

After inputting the temporal variable "TargetYEAR" in the attribute table, the roads were grouped according to two classifications: (1) a temporal variable which refers to the respective phases in the MMETROPLAN in which the proposed construction projects belong, and (2) a categorical variable which refers to whether the project is a construction of a completely new road or an improvement of an already existing road. Using ArcMap, the former is symbolized by the color of the linear features, while the latter is symbolized using the dashed line style. The resulting map on is an overlay of these information together with Metro Manila and its road network in the 1970s (See Figure 11).

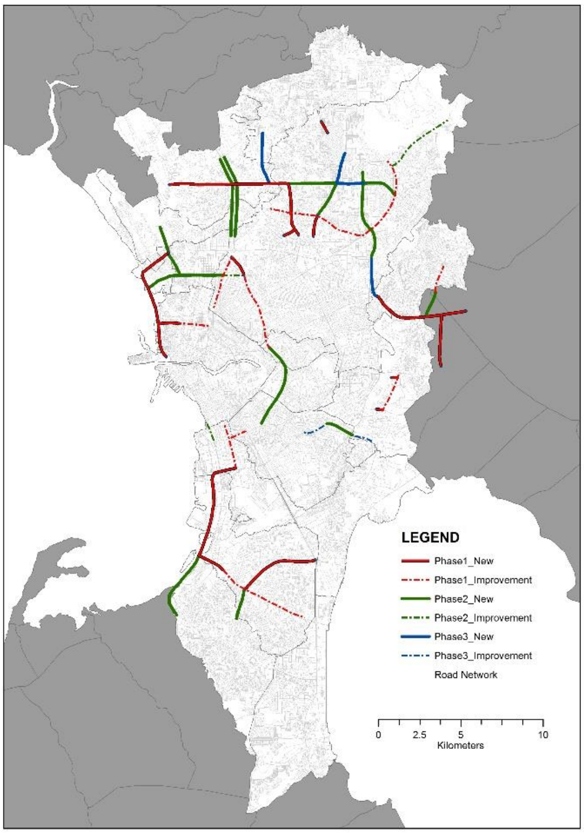
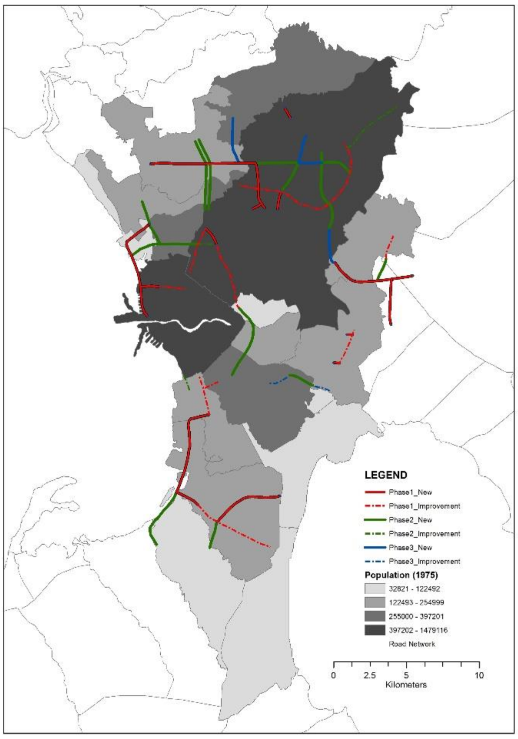
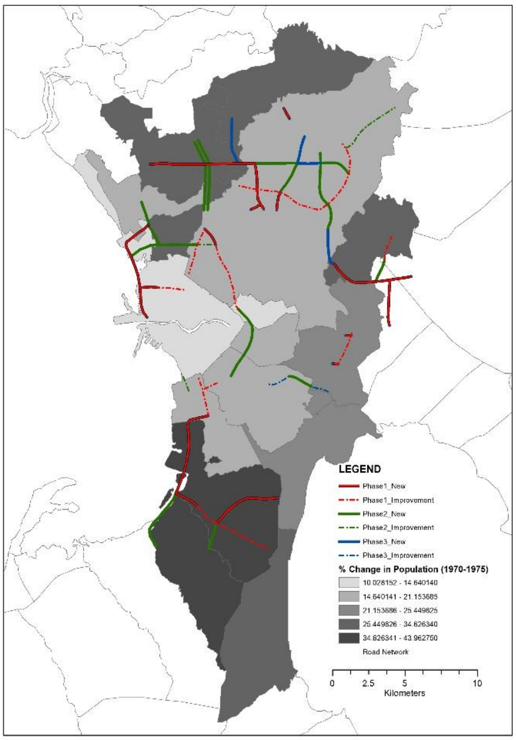


Figure 11. Phases and Classification of Road Construction Projects proposed in the MMETROPLAN

In the attempt to find a correlation between the transport plan and the concentration of people in the metropolitan area in the 1970s, a dataset on the population of Metro Manila cities and municipalities from 1970 to 1975 was obtained from the Philippine Statistics Authority. Besides the actual population, the rate of population change is also computed for the five-year period per town. While this may be a thesis for another research, it can be hypothesized the population and/or its high rate of increase may be the basis of denser infrastructure construction. This data is then inputted to the attribute table of the municipal administrative boundaries. Using a grayscale gradient for symbolizing the (a) population in 1975 and (b) rate of population change from 1970-1975, overlaid with the MMETROPLAN map, below are Figures 12 and 13 respectively. It can be observed that the proposed construction activities were denser in Quezon City and Parañaque. These two areas appeared to have either high population or high rate of population increase at the time the plan was drafted.





Left: **Figure 12.** MMETROPLAN roads overlaid with the population map of 1975
Right: **Figure 13.** MMETROPLAN roads overlaid the rate of population change for 1970-1975

IV. Potential Sources of Historical Maps and Planning Data on Transportation

Transport plans and urban planning researches are also excellent sources of historical maps, with themes and subjects which can be selectively digitized for a comprehensive geodatabase. These documents also represent the planning priorities and philosophies employed by the planners. David Pinnock's paper "MMETROPLAN: Manila Transport, Land Use and Development Planning Project" (1976), is a goldmine of time series maps of the Metro Manila from 1940 to 1975. Pinnock used the maps to narrate the urbanization and changes with the transport network of the area. While the maps are simply indicative and lacking of administrative boundaries, they can be digitized and georeferenced. Suggested land use patterns and transportation network can also be found in the book *Metro Manila Today and Tomorrow* (Abueva et al., 1972). Abueva emphasized the importance of harmony between land use and transport to address the pressing issues of rapid urbanization and traffic congestion. One suggested solution, which is also presented in a map, is the introduction of a monorail transit system.

Another document that contain spatial information is the *Metro Manila Ring Development Projects Office Situation Report* (DPWTC 1973). The short situation report, which was intended as means of public advisory for transport feasibility studies, included maps of Manila and surrounding localities that were targeted for development. These maps include municipalities in the provinces of Tarlac, Zambales, Nueva Ecija, Bulacan, Rizal, Laguna, Quezon, Batangas and Cavite. It is important to note that these areas were explicitly stated in DPWTC's *Integrated Development of the Manila Bay Region: Overall Framework Plan* (1973), and in Apolo Jucaban's (1976) paper, *The Polar Development Concept*, as target development areas under the Manila Bay Metropolitan Region Strategic Plan. DPWTC's framework defined and mapped an optimum pattern of social and economic activities, and physical development to serve as basis for decisions about infrastructure projects. The strategy employing the polar development concept involves the selection of five strategic poles or centers of growth some 50-75 km away from the core of Metro Manila. Mapping these development poles and their links to Manila would provide a more nuanced perspective on how planners come up with today's road and rail network.

The paper "Urban Transportation in Metro Manila" by selected officers of the Ministry of Transportation and Communication (1985) provides a brief history of transportation development in Metro Manila from the late 1800s to the 1980s. Maps included in the plan were the actual road network of the metropolitan area, as well as the conceptual and unimplemented highway network. Also illustrated in the document are the route structures of buses and jeepneys which seemed complementary but, along many routes, were in direct competition against each other. Such networks and variables, when digitized, would provide better insight to how the rail system was born into and how it affected the system.

V. Some Notes on the Sources of Modern Spatial Data

Shapefiles of administrative boundaries from the country level down to the barangay level were downloaded from the PhilGIS. The administrative boundaries are all polygon-type shapefiles, with attributes such as boundary delineation, name of the administrative unit and land area. The correctness of positions, attributes, and names of polygons within Metro Manila and the surrounding provinces, namely Bulacan, Pampanga, Nueva Ecija, Cavite, Batangas, and Rizal have been verified against Google Earth and political maps of these provinces.

The road shapefile, on the other hand, was constructed by combining information from Open Street Maps (OSM 2011) and features digitized from Google Earth satellite imagery. Using the built-in extract feature from the OSM website, the road network for the entire island of Luzon is downloaded. Then, the file was clipped according to the boundaries of each map. The most recent image from Google Earth (2015 for Metro Manila, 2011-2015 for adjacent provinces) was used to verify the correctness of the OSM data as well.

VII. Potential Applications and Directions for Future Research

This process model can serve as stepping-stone towards the popularization of historical geographic information on the history of Metro Manila's mass transit. At this point, it is vital to look into the existing practice of integrating GIS with the Internet. Many cartographic applications in the Internet have efficient toolsets that allow basic GIS tasks such as data upload and download, access to the attributes of spatial data, georeferenced data presentation. Koehl et *al.* (2008), in their paper "Interface for Dissemination of GIS Applications on Internet" broadly defined "web maps" as every map available in the internet. These include static papers maps which were scanned and uploaded to a website. However, web maps may become more appreciable by the public by the inclusion of some classical GIS functionality such as querying attribute data by clicking on the features of the map. For instance, clicking on a feature such as a railway line prompts the interface to display information such as the line's name, length, and other information saved in the attribute table (see Figure 14). Other GIS features, which can be added to web maps, are the selection and toggling the visibility of layers, basic navigation, and zooming.

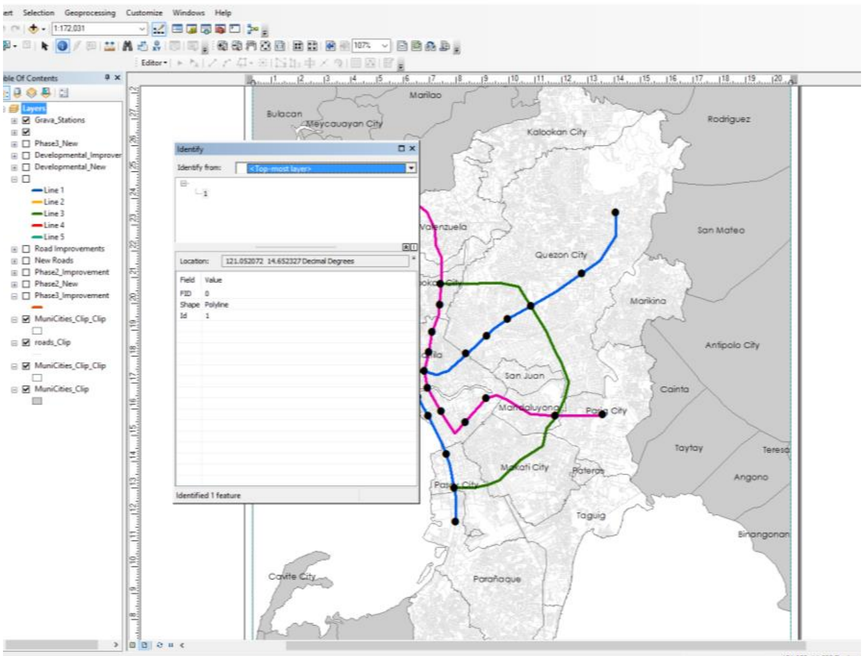


Figure 14. Interactive GIS interface. Clicking a spatial feature in the ArcGIS environment displays the feature's characteristics as saved in the attribute table

Two popular examples of web map applications are *Google Earth* and *Google Maps*. Google Earth is an excellent source of satellite imagery for the last 15-20 years. While the company prohibits the sale and distribution of images from Google Earth and Google Maps, users are allowed to digitize and download spatial features from it. (Google, 2015). Besides being a source of satellite photos, Earth and Maps are excellent platforms for uploading and popularizing GIS-generated information, free of charge. The process entails the conversion and upload of GIS files into the simpler format Keyhole Markup Language (KML and KMZ), which can easily be viewed in computers and smartphones with Google applications (See Figure 15).

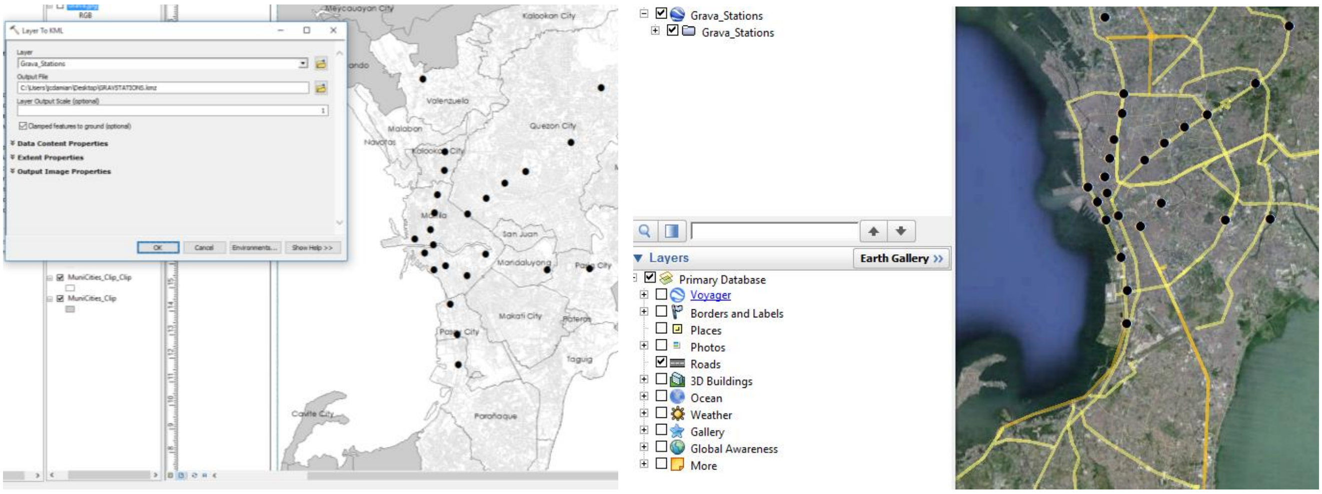


Figure 15. Digitized historical maps in GIS can be saved in exportable formats. These can be uploaded to electronic and mobile map viewers such as Google Earth.

Another benefit of HGIS reconstruction of transport information is its potential for transport modelling. In the paper “Aspects of Urban Land Management: What Metro Manila Needs” by Rosauro Paderon, he presented a history of Metro Manila’s geographic composition. Paderon cited a set of criteria that planners referred to when determining whether a municipality qualified as part of the metropolitan area. The Contiguity Criterion, which is defined by Paderon as simple geographic contiguity of the municipality with Metro Manila, can be easily identified on a map and clipped using GIS. Transport Interdependence, another criterion and defined as satisfied when an area can be reached within an hour by commuting from Manila (Encarnacion 1969), can be modelled using network analysis tools in GIS.

While not GIS-intensive, Vicente Reyes’ (1990) undergraduate thesis *Economic Impact Evaluation of the Light Rail Transit-1 on its First Five Years of Operations (1985-1990)* provided a straightforward approach in analyzing how the stations of LRT-1 changed the surrounding landscape. The study noted the effects that the LRT on the land use of the immediate surroundings in the areas the line traverses, noting that there were places with mainly residential land use that experienced increases in businesses (i.e. groceries, shops) that benefitted from the high foot traffic generated by the LRT. Reyes' (1990) work is tangent to the framework of the Metro Manila Commission's research, *Urban Land Metro Management Study (ULMS): Urban Redevelopment in Connection with Metrorail* (1985). In the ULMS, the MMC and consultants from the Electrowatt Engineering Services noted increases in foot traffic and economic activities along LRT-1 since several of its stations serve as route interchange. These seeming effects of building railways and stations to nearby areas can also be mapped in GIS. Furthermore, relational models such as Tangphaisankun's (2010), can be used in predicting further effects of the transport system to the area.

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