Cartographic transport infrastructure data survey

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Kurzfassung

Dieser Arbeitsbericht beurteilt kartografische Datenquellen für historische und aktuelle Transportinfrastruktur hinsichtlich einer Nutzung innerhalb des ETH Forschungsprojektes ETH48 “The effect of resource endowments and limited state capacity on political conflict”. Die betrachteten Quellen werden auf ihre Eignung für eine systematische, quantitative Datenanalyse auf Basis ihrer Digitalisierung geprüft. Gemäss der definierten Kriterien eignet sich die Kombination aus AMS (Army Map Service) Karten und des Datenmaterials des Open Street Map Projektes am besten für die Erstellung eines zeitvarianten Transportinfrastrukturdatensatzes. Dieser Arbeitsbericht beinhaltet für jede Datenquelle einen Steckbrief mit Informationen bezüglich Verfügbarkeit und Eignung. Gewisse juristische Aspekte der Kartennutzung werden ebenfalls behandelt.

Schlagworte

Karten, historische Strassenkarten, AMS, VMap0, gRoads, ISCGM, OSM, Urheberrecht

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Cartographic Transport Infrastructure Data Survey

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Abstract

This document assesses cartographic data sources on historical and current transport infrastructure for potential use in the ETH48 project, "*The effect of resource endowments and limited state capacity on political conflict*". Specifically, the listed sources are assessed with respect to their potential for systematic, quantitative data analysis on the basis of digitized cartographic material. According to evaluation criteria defined by the authors, the combination of AMS maps and the data material offered by the Open Street Map project serves the purpose of constructing a time-variant transport infrastructure data set best. This working paper provides a profile for every map source and informations regarding access and suitability. Some key legal issues are discussed as well.

Keywords

Maps, historical road maps, AMS, VMap0, gRoads, ISCGM, OSM, copyright

Preferred citation style

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1 Purpose and overview

The working package (WP) 3.2 is part of the core project (CP) 3 of ETH48 research project "Systematic risks, systematic solutions" and deals with *The effect of resource endowments and limited state capacity on political conflict*. ETH48 research project is led by the ETH Risk Center. In order to examine state capacity and state reach we use transport infrastructure as a proxy. Thus, a time series of global transport networks is of interest. The aim is to first scan and digitise this data and second to extract, vectorise and classify specific features, such as the road network (see Hunziker and Fuhrer, 2013).

In the next part, our criteria are introduced and justified; followed by profiles of historical map sets and next by current map sets; and finally by some conclusions.

2 Assessment Criteria

We define “current” and “historical” in this working paper as after and before the year 2000 respectively.

Our aim is to be able to compare global transport networks over time. The most important aspects in this respect are the road networks, followed by train, and finally by water and airway infrastructure. Ideally, data on road networks includes tracks and paths (this means unpaved pass ways) as well. These requirements are reflected in the first criterion, listed below. Criterion 2 follows from the fact that data on transport infrastructure will be extracted automatically using an automated image processing procedure. Ensuring comparability for spatial statistics dictates the third criterion.

1. Maps provide global data on classified road infrastructure.

2. Maps come in a globally uniform cartographic style.

3. Maps do not exhibit spatially correlated accuracy.

4. Maps are available to the public.

5. Maps are available at no or low costs.

3 Historical data sets

Historical data sets mainly differ regarding their time periods of production, accuracy, coverage and availability.

3.1 VMap0 - road/trail layers

Full name:

Vector Smart Map 0 (VMap0) transport-road and transport-trail layers.

Source:

US National Geospatial Intelligence Agency (US NGA).

Format:

Geographical Information System (GIS). Original data comes in the NGA's own “Vector Product Format” (VPF). However, several distributions in ESRI (Environmental Systems Research Institute) shapefile format are available (see below).

License:

Public domain - no license agreement issued. Documentation requires citation if data is used, but imposes no use constraints. However, some features, political boundaries for example, seem to be under the copyright of ESRI, but users are free to alter and process the data.

Time period of content:

1974 - 1994, but mixed within one data set.

Transport infrastructure information:

The VMAP0 data collection offers two road-network relevant layers: A “trail” layer and a “roads” layer. According to the documentation, the primary source for these data layers has been the US NGA's Operational Navigation Charts (ONC) representing information from between 1974 and 1994. The inclusion criteria for roads and trails are not clearly stated in the documentation, but visual inspection reveals that the data mostly cover cross-country roads/trails connecting populated places. There is no information on road quality apart from the separation into trails and roads, but even the latter is highly inconsistent (see below). The

VMAP0 Roads layer separates roads into “primary“ and “secondary” routes; however, approximately 15% of all road geometries are marked as being of “unknown” type.

Availability:

A full version of the VMAP0 dataset in ESRI Shapefile format is available for download at http://gis-lab.info/qa/vmap0-eng.html (accessed on 21/11/2013). The data is available in the VPA format from http://www.mapability.com/index1.html?http&&&www.mapability.com/info/vmap0_intro.html (accessed on 21/11/2013). Note that the data comes in four continental tiles which have to be recombined with suitable software http://www.mapability.com/download/nima_muse/ (accessed on 21/11/2013).

Locational accuracy:

Documentation indicates horizontal positional accuracy of 2040m and vertical positional accuracy of 152.4m. Data sourced from maps at a scale of 1:1'000'000.

Assessment:

Advantages of the VMAP0 data include that it is digitized, offers global coverage and all road geometries line up precisely, allowing network-based analysis. However, there are a number of serious disadvantages. First, the classification of roads into primary routes, secondary routes and trails is highly inconsistent across tiles, making cross-country comparisons of road-network quality close to impossible (cf. Nelson et al. 2006). Second, the data seems to be erroneous in some regions. Specifically, the road data for parts of Somalia show very suspicious raster-like patterns. Third, the data is poorly documented, with little or no information available on the exact coding criteria for the road-network data. Another severe disadvantage is the combination of different time periods into one data set without the possibility to create time-series like layers.

3.2 gROADS

Full name:

Global Roads Open Access Data Set (gROADS) Version 1.

Source:

Center for International Earth Science Information Network (CIESIN).

Format:

GIS: Available in ESRI shapefile format and the ESRI geodatabase file type.

License:

Creative Commons Zero license. Some parts under Creative Commons Share Alike license.

Time Period of Content:

Data was compiled between 1980 and 2000, depending on country. However, most countries have no confirmed date.

Transport infrastructure information:

The gROADS project aims at providing comprehensive road network data for the entire world with a focus on “roads between settlements (not streets)”. The underlying data is compiled from various sources, including updated and cleaned VMAP0 data, various UN agencies, custom data generated with GPS-enabled PDAs, and data generated on the basis of satellite imagery. All features, mainly different road segment, information is in line with the UN Spatial Data Infrastructure Transport (version 2) classification (UNSDI-T). This means, for example, detailed data on road quality (for instance surface paved, seasonal usage constraints) and capacity (that is number of lanes) is available. However, the authors state that only very few spatial regions of the data sets provide such details, and if they do, only a few of the various attributes are available. Furthermore, the authors promise consistent coding, thus allowing network-analysis.

Availability:

Data is available as either a global data set or as six continental data sets from a download page: http://sedac.ciesin.columbia.edu/data/set/groads-global-roads-open-access-v1/data-download (accessed on 25/11/2013).

Locational accuracy:

The sparse data documentation (http://sedac.ciesin.columbia.edu/downloads/docs/groads/groadsv1_documentation.pdf, accessed on 25/11/2013) reports a locational accuracy between 530m and 1265m (VMAP0 source) and 30 to 500m (updated regions). The data is optimized for mapping at an approximate scale of 1:250'000.

Assessment:

The current version (version 1) is a modestly updated VMAP0 data set. If the next version lives up to the standards promised by the authors, the gROADS project will probably constitute the most comprehensive and detailed public domain road network data set. Whether this is going to be the case is difficult to judge; the pre-alpha version was lacking almost all road quality information and seems to be mostly drawn from the matching VMAP0 layers without much modification. However, the authors promised major updates for future versions via private correspondence. The current version, however, does not yet provide the announced additional information.

3.3 ISCGM Global Map, Version 2, road layer

Full name:

ISCGM Global Map V.1/V.2 road layer.

Source:

International Steering Committee for Global Mapping (ISCGM).

Format:

GIS with ITRF94 reference coordinate system. Country maps are distributed in “Vector Product Format“ (VPF) and ESRI shapefile format.

License:

ISCGM maps are “free of charge for any purpose“ for non-commercial applications (as noted in the “Read-me“ files accompanying the maps). However, explicit license agreements may vary for some source material in certain maps.

Time period of content:

Varies across maps, and thus countries. Maps updated with country-specific source material seem to be fairly up to date (the inspected subset claimed to be accurate for the post-2000 period). However, some maps, especially for low-income countries, simply use the VMAP0 layers (as discussed above).

Transport infrastructure information:

All ISCGM maps include a road network layer. Since the ISCGM version 1 or 2 maps are distributed on a country-by-country basis, the underlying source material varies across maps. Where the ISCGM maps have been updated by the respective countries' official mapping agencies (which are responsible for providing the ISCGM maps), the data comes with detailed information on road quality and capacity. For some low-income countries, however, the ISCGM maps seem to be based solely on the VMAP0 data and the map attributes indicating road quality and capacity are all marked as being of “unknown” type. Furthermore, although the ISCGM aims at providing global data, version 1 or 2 maps are only available for about half of all countries. The current situation is listed here: http://www.iscgm.org/cgi-bin/fswiki/wiki.cgi?page=News+Archives (accessed on 25/11/2013).

Availability:

Data may be downloaded for free (after registration) from http://www.iscgm.org/ (accessed on 25/11/2013). Detailed documentation is available from http://www.iscgm.org/cgi-bin/fswiki/wiki.cgi?action=ATTACH&page=Documentation&file=Global+Mapping+Specifications+Version+2%2E1%2Epdf (accessed on 25/11/2013).

Locational accuracy:

Documentation indicates horizontal positional accuracy between 500m and 2km (maxima, depending on map status) and vertical positional accuracy of 150m. Data is optimized for mapping at an approximate scale of 1:1'000'000.

Assessment:

Where the data has been provided by official national mapping agencies, the ISCGM maps appear to be a valuable source for up to date road network information. However, coverage is limited to about half of all, and only some of the available maps are complemented by original data (and not only VMAP0 data).

3.4 US AMS world map series

Full Name:

US Army Map Service international map of the world (Series 1301)

Source:

US Army Map Service, predecessor organization of the US National Geographical Intelligence Agency.

Format:

Map hard-copies; around 50% of the series is available as high-resolution scans from the University of Texas (see paragraph “Availability“ below).

License:

Public domain - no license agreement issued.[1] This holds true within the United States of America. In general, the legal situation in all other countries is not clear. If maps shall be reproduced, it is necessary to check relevant copyright restrictions. Apart from AMS, the following institutions can be copyright holder: Directorate of Overseas Surveys (Tolworth UK), Institut Géographique National (Paris) and United Nations Cartographic Unit (New York, Geneva). A detailed discussion on legal issues can be found in section 5.

Time period of content:

Approx. 1940 - 1992; varies across maps and editions. Every sheet was published in various editions, with chronological numberings. However, the edition’s number and corresponding time series are not consistent due to different starting dates.

Transport infrastructure information:

The AMS Series 1301 topographic maps include information on roads and tracks, with an apparent focus on roads connecting populated places (this means not streets). With very few exceptions (sheet NF-37 for example), the AMS maps indicate roads as red lines, and graphically distinguish between highways, primary roads, secondary roads and trails/tracks. Furthermore, most map sheets provide information on the general quality of roads in reference to the road type, in particular whether primary and secondary roads are generally paved, and whether usage is seasonally restricted. Railway lines are included as well. It is also indicated whether the line is electrified or not.

Availability:

Around 50% of the series is available as high-quality scans from the University of Texas Perry-Castaneda Library (PCL); these documents may be downloaded for free at

[1] According to US Executive Order 13526, classified information enters the public domain after 25 years.

http://www.lib.utexas.edu/maps/imw/ (accessed on 25/11/2013). An overview of the scanned maps at the PCL is available at http://www.lib.utexas.edu/maps/imw/index_world.html (accessed on 25/11/2013). The remaining map sheets may be obtained from Zentralbibliothek Zurich or ETH Zurich library, which host most sheets of several editions.

Locational accuracy:

Maps are at a 1:1'000'000 scale. Qualitative accuracy estimates („Good“, „Fair“, or „Poor“) are provided on a sheet-by-sheet basis. This may include locational accuracy or accuracy in general (for instance completeness of the road network). The former Soviet Union regions might be problematic as it might have been difficult for AMS to carry out cartographic activities there. However, according to a military history map expert (Hegedűs, 2013[2]), accuracy in Eastern Europe is good. If there is an issue with accuracy, it might be in the Asian part of the former Soviet Union, but this is unlikely to be the case.

Assessment:

The AMS World Map Series is probably the most convenient source for the analysis of historical road-network data, as the maps are readily available, feature global coverage, are fairly consistent, and seem sufficiently accurate. Moreover, the period covered (approximately 1940 - 1992) is substantively interesting for applications tending to quantitative conflict research, as the latter is concerned primarily with the second half of the 20th century and beyond. Finally, since the map series has been assembled by an organization with substantial incentives for generating accurate information, we may assume that there are no systematic bias due to under- or over-reporting. However, limitations abound. First, due to the sheer number of maps available (approximately 750), vectorisation of the scanned material will require (semi-) automated processing. In this context, even slight differences in the cartographic representation of roads across individual maps (in terms of colour values, line type and thickness and so forth) constitute significant problems, requiring potentially long (and expensive) periods of manual pre- or post-processing. Second, based on the online available maps from PCL, we know that between a quarter and a third of all maps come without information on the road types. Obviously, if information on road quality is missing for a substantial number of maps, this could pose serious limits to the identification of actual roads, rather than only trails and paths. Finally, a third potential issue stems from the fact that the AMS World Map Series are not homogenous in their temporal scope. Consequently, digitizing and reassembling the AMS material might lead to inconvenient tiling effects. For instance, if one map covers source material from a later period than an adjacent one, roads may suddenly end at map edges in the fi-

[2] Personal communication

nal digitized data set, thus making network-analysis substantially more difficult. This can be omitted by working with maps of narrow enough a time period.

3.5 USSR VTU topographic maps

Full name:

Soviet Military Topographic Directorate (VTU - *Voyenno Topograficheskogo Upravleniya*) topographic map series, 1:200'000 edition.

Source:

Soviet Military Topographic Directorate, predecessor of the Russian Military Topographic Directorate.

Format:

Originally map hard-copies; the entire series is available as high-quality scans from several online sources.

License:

Supposedly public domain, but information could not be obtained.

Time period of content:

Approximately 1980 to 1988; varies across maps.

Transport infrastructure information:

The VTU topographic maps include information on cross-country roads and highways. Specifically, roads are depicted as orange lines quite consistently across maps. Road importance is indicated graphically, and also allows some conclusions about road quality (the Soviet Topographic map symbols guide issued by the US Army indicates that only roads that are "regularly maintained" are represented as such). However, there is no explicit information on road quality.

Availability:

The entire series (possibly with very few exceptions) may be purchased as scanned and geo-referenced maps from http://www.mapstor.com (accessed on 25/11/2013) for around 1000

USD (since the maps are packaged in individually sold regional sets, the exact price is difficult to determine). Moreover, most of the series may be downloaded for free as high-quality (but non-referenced and without year of production) scans from http://maps.vlasenko.net/soviet-military-topographic-map/ (accessed on 26/11/2013). However, downloading maps covering the southern hemisphere from the latter source is cumbersome and some are even only available from dubious sources. Moreover, a significant part of the series is available in hard-copy format from the Zentralbibliothek Zurich and the ETH library.

Locational accuracy:

Most of the maps are at a 1:200'000 scale; locational accuracy unknown.

Assessment:

The VTU map series features some advantages: It covers almost the entire globe and is completely standardized, thus making automated vectorisation a viable option. However, there are some significant disadvantages. First, the low resolution of the series (1:200'000 scale maps) hugely inflates the number of maps that require vectorisation and/or scanning. With even medium sized countries being covered by 50 -- 100 maps, large-scale digitization efforts become either extremely costly, or very inaccurate. The VTU also compiled maps at lower resolutions (1:500'000 and 1:1'000'000), however, in these maps, the road-network information is even more rudimentary. Second, obtaining scanned versions of the VTU maps will almost certainly require some initial expenditure, since the only comprehensive and well-documented online source is http://www.mapstor.com, which charges nominal fees for their scanned map sets. Third, there are potential copyright issues. The current legal status of the VTU maps is not clear, as the maps apparently have not been issued into the public domain by the Russian state, but by other Soviet Union successor states.

4 Current data sets

4.1 ISCGM global map, version 2, road layer

Some countries or areas are produced with data more recent than the year 2000. For details see corresponding section above.

4.2 Open Street Map

Full name:

OpenStreetMap

Source:

One million OpenStreetMap (OSM) users uploading their GPS and other georeferenced data. Institutions from all over the world contributing their geodata, mostly processed satellite images and mapped material (list: http://wiki.openstreetmap.org/wiki/Contributors (accessed 02/12/2013) and http://wiki.openstreetmap.org/wiki/Import/Catalogue (accessed 02/12/2013)).

Format:

Data comes as .osm XML file format (UTF-8 encoder), which one can easily convert into other formats, such as ESRI Shapefile. The full list of possible data conversions can be found here: http://wiki.openstreetmap.org/wiki/Convert (accessed 02/12/2013). The OSM project recommends using the Osmosis software (http://wiki.openstreetmap.org/wiki/Osmosis (accessed 02/12/2013) for converting formats.

License:

Open Data Commons Open Database License (ODbL) allows the use of the data for non-commercial purposes in any way. To cite data source it is required to use "© OpenStreetMap contributors". The cartography is licensed as Creative Commons Attribution-ShareAlike 2.0 (CC-BY-SA).

Time period of content:

Varies across the map, but is very current. It is possible to track back every feature's year of compilation. The global data file is updated weekly, usually on Thursdays.

Transport infrastructure information:

Roads, tracks, paths and other infrastructure elements are provided. Roads are categorised into different types including motorway, trunk road, primary road, secondary road, unsurfaced road, track, byway, bridleway, cycleway, footway, railway, subway, light rail and tram, cable car and chair way, airport runway and taxiway.

Availability:

The whole planet data file as well as the latest changes can be downloaded from http://planet.openstreetmap.org/ (accessed 02/12/2013. The download of spatial extractions is also possible. Currently, the whole data volume consists of 25GB data (packed, unpacked over 400GB), but it has been growing at approximately 0.2 per year. After having downloaded the whole data set, it is possible to only add the updates (almost 1GB).

Locational accuracy:

WGS 84 reference system is used. The maps can be drawn at scale levels between 1:5 000 000 and 1:1 000. Accuracy tends to be better in denser populated than in sparsely populated areas, as there are more users that refine the information. According the OSM documentation, we can assume a locational accuracy of 10m in most cases.

Assessment:

This seems to be one of the most comprehensive and up-to-date data sets. Positive points are the free availability, the frequent updates and the flexible data format. The best feature is the detailed categorisation of different transport infrastructure elements. Negative points are the variation across the file in terms of level of detail, local accuracy and time period. Also, the data set includes many features that are not of interest - such as some points of interest, for example hospitals or shops - which lead to massive data amounts.

4.3 DDS data set

Full name:

Digital Data Services (DDS): Digital Data Streets; Digital Data Tracks; POI: airports and ports - worldwide. http://www.ddsgeo.com/products/geodata.html (accessed 02/12/2013).

Source:

The road and street network as well as traffic rules are based on Navteq data (http://www.navteq.com/products_data_whatis.htm (accessed 02/12/2013)) and completed by DDS staff. Navteq claims to be the world leader in street data informations usable for navigation in cars.

Format:

Different formats available.

License:

Depends on purchase contract and such contracts can include regular updates. Usually, there are no time restrictions for using the data set.

Time period of content:

No exact information given by DDS staff, probably varying. According to DDS as recent as possible. They provide one or two updates a year.

Transport Infrastructure Information:

A global road and track network is provided. However, only paved roads are included. They are categorised into a few types. In urban areas most streets are included, in interurban areas only motorways and major roads. The first is only available in Western Europe. There are also railways. Fact sheets: http://www.ddsgeo.com/services/flyer.html (accessed 02/12/2013).

Availability:

The file has to be bought at a price of € 250’000 minimum. Data from China and North Korea is missing due to their national data policies.

Locational accuracy:

DDS claims 5 to 10m in urban and 25m in interurban areas. Maps are produced for display at a scale of 1: 25 000 to 1:2 000.

Assessment:

The data is far too expensive and thus not a valid option. Considering this example, the purchase of other proprietary transport-network data is generally not a valid option, as prices would be similar.

5 Legal issues

In this section, legal questions such as copyright, processing, or publishing of maps are discussed. The discussion addresses the case of AMS maps, but many aspects are applicable more generally.

First, the question what actually is protected by a copyright on maps needs to be answered. In general, a copyright protects a specific realisation of a work. This means, the shape, style, arrangement or form is protected (https://www.ige.ch/en/copyright.html (accessed 03/12/2013)), but not the actual content, information or idea. Regarding maps, in simple words, the cartography is protected, but not the map information as such. This means in particular, that it is legal to use mapped information, for example distances or number of paths between two points, and process this information.

Second, the question whether it is legal to copy maps needs to be answered. Replications of maps are forbidden by Swiss law (Bundesgesetz vom 9. Oktober 1992 [as of 1st January 2011] über das Urheberrecht und verwandte Schutzrechte (URG)).

To summarise, it is legal to extract information from AMS maps, but the necessary scanning process is, in principle, illegal.

Third, the question if there are any exceptions mentioned in the URG needs to be answered. Reproduction for own use is allowed according to Art. 19. This includes also the […] reproduction within public institutions for internal information and documentation. On condition that there is no complete or almost complete version of the maps in trade. If complient with these terms, the user is allowed to let others – including libraries – do the reproduction of the maps.

In summary: First, relying on this exception together with the addition to transfer this right to a library, it is legal to let a library scan AMS maps. Second, it is permissible to extract the networks via their topology (nodes, links, coordinates). Third, any maps of these networks have to be designed from scratch.

6 Conclusion

The situation for historical and current data differs. Regarding historical sources the main problems are the completeness of the data sets and fragmentary documentation, but it is the availability at low costs regarding current sources. Providers of current transport infrastructure data are able to deliver electronic and geocoded networks that can be processed by standard software, whereas historical data sets consist of, at maximum, scanned paper maps or only of raw map sheets, keys and tables. They first need to be converted into network graphs, which can be processed in, for example, geographical information systems.

Looking for current data, several providers are worth considering. Most of them are commercial companies. We thus have to be aware of possible consequences: There are economic incentives to have comprehensive and accurate data available in regions where demand is high – Western countries and densely populated areas – and to have less detailed data in other regions. This likely biases spatio-temporal analyses. In addition, several companies are not willing to share their data (Google Maps, for example), or prices are too high for a university institute. The Open Street Map project fills this gap.

There are several historical data providers, each with advantages and disadvantages. If the five criteria stated in section 2 are applied, AMS maps are the best choice. Their biggest advantages include almost uniform mapping style amongst different sheets and editions, and clear documentation of the age and reliability of the mapped information. However, contributors of other historical mapping projects communicated further improvements on their data sets and we might expect currently non-public data to become publically available in future.

As an overall result of this research, we recommend Open Street Map maps to model current transport networks and Army Map Service maps for the historical models.

7 Literature

Hunziker, P. and R. Fuhrer (2013) AMS transport network vectorisation, *Arbeitsberichte Verkehrs- und Raumplanung*, **931**, IVT, ETH Zurich, Zurich

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