THE STATUS OF TOPOGRAPHIC MAPPING IN THE WORLD A UNGGIM - ISPRS PROJECT 2012 – 2014

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ABSTRACT
In December 2011 UNGGIM initiated a cooperative project with ISPRS to resume the former UN Secretariat studies on the status of topographic mapping in the world conducted between 1968 and 1986. After the design of a questionnaire with 27 questions, the UNGGIM Secretariat sent the questionnaires to the UN member states. 113 replies were received from the 193 member states and other regions the 51 non-member countries and territories. Regarding the global data coverage and age the UN questionnaire survey was supplemented by data from the Eastview database. For each of the 27 questions an interactive viewer was programmed permitting the analysis of the results. The authoritative data coverage at the various scale ranges has greatly increased between 1986 and 2012. Now a 30% 1:25 000 map data coverage and a 75% 1:50 000 map data coverage has been completed. Nevertheless there is still an updating problem as date for some countries are 10 to 30 years old. Private Industry with Google, Microsoft and Navigation system providers has undertaken huge efforts to supplement authoritative mapping. For critical areas on the globe MGCP committed to military mapping at 1:50 000. ISPRS has decided to make such surveys a sustainable issue by establishing a working group, which also will enlarge its scope toward global land cover mapping.

1 ORIGINS OF THE PROJECT

In 1986 the Department of Technical Cooperation for Development of the United Nations Secretariat has completed the last survey on the “Status of World Topographic and Cadastral Mapping”. The results of the survey were published by the United Nations, New York 1990 in World Cartography, Vol. XIX. The text was submitted by the UN Secretariat as document E/CONF 78/BP7 in 1986 prepared by A.J. Brandenberger and S.K. Ghosh of the Faculty of Forestry and Geodesy at Laval University, Quebec, Canada. It referred to previous surveys submitted by the Department of Technical Cooperation for Development of the United Nations Secretariat in 1968 published in World Cartography XIV and in 1974 and 1980 published in World Cartography XVII.
The paper published in World Cartography XIX in 1990 summarized the progress made in topographic mapping across the globe between 1968 and 1980 in 4 scale categories:

range I; scales between 1:1000 and 1: 31 680
range II; scales between 1:40 000 and 1:75 000
range III; scales between 1:100 000 and 1:126 720
range IV; scales between 1:140 000 and 1:253 440

These ranges represent the more recently standardized scales:

range I;	scale 1:25 000
range II;	scale 1:50 000
range III;	scale 1:100 000
range IV;	scale 1:250 000

While scale in the age of digital cartography has changed the meaning, the scale ranges nevertheless maintain their significance with respect to the resolution of mappable details.
The 1986 survey covered the following number of countries or territories:

Africa	53 countries	4 territories
North America	24 countries	13 territories
South America	12 countries	3 territories
Europe	39 countries	4 territories
Asia	40 countries	3 territories
USSR	1 country	0 territories
Oceania	11 countries	17 territories

Antarctica was not included in the survey.

Source of the data obtained by the surveys were completed questionnaires, sent by the UN Secretariat to the UN member countries, plus additional surveys made directly by Laval University for UN member countries not having answered the questionnaires, for non-UN member countries and for territories under foreign administration. The result of the survey was for each region and for the different scale ranges:

	range I	range II	range III	range IV
Africa	2.3%	29.7%	20.6%	86.8%
North America	41.3%	68.2%	8.0%	92.8%
South America	9.7%	29.0%	44.2%	50.4%
Europe	92.5%	93.8%	81.3%	95.7%
Asia	16.0%	62.7%	65.4%	92.0%
USSR	>5%	>60%	100%	100%
Oceania	13.3%	15.6%	36.1%	99.8%

The areas covered by the survey were:

	range I	range II	range III	range IV
Africa	75.8%	100%	100%	100%
North America	90.7%	100%	100%	99.5%
South America	100%	100%	100%	100%
Europe	98.0%	90.2%	97.25%	96.7%
Asia	87.8%	90.9%	87.6%	90.2%
USSR	100%	100%	100%	100%
Oceania	94.1%	94.5%	94.3%	99.9%

World summary:

	range I	range II	range III	range IV
area of survey 1986	90.1%	97.4%	97.0%	97.75%
1986 map coverage	17.9%	49.3%	46.4%	87.5%
1980 map coverage	13.3%	42.2%	42.2%	80.0%
1974 map coverage	11.6%	35.0%	40.5%	80.5%
1968 map coverage	7.7%	23.4%	38.2%	81.0%

Since the last survey in 1986 considerable progress has been made in data coverage:

	range I	range II	range III	range IV
2012 map coverage	33,5%	81.4%	67.5%	98.4%

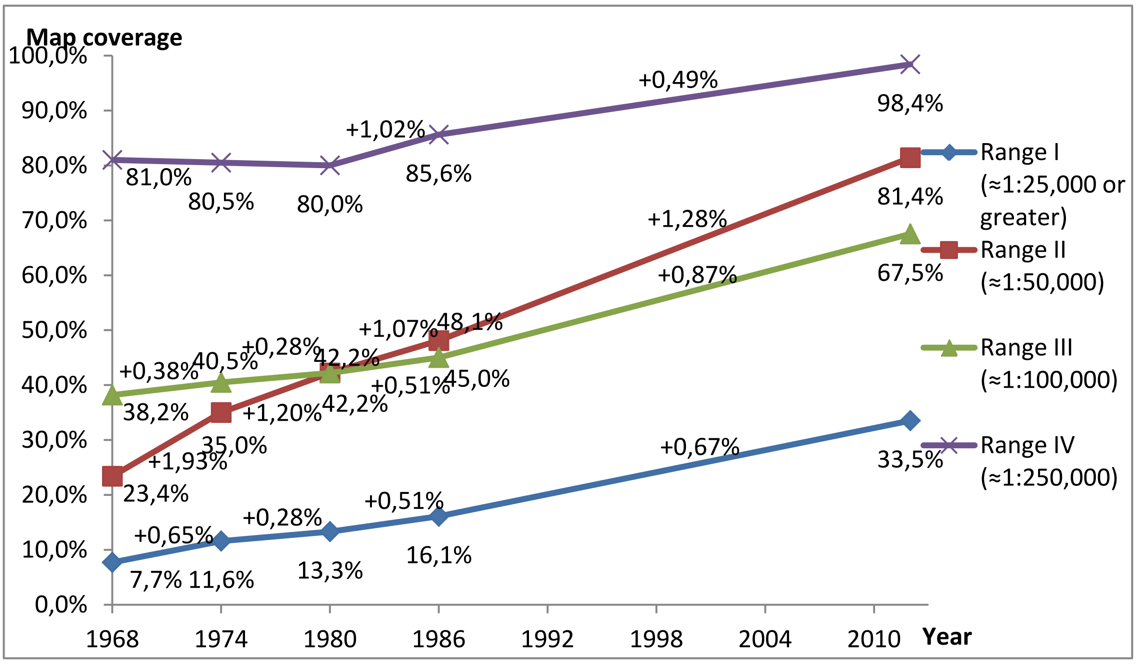


Chart 1: Percentages of total world area covered in each scale category, 1968-1974-1980-1986-2012

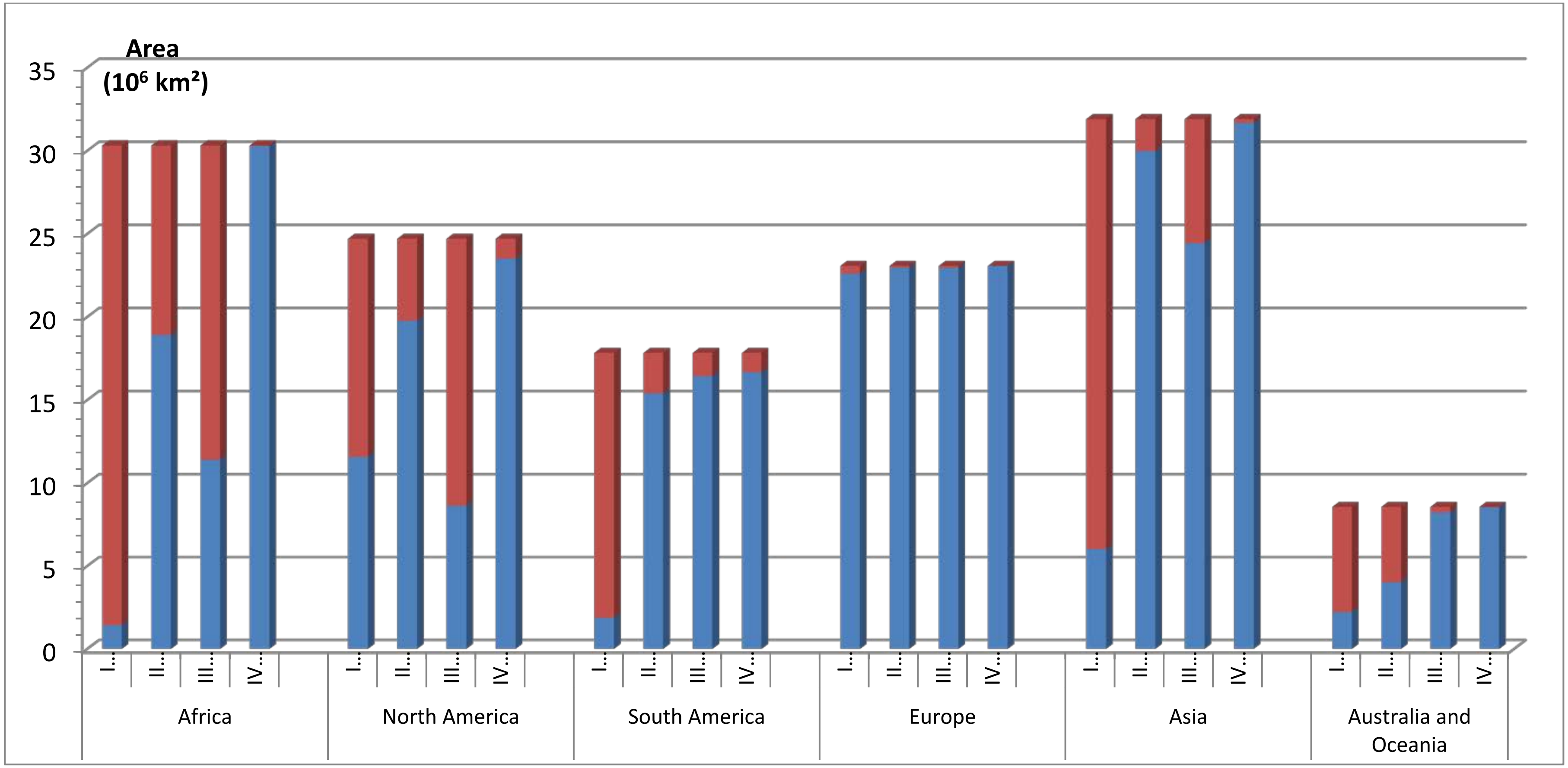


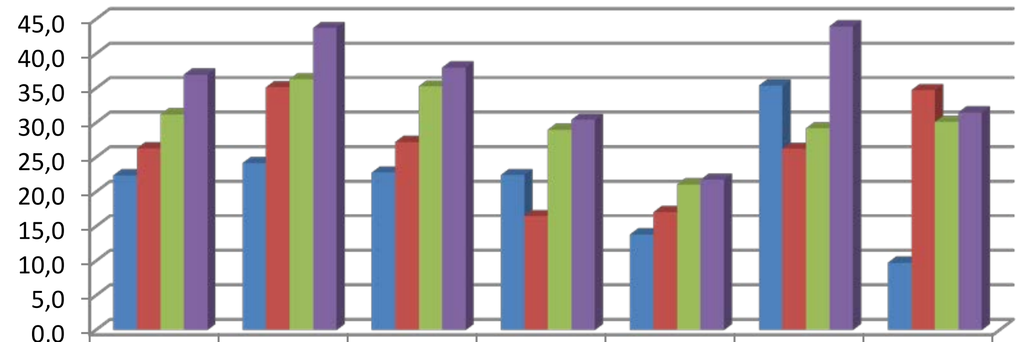
Chart 2: Area covered by topographic mapping on four scale ranges, by geographical region, 2012

While the surveys presented in 1986 did not concentrate on map revision on a global basis, they nevertheless derived an update rate for the four scale ranges:

	range I	range II	range III	range IV
update rate 1986	3.2%	1.8%	2.7%	3.6%

This points to the fact, that in 1986 the maps at the scale relevant to national planning operations 1:50 000 were hopelessly out of date.

	range I	range II	range III	range IV
update rate 2012				



	Global	Africa	Asia	Australia and Oceania	Europe	North America	South America
Range I	22,4	24,2	22,8	22,4	13,8	35,4	9,8
Range II	26,3	35,1	27,2	16,5	17,1	26,3	34,7
Range III	31,2	36,3	35,3	29,0	21,1	29,2	30,1
Range IV	37,0	43,7	38,0	30,4	21,8	44,0	31,5

Chart 3: Average map age in years counting from 2012

Other aspects of the surveys conducted in 1980 were directed toward the existence of geodetic networks and their density. In 1980 there existed 3.67M horizontal and 3.16M vertical control monuments on the globe, but again their density varied from 2.66km^2 per horizontal control monument and 3.61km^2 per vertical control monument in Europe to 232km^2 in Africa with an average of 42.5km^2 per horizontal control monument to 46.4km^2 per vertical control monument.

Today the GNSS technology makes control point densities irrelevant, except for the case, when old map data need to be referenced to a global datum.

In 1980 the national mapping agencies possessed 12 120 theodolites, 5790 precise leveling instruments and 1914 EDM devices, 162 airplanes for aerial photography, 267 aerial survey cameras and 3120 photogrammetric stereo plotting instruments. Disregarded in that survey are instruments owned by companies mapping for governments under contract.

Again, the availability of geodetic instrumentation is not of essence to judge progress any more.
The attempts of 1980 to determine the existing manpower of the national mapping agencies for each region were based on few countries only (e.g. Algeria and Nigeria for Africa, the USGS in the USA, the Surveys and Mapping Branch in Canada, the IGN France in Europe). These data were used to extrapolate the requirements in other countries with the attempt to develop a budget of global expenditures, yielding a global sum of US$ 868 million, at that time 0.010% of the gross national product, while the global surveying and mapping activities at that time were estimated to be between 8 to 9 billion US$ per year. A program for increasing the expenditures to 0.02% of the GNP was recommended in the report to meet the need for lacking mapping coverage and lacking map updates.
The financing of geospatial information is a very complex issue. To track progress these tasks should now be transferred to another UNGGIM Working Group.
The rather inaccurate and inconclusive results of 1986 may have discouraged the UN Secretariat in continuing the past surveys due to lack of a budget for this purpose.

2 THE UNGGIM-ISPRS PROJECT

The United Nations Regional Cartographic Conferences (UNRCC) for the Americas and for Asia and the Pacific nevertheless continued to recommend to the Secretariat to continue the studies on the global status of mapping. One of these resolutions of the UNRRCC for the Americas in 2009 gave the mandate to the Secretariat for a new survey.
This happened at the time, when UNGGIM (United Nations Global Geospatial Information Management) was created as a new structure.
ISPRS approached the director of UNGGIM in 2011 to start a joint project on the survey of the status of topographic geospatial information, because:

- the issue is of global interest
- new technologies, such as GNSS (GPS, GLONASS), digital aerial mapping, high resolution satellites for mapping, digital photogrammetry and GIS have taken over as new mapping methodologies
- large private organizations such as the navigation industry (Here, Tomtom), Google Earth and Microsoft Bingmaps have entered the mapping effort, which was previously the domain of the national mapping agencies.

The project was approved in December 2011 by Dr. Paul Cheung, director of UNGGIM at that time, who nominated Dr. Amor Laaribi as UNGGIM contact, and by Chen Jun, President of ISPRS, who nominated Prof. Gottfried Konecny of Leibniz University Hannover as ISPRS contact.
In January 2012 a questionnaire to the UN member states was designed, mutually discussed, translated to French, Russian and Spanish and mailed to the contacts of the UNGGIM Secretariat in the UN member states. Ms. Vilma Frani of the UNGGIM

Secretariat sent the replies to Leibniz University Hannover, where they were placed in a database designed by Uwe Breitkopf for further analysis.

3 THE QUESTIONNAIRE

The jointly designed questionnaire consists of five parts including 27 Questions:

- PART A: Background Information
- PART B: National Topographic Mapping Coverage
- PART C: National Imagery Acquisition
- PART D: National Surveying and Cadastral Coverage
- PART E: Organization

See Appendix I for the original Questionnaire.

Until March 13, 2015 altogether 113 responses have been received from 193 UN member states. In addition, there are 51 non-UN member countries and territories, which are also covered by map data. These map data for 244 UN member states and regions were generated in UN member states, but these have in general no direct responsibility for mapping these territories.
Figure 1 shows the 113 UN Member States, which have answered the UNGGIM-ISPRS questionnaire.

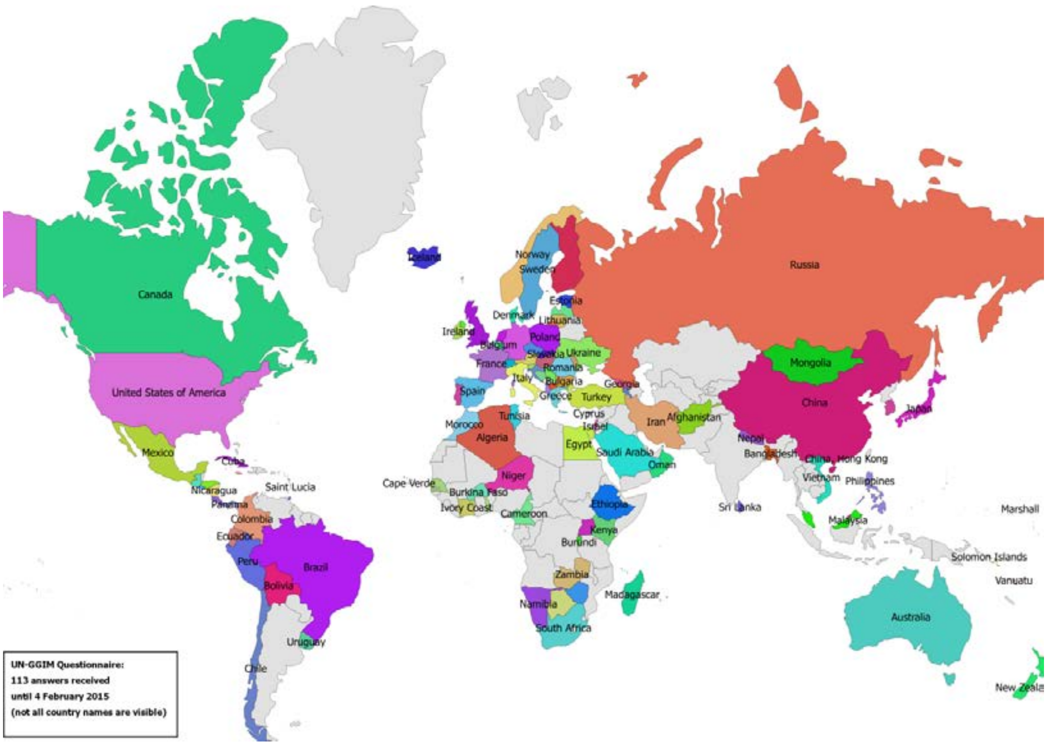


Figure 1: 113 countries have replied the Questionnaire until February 2015

4 CONTENT OF THE DATABASE

While not all of the 27 questions need to be answered globally, this is, however, important for questions 1 and 2, since they characterize the global data coverage at the different scale ranges and their age of the data. To assess the global status the Eastview database is a fundamental component to answer these questions. Dr. Kent Lee, CEO of Eastview has kindly agreed to make the missing data available from their database.

Regarding question 1 Figure 2 to Figure 5 show the global coverage in the scale ranges 1:25 000 or greater, 1:50 000, 1:100 000 and 1:250 000.

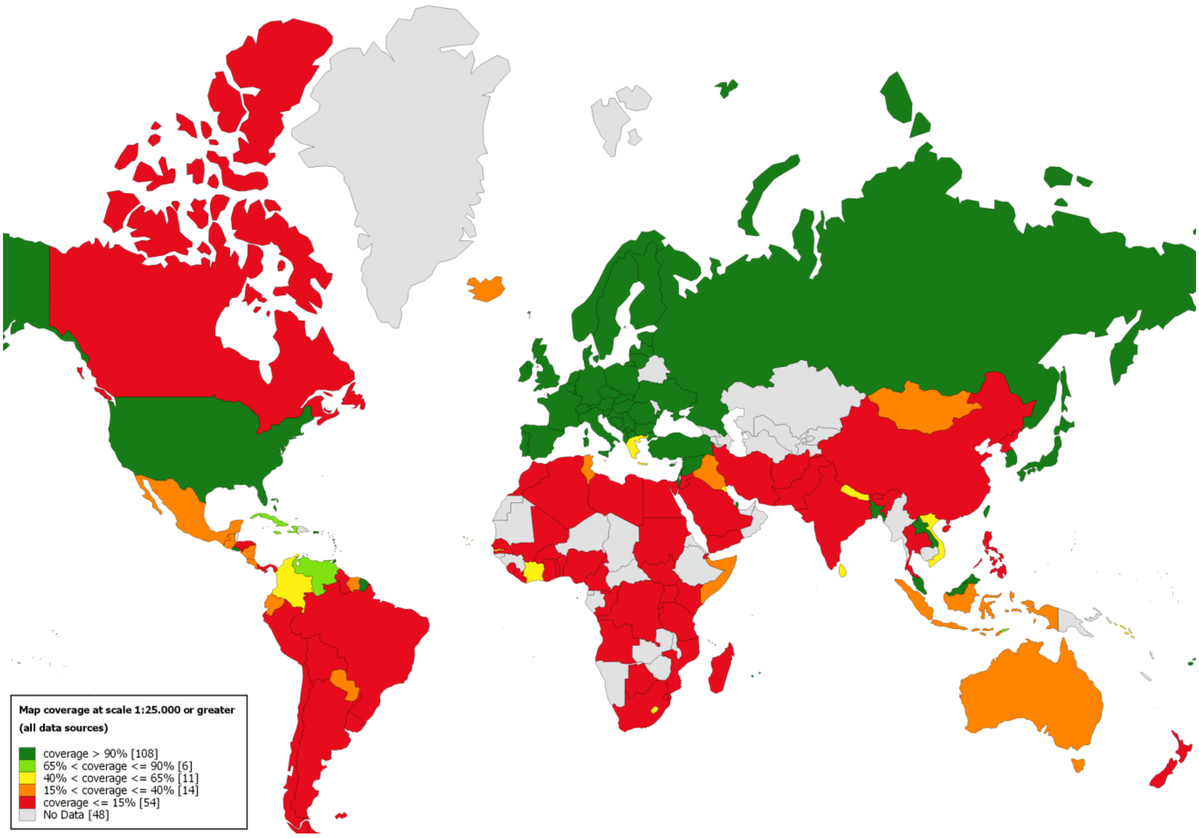


Figure 2: Map coverage at scale 1:25 000 or greater

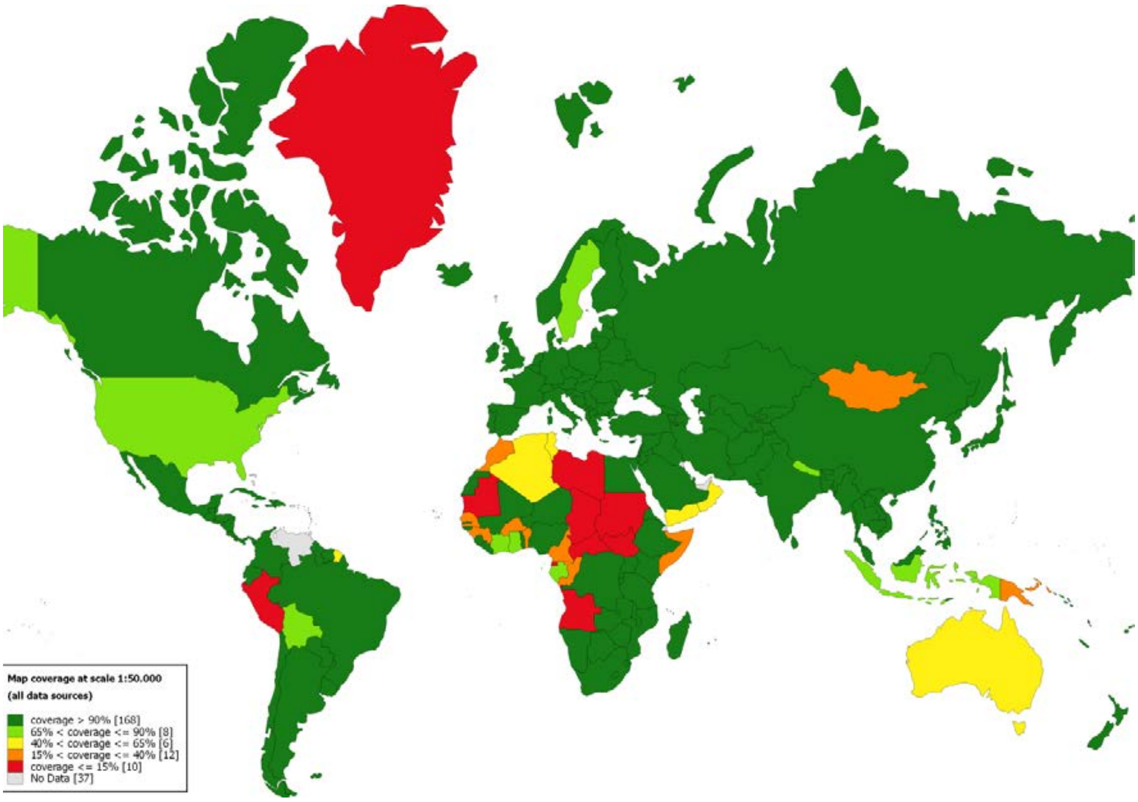


Figure 3: Map coverage at scale 1:50 000

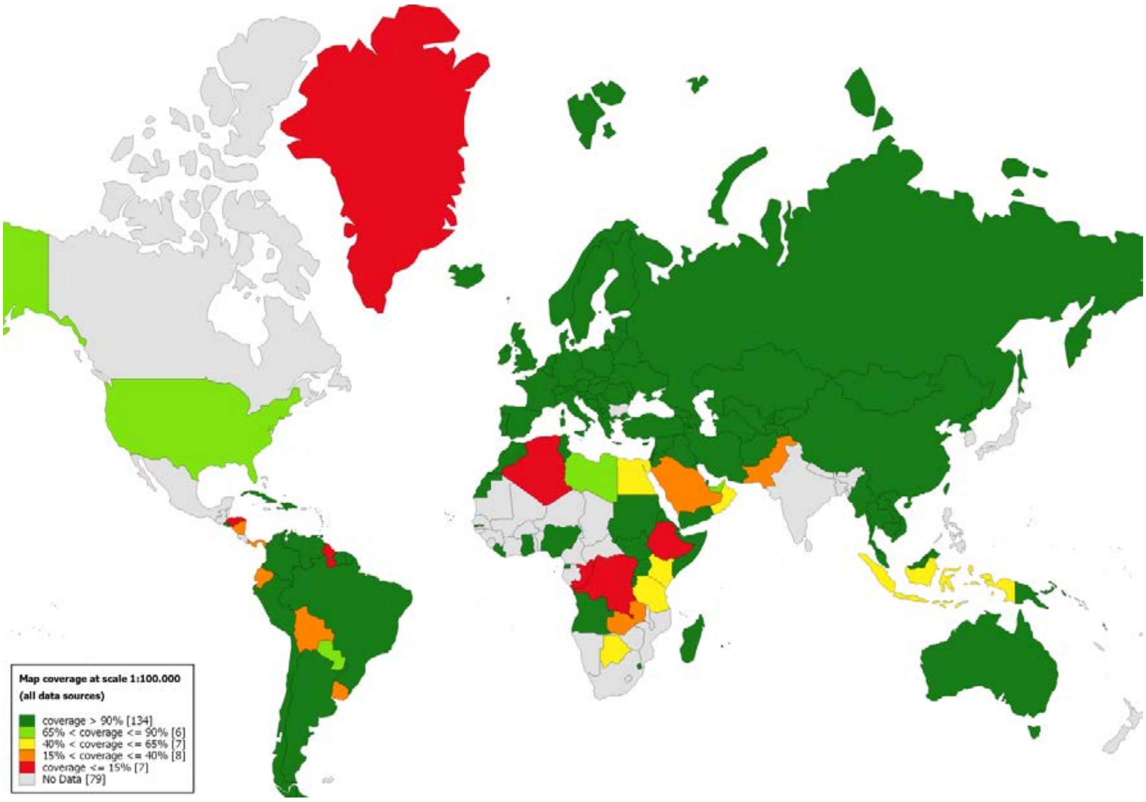


Figure 4: Map coverage at scale 1:100 000

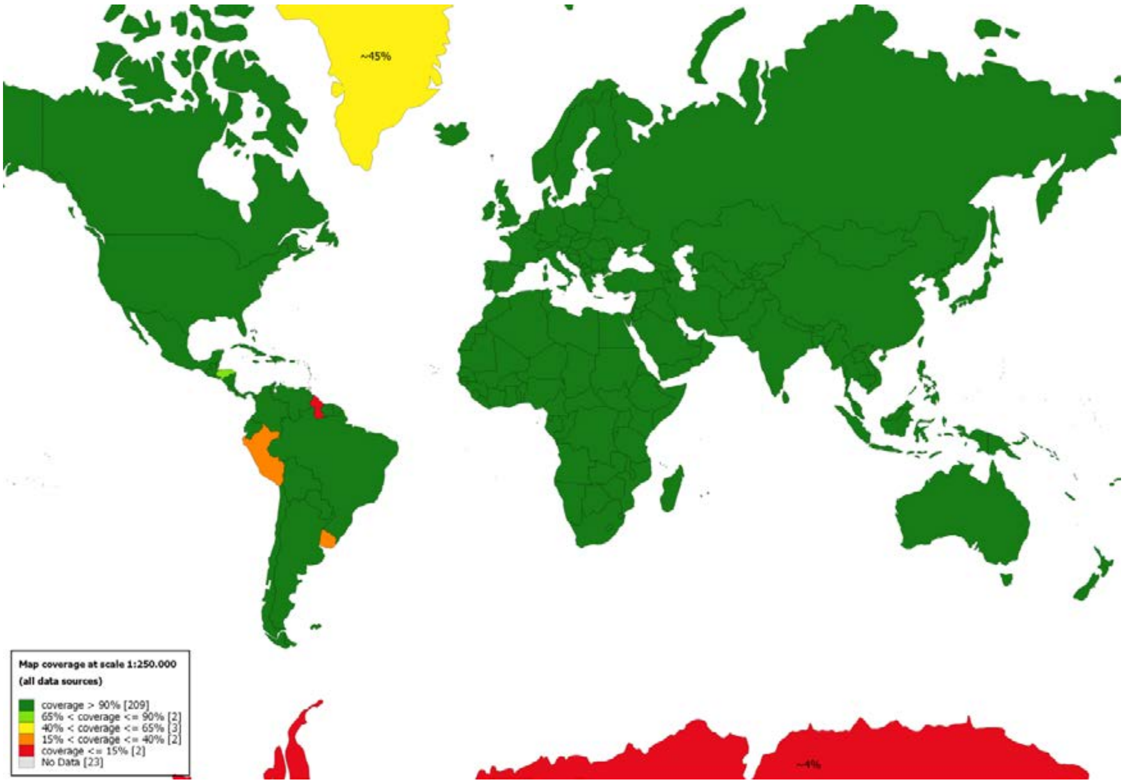


Figure 5: Map coverage at scale 1:250 000

Chart 1 and Figure 6 to Figure 9 give the source of the metadata information for Figure 2 to Figure 5. This answers question 1.

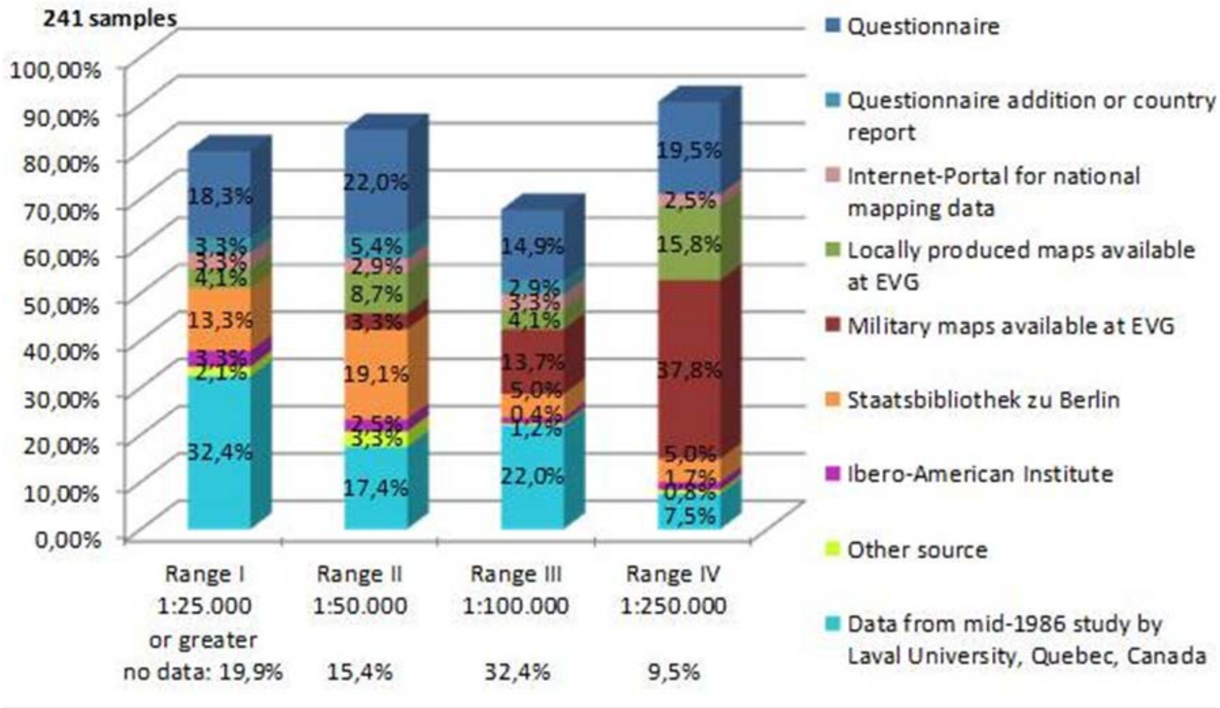


Chart 4: Data source for coverage per scale category

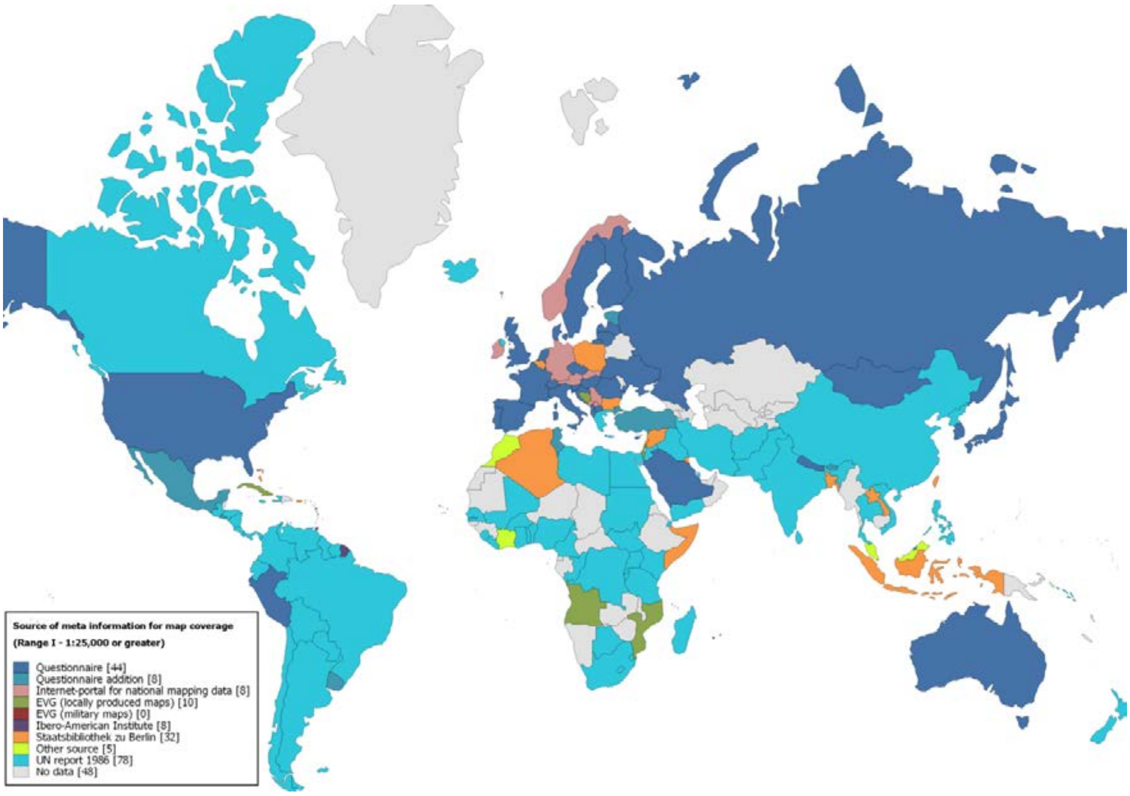


Figure 6: Source of meta information for map coverage in range I - 1:25 000

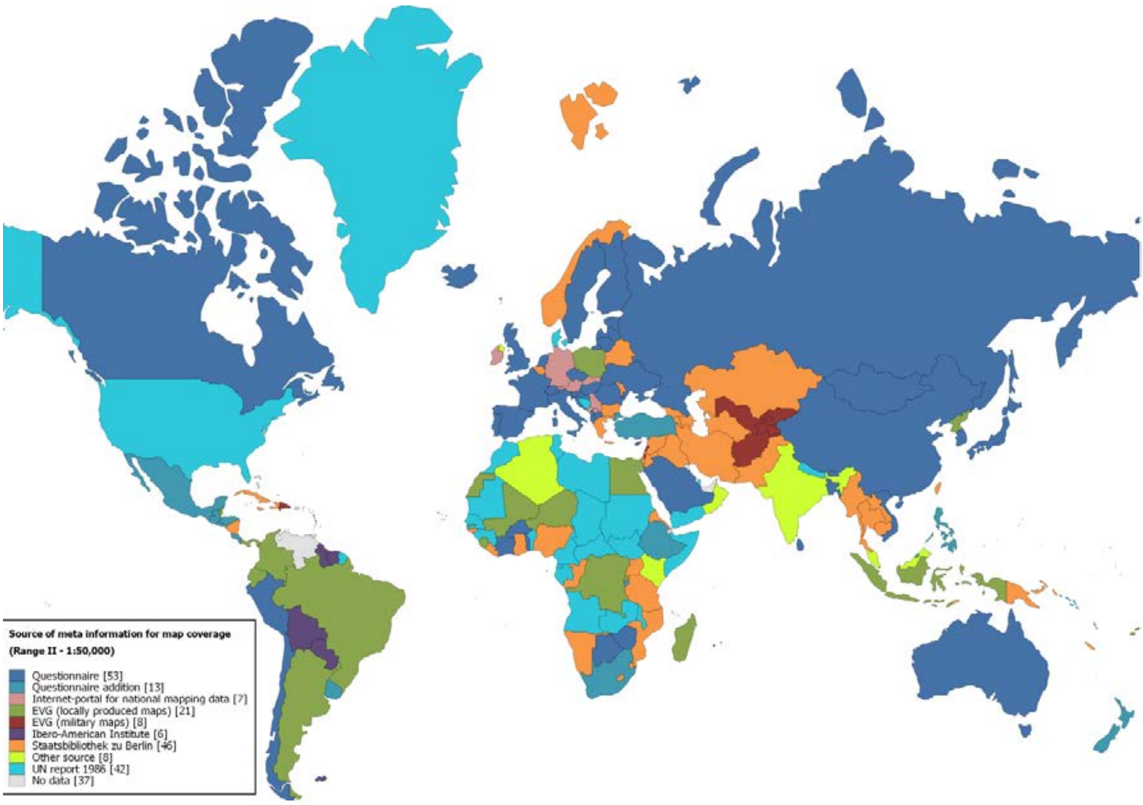


Figure 7: Source of meta information for map coverage in range II - 1:50 000

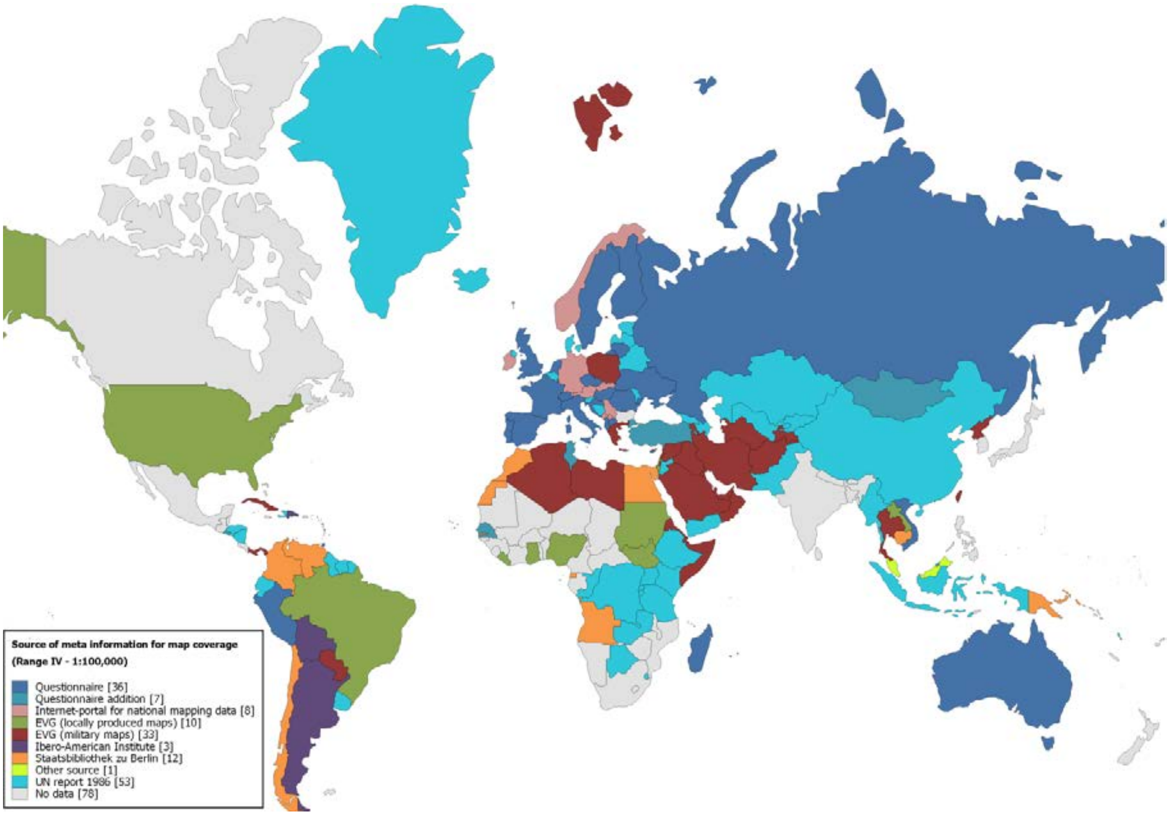


Figure 8: Source of meta information for map coverage in range III - 1:100 000

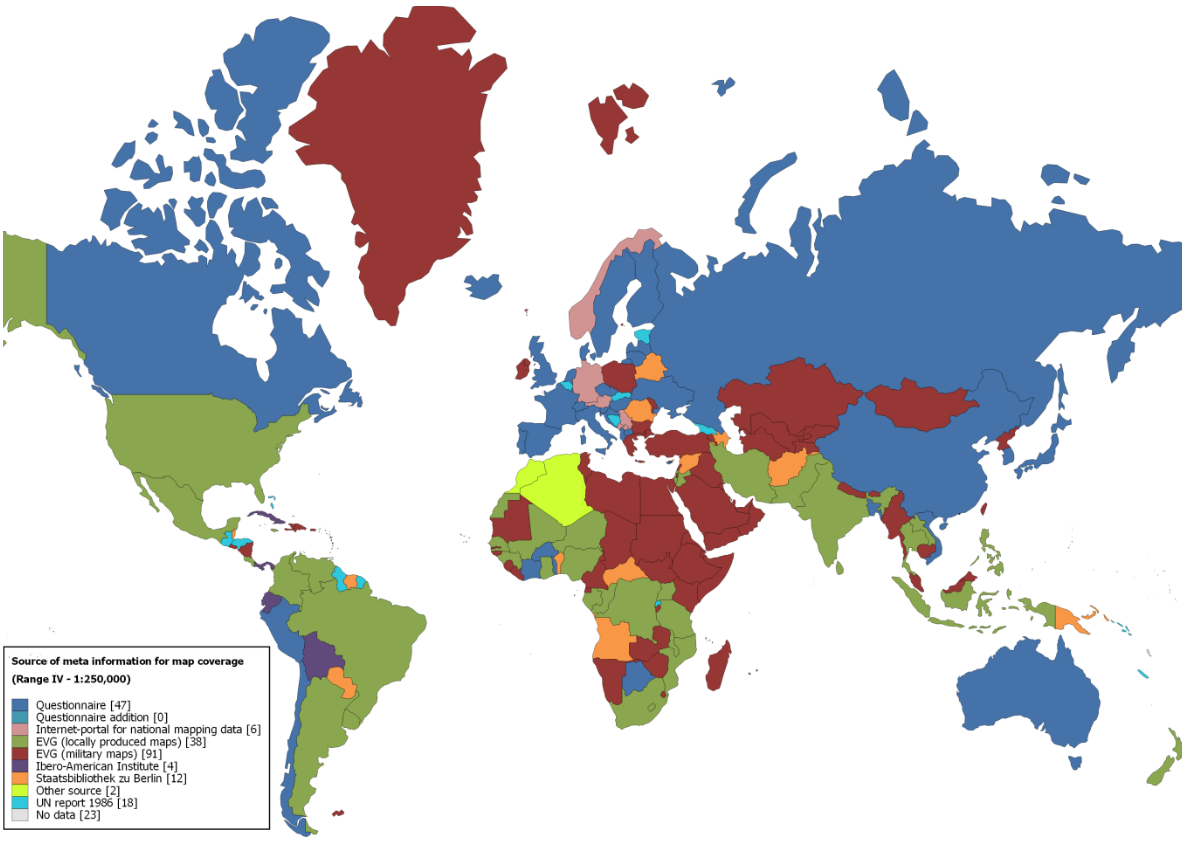


Figure 9: Source of meta information for map coverage in range IV - 1:250 000

Figure 6 to Figure 9 shows the equivalent data to Figure 2 to Figure 5 for the year 1986, depicting the huge progress made through technology from 1986 to 2012. Also Figure 14 highlights the change in map coverage between 1986 and 2012.

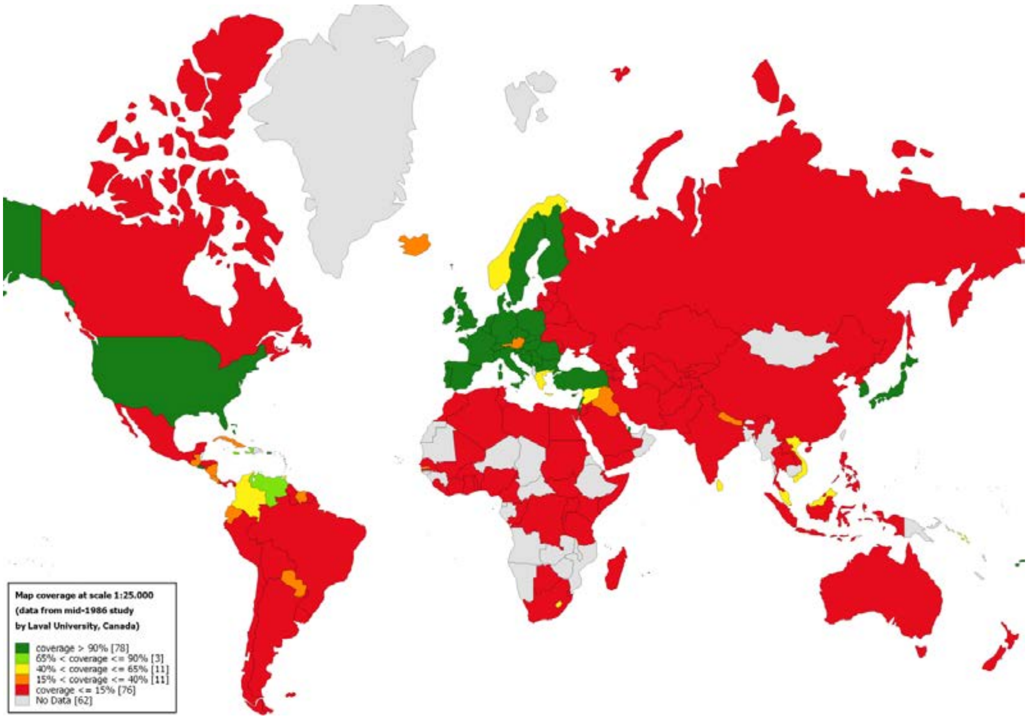


Figure 10: Map coverage 1986 at scale 1:25 000 or greater

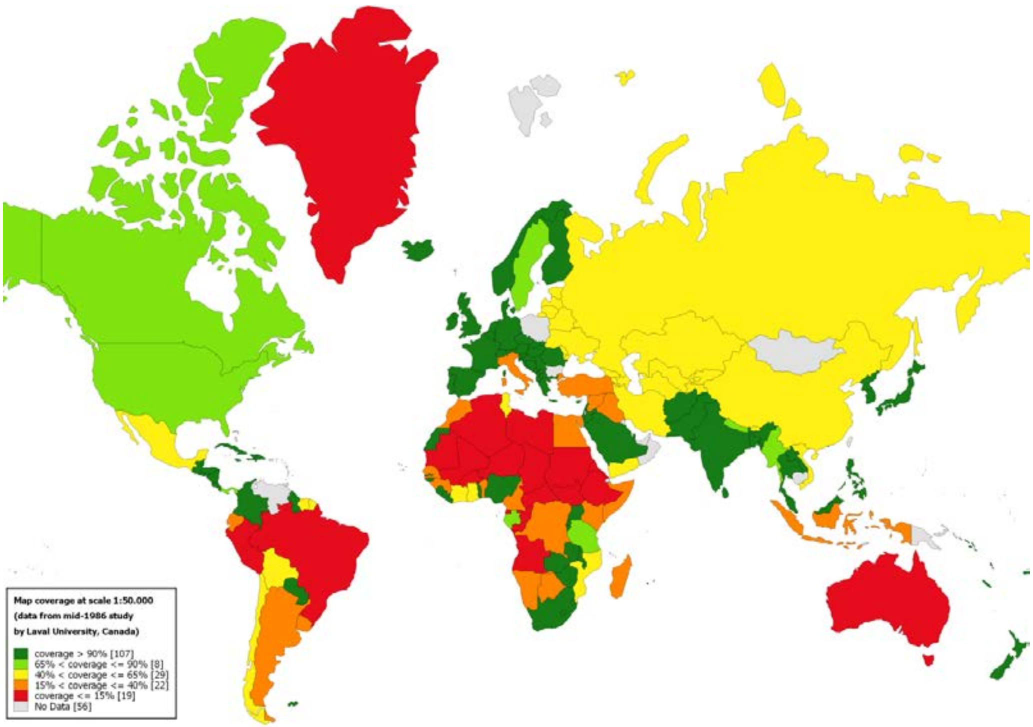


Figure 11: Map coverage 1986 at scale 1:50 000

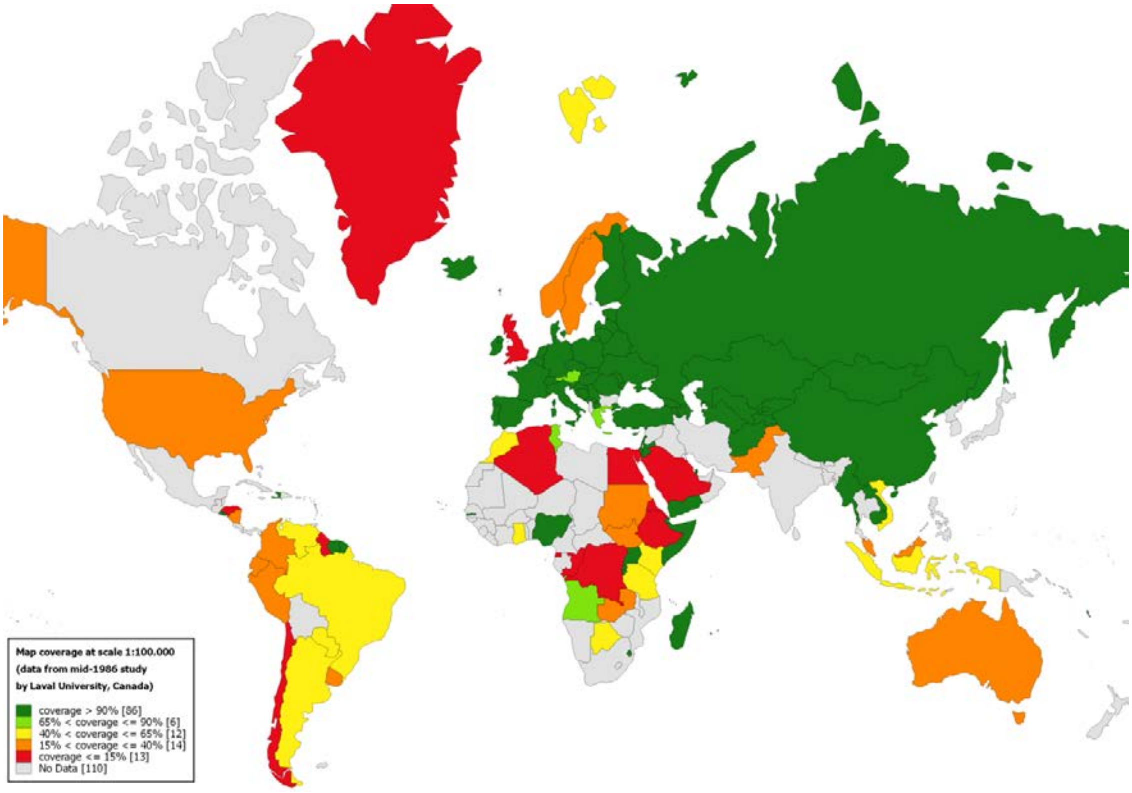


Figure 12: Map coverage 1986 at scale 1:100 000

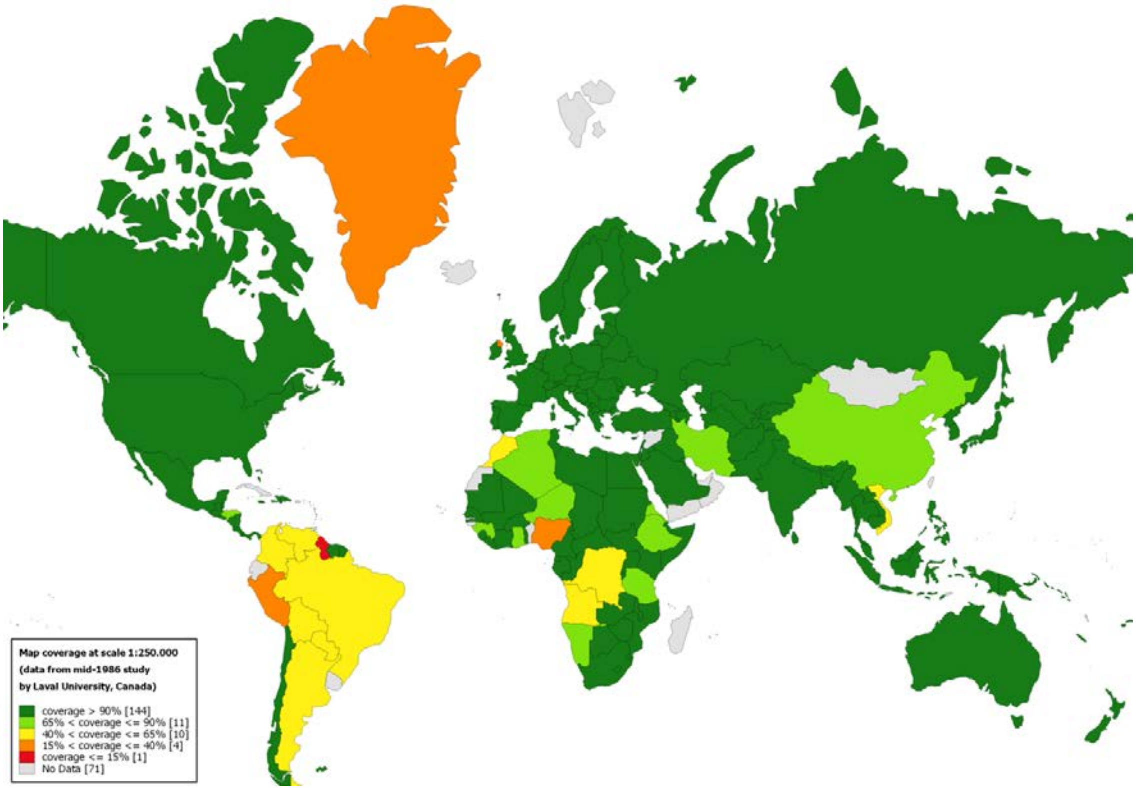


Figure 13: Map coverage 1986 at scale 1:250 000

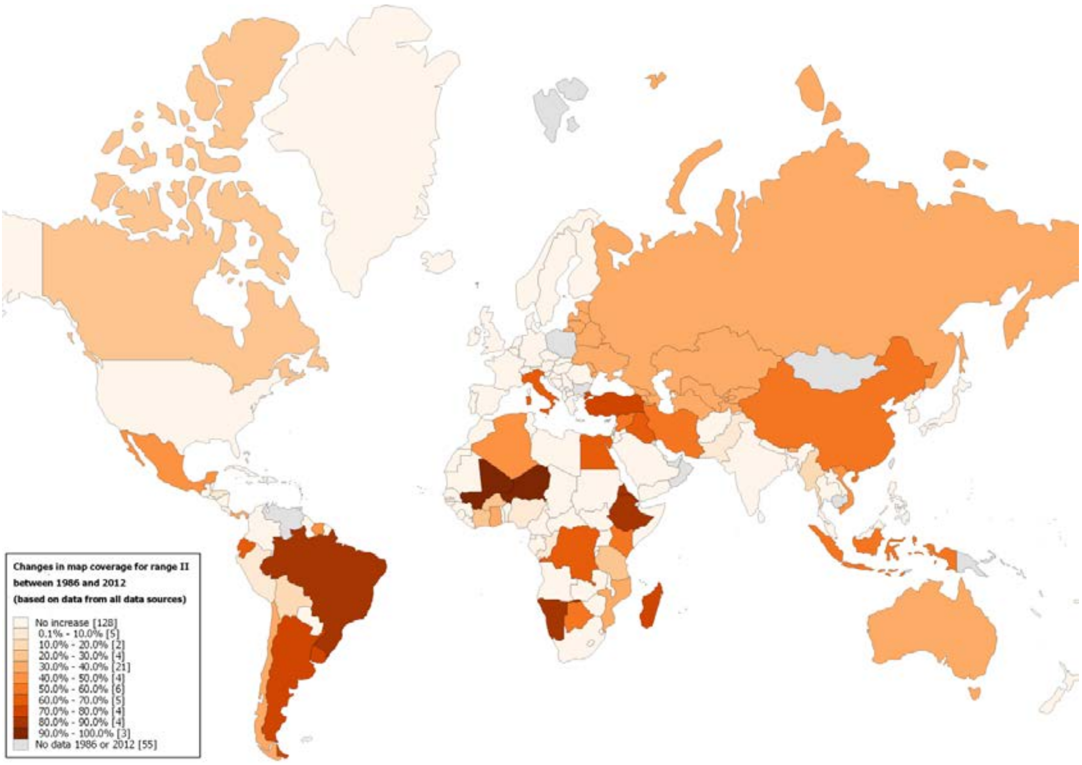


Figure 14: Change in map coverage between 1986 and 2012 for range II - 1:50 000

This answers question 2 at least in part.
The other 25 questions characterize the general global infrastructure for provision of map data. Figure 10 to Figure 30 give answers to most of the questions 3 to 27.

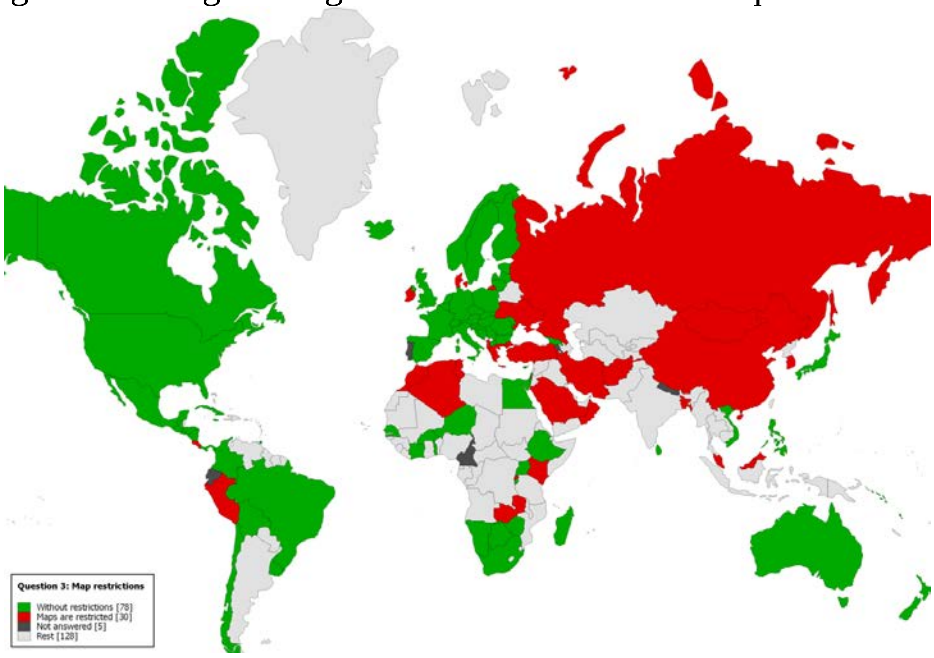


Figure 15: Question 3. Restricted access or limited circulation to maps and/or data

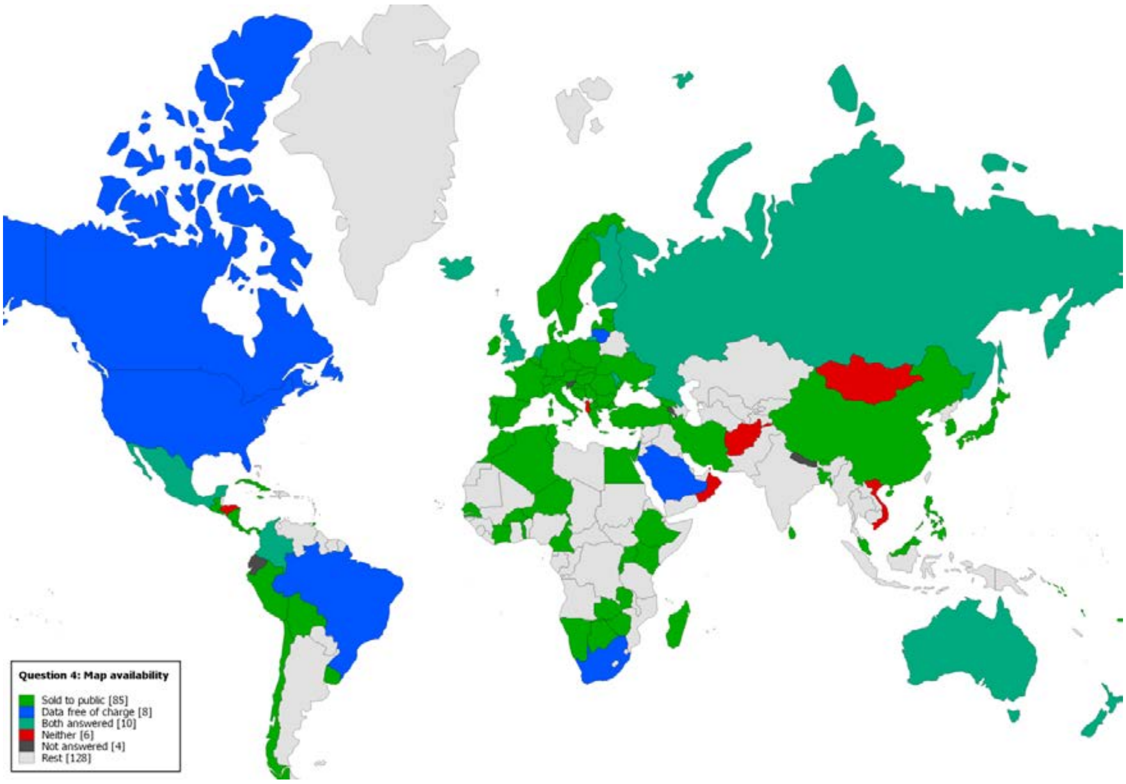


Figure 16: Question 4. Maps and/or digital data sold to the public or data free of charge

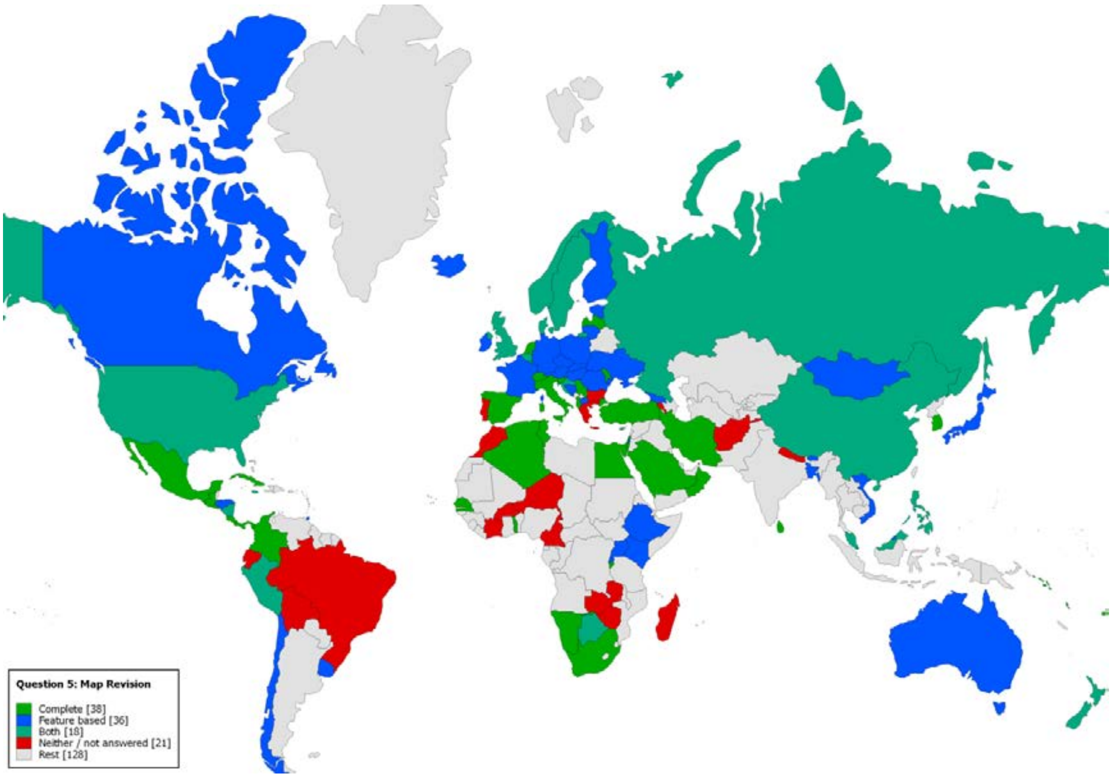


Figure 17: Question 5. Cycle of map and data revision by complete mapping, i.e. revision of a national series or mapping of changed features

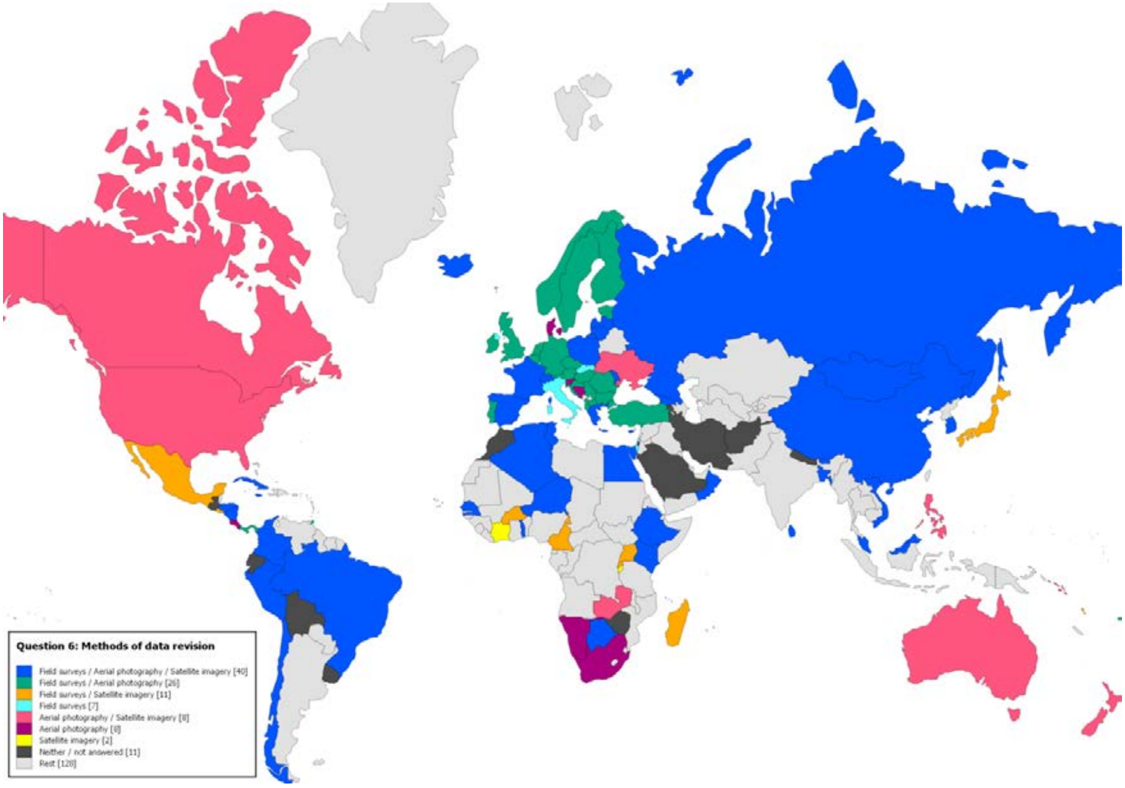


Figure 18: Question 6. Methods of national data revision and map updating

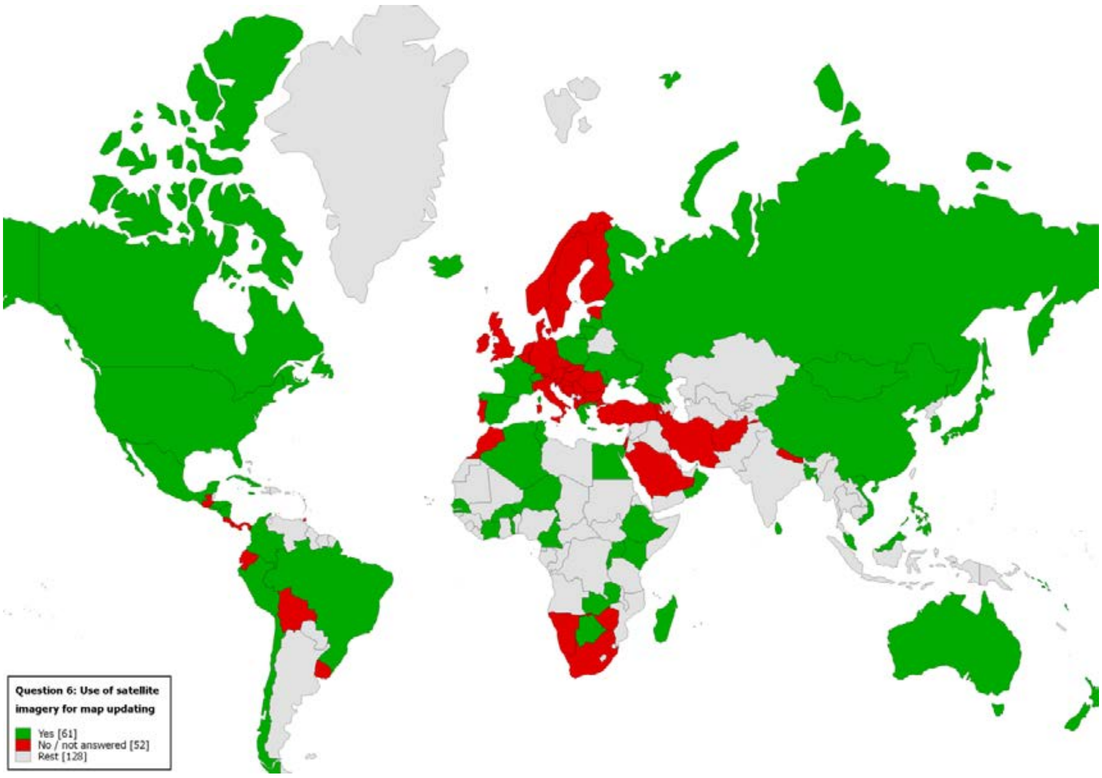


Figure 19: Question 6. Use of satellite imagery for national data revision and map updating

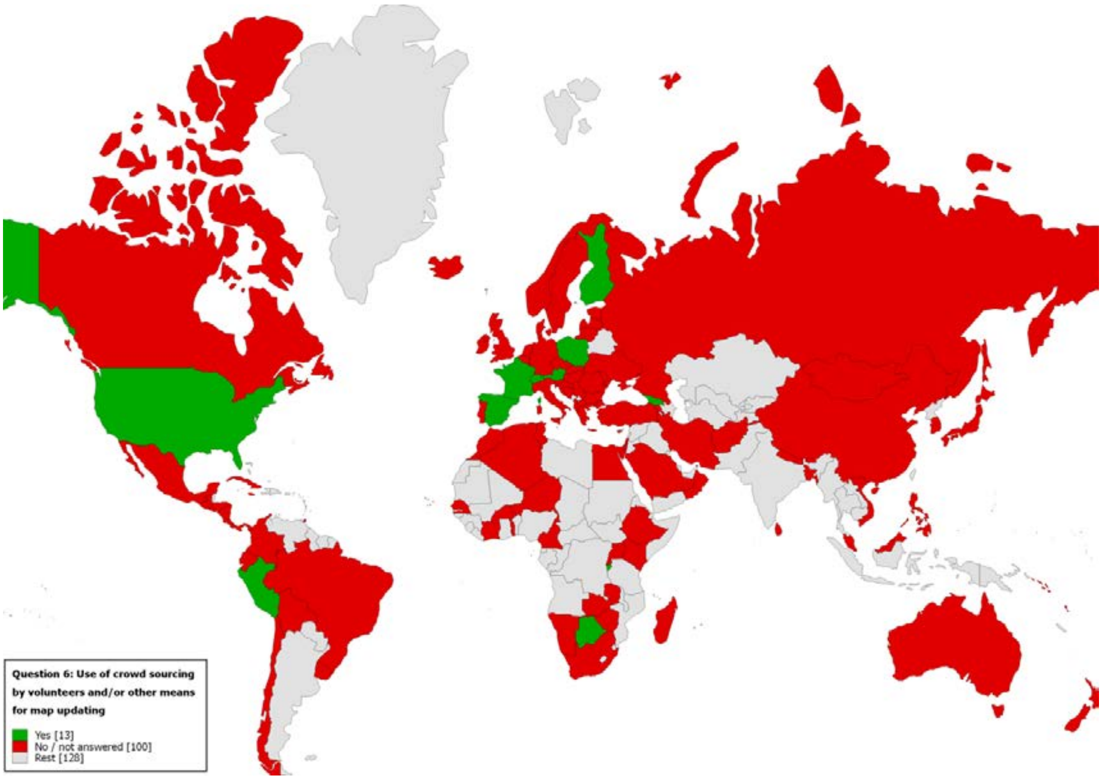


Figure 20: Question 6. Use of crowd sourcing for national data revision and map updating

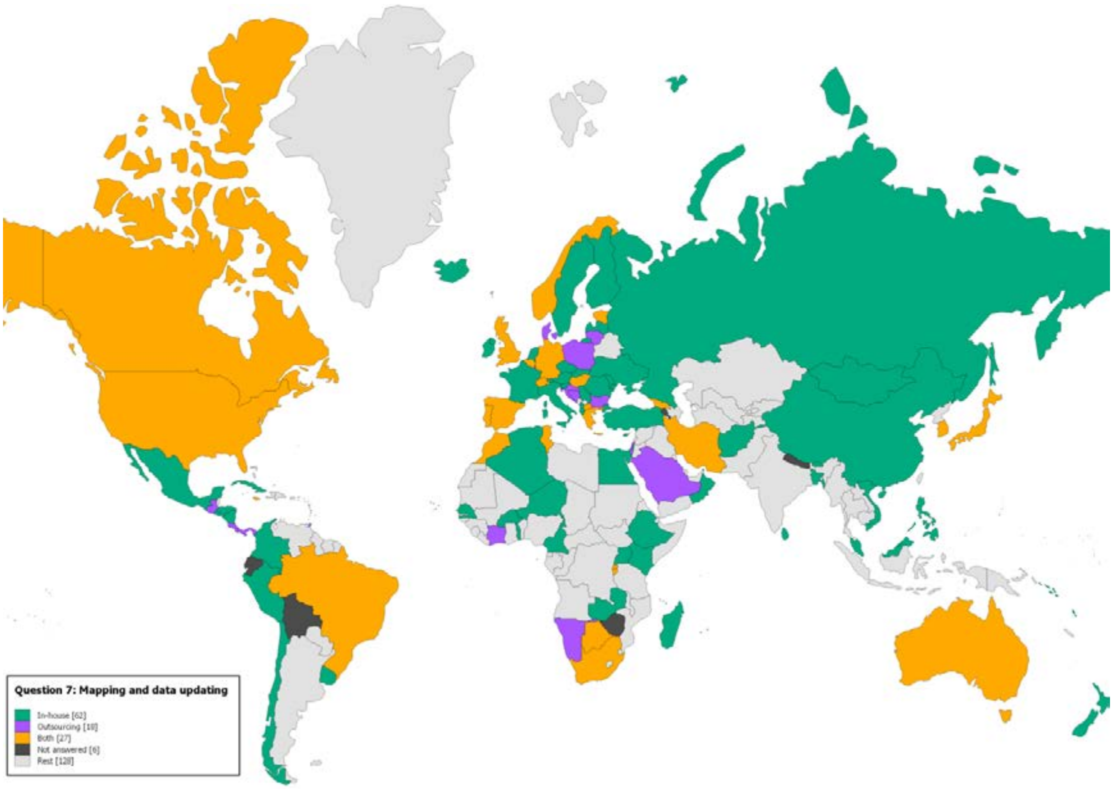


Figure 21: Question 7. Mapping and map updating done in-house or by outsourcing

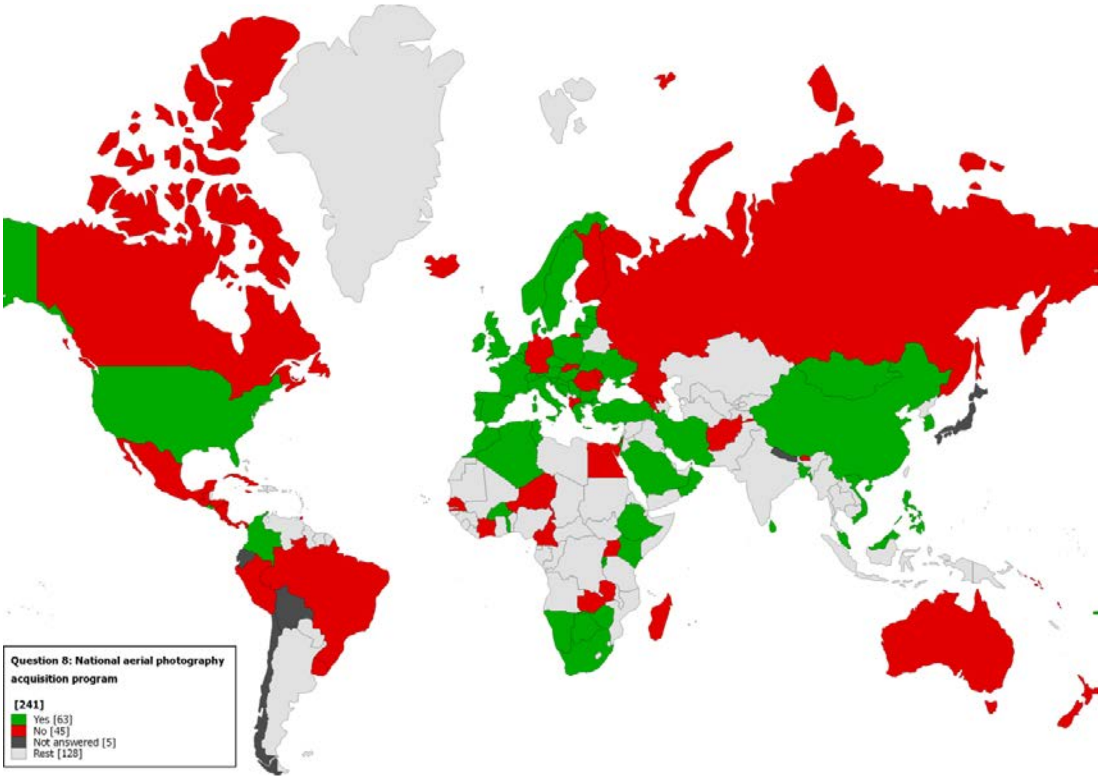


Figure 22: Question 8: National aerial photography acquisition program

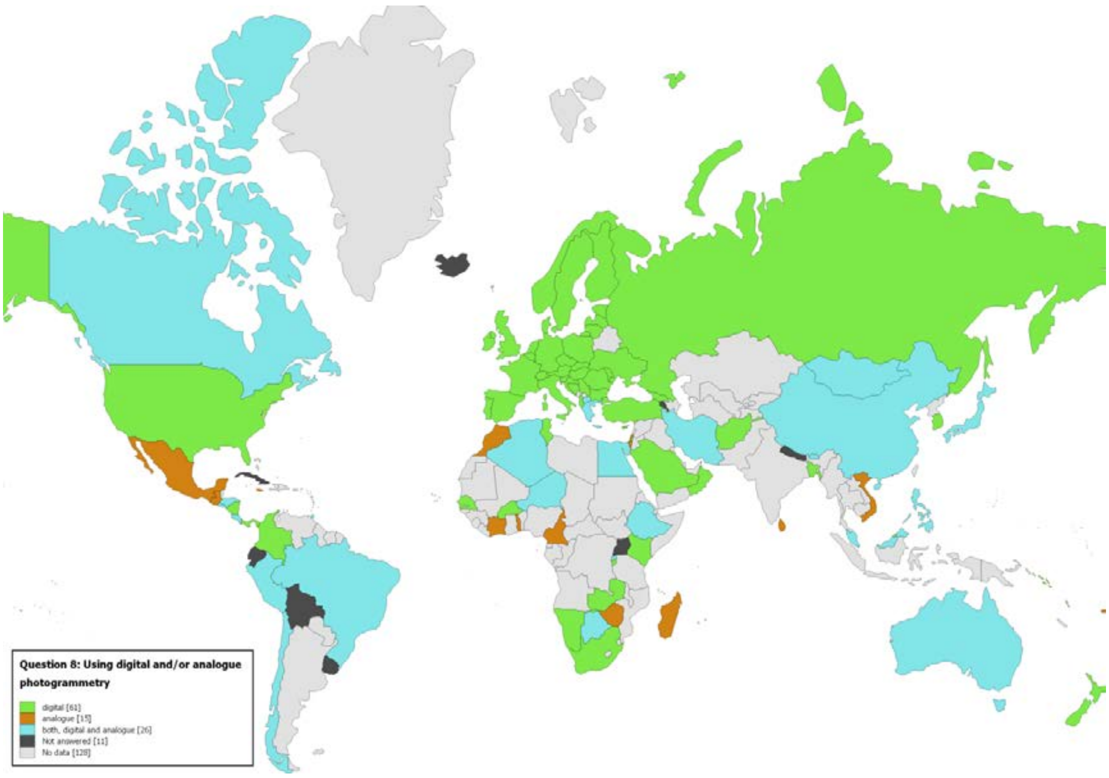


Figure 23: Question 8. Using digital and/or analogue photogrammetry

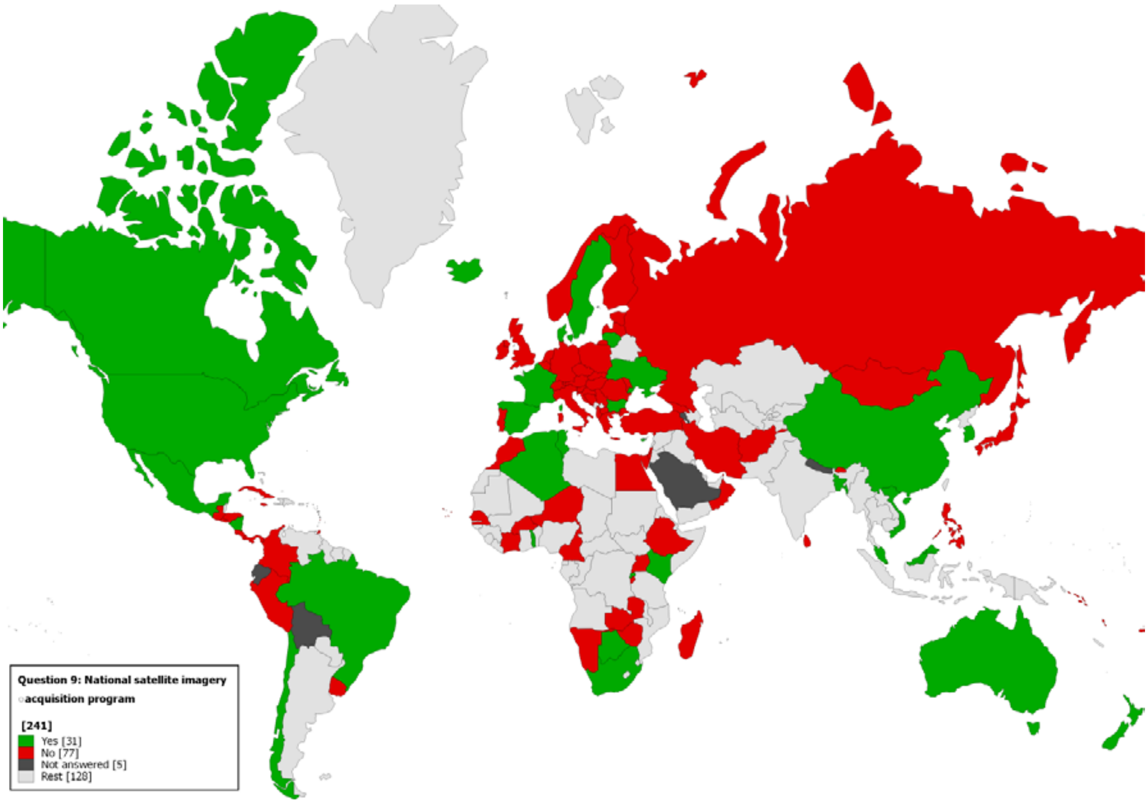


Figure 24: Question 9: National satellite imagery acquisition program

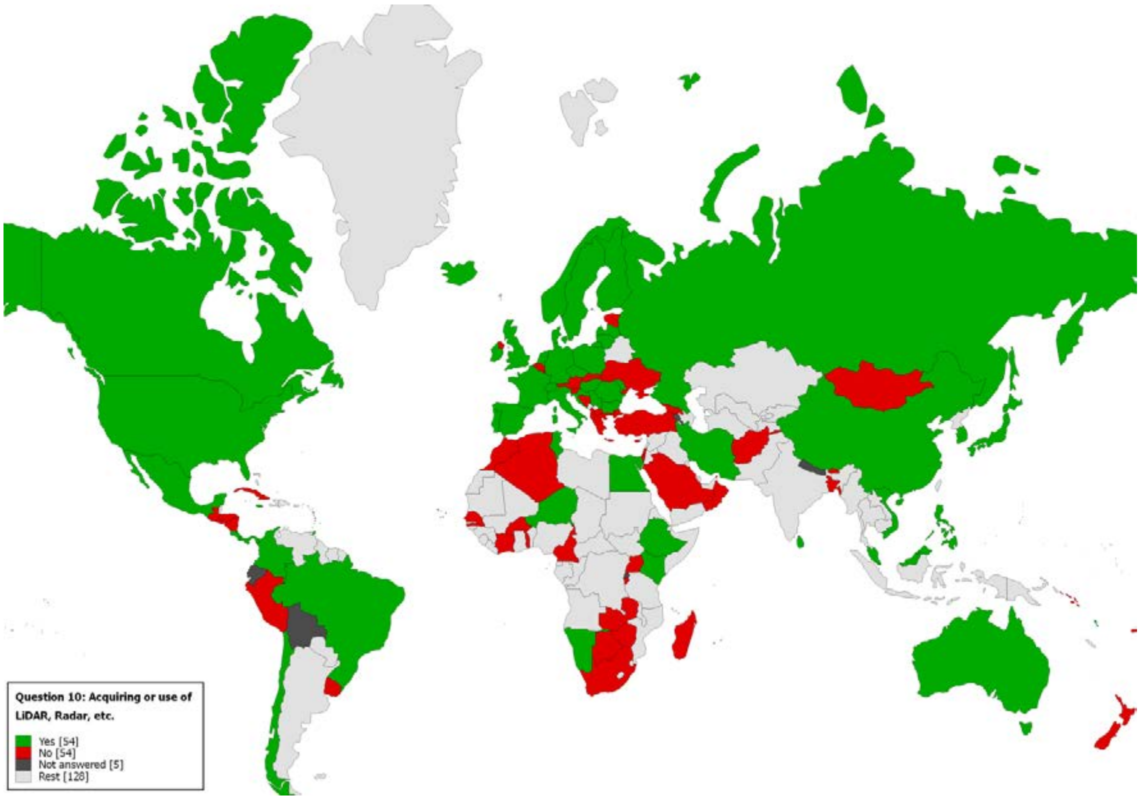


Figure 25: Question 10. Acquiring and/or using other imagery types (such as LiDAR, RADAR, etc.)

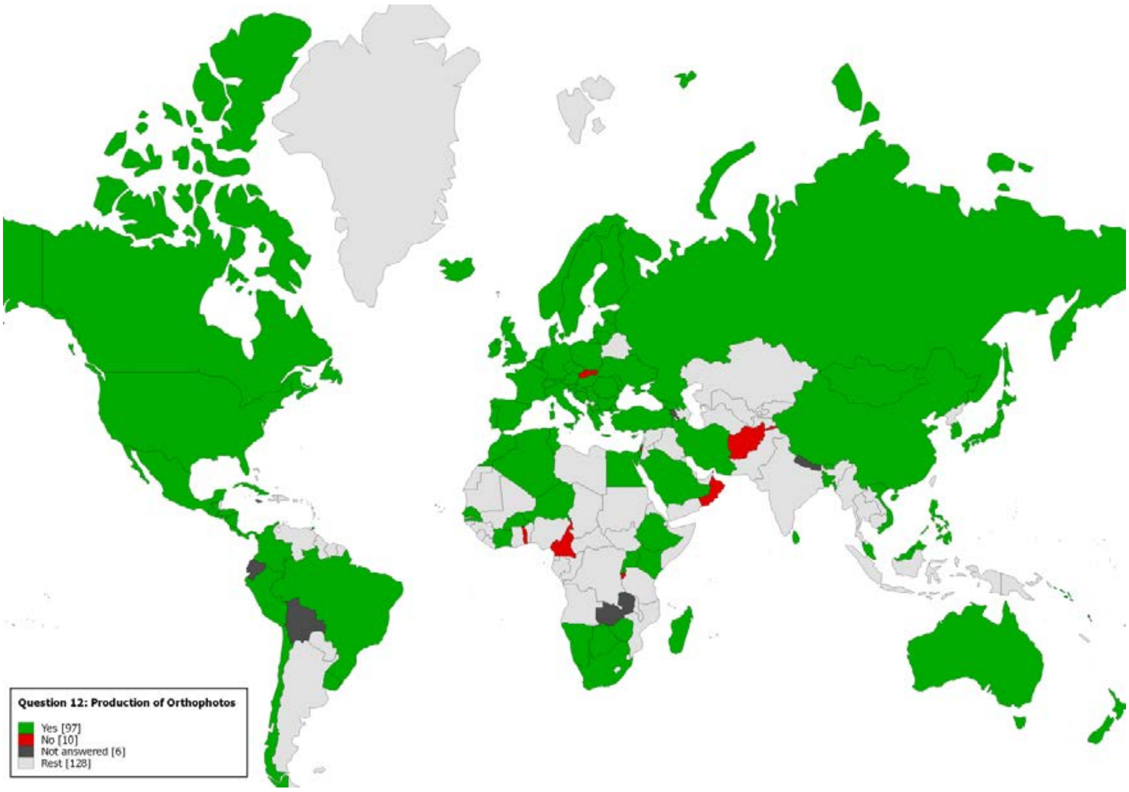


Figure 26: Question 12. Production of orthophotos and orthophotomaps

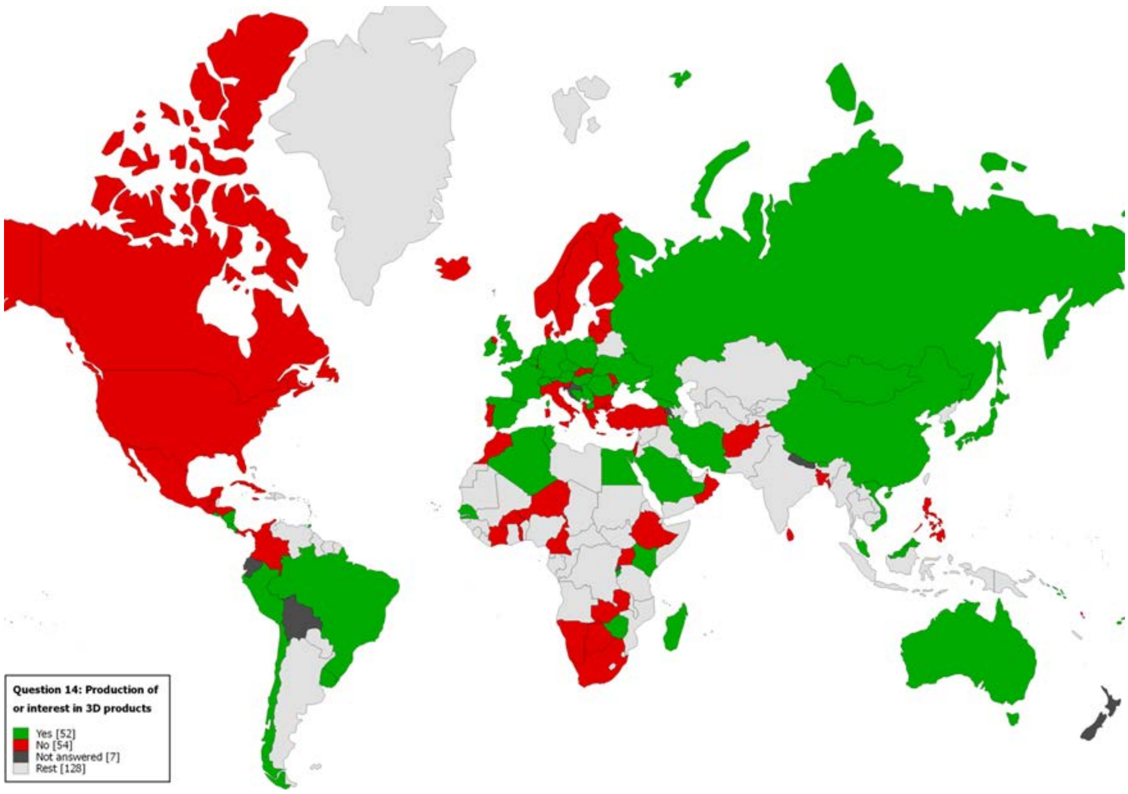


Figure 27: Question 14. Production or intention to produce, 3D urban and rural landscape models and/or product visualization

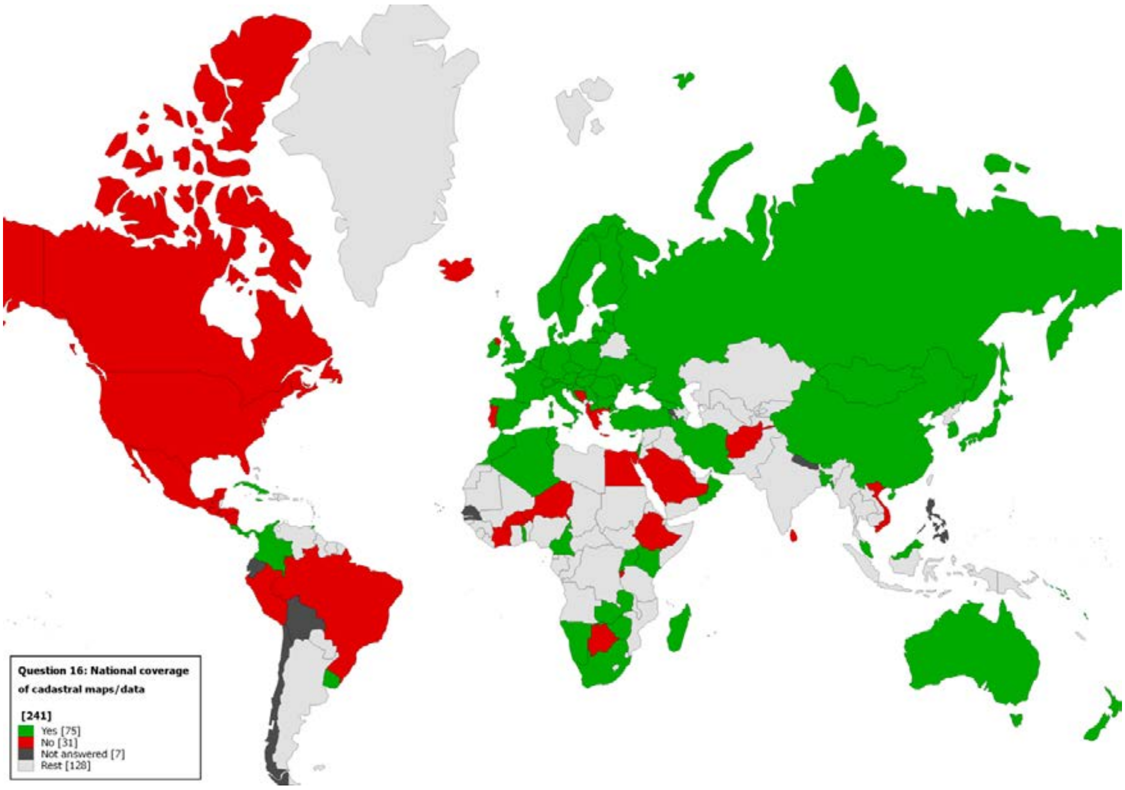


Figure 28: Question 16. National coverage of cadastral maps and/or data available

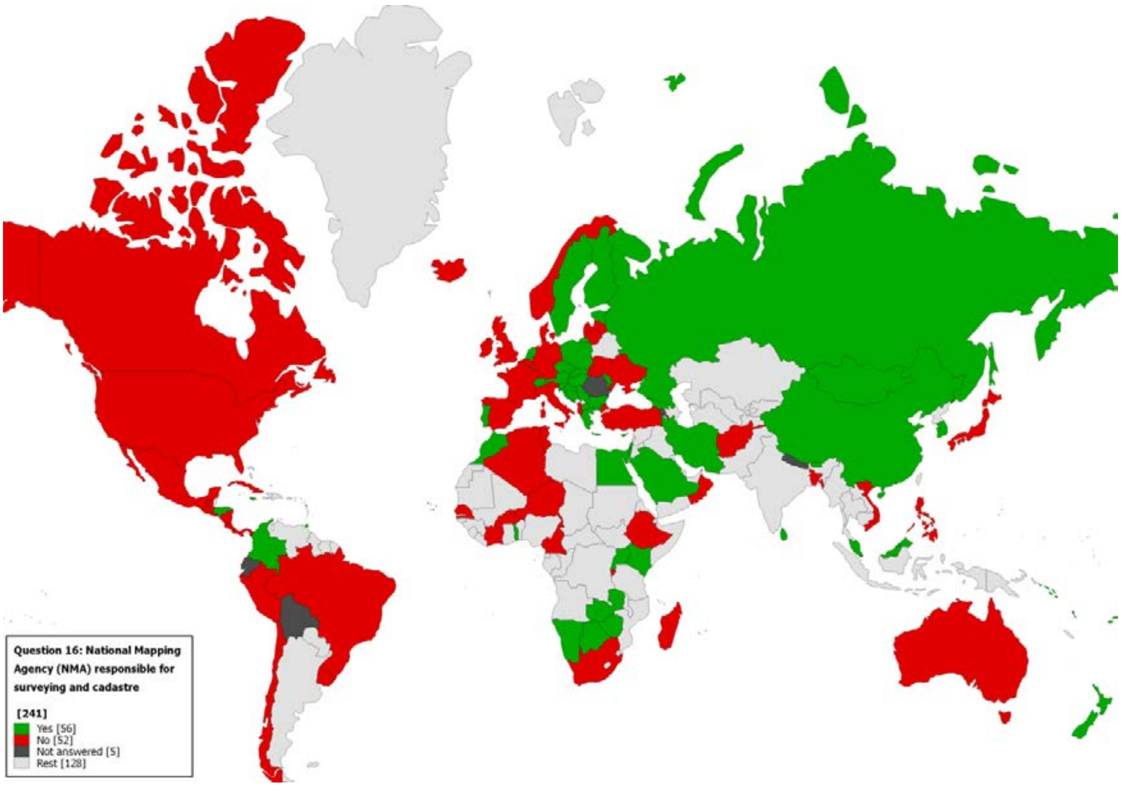


Figure 29: Question 16. National Mapping Agency (NMA) responsible for surveying and/or land titles and cadastre

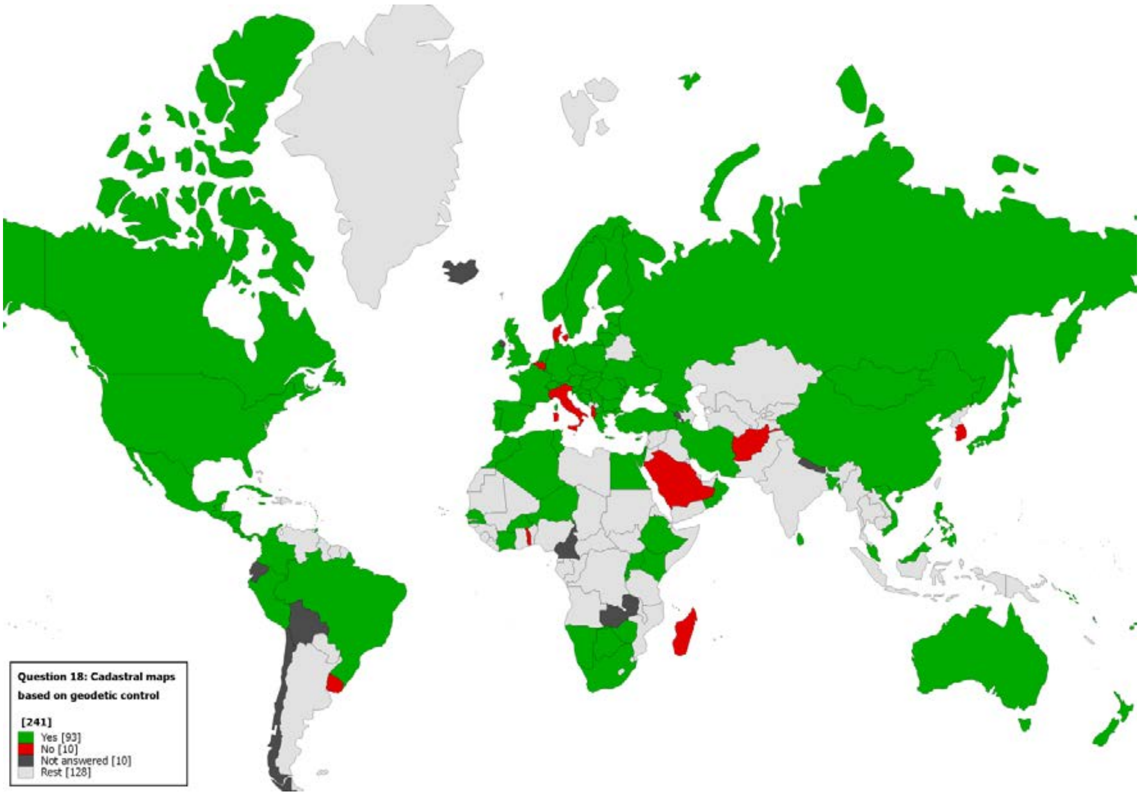


Figure 30: Question 18. Cadastral maps based on geodetic control

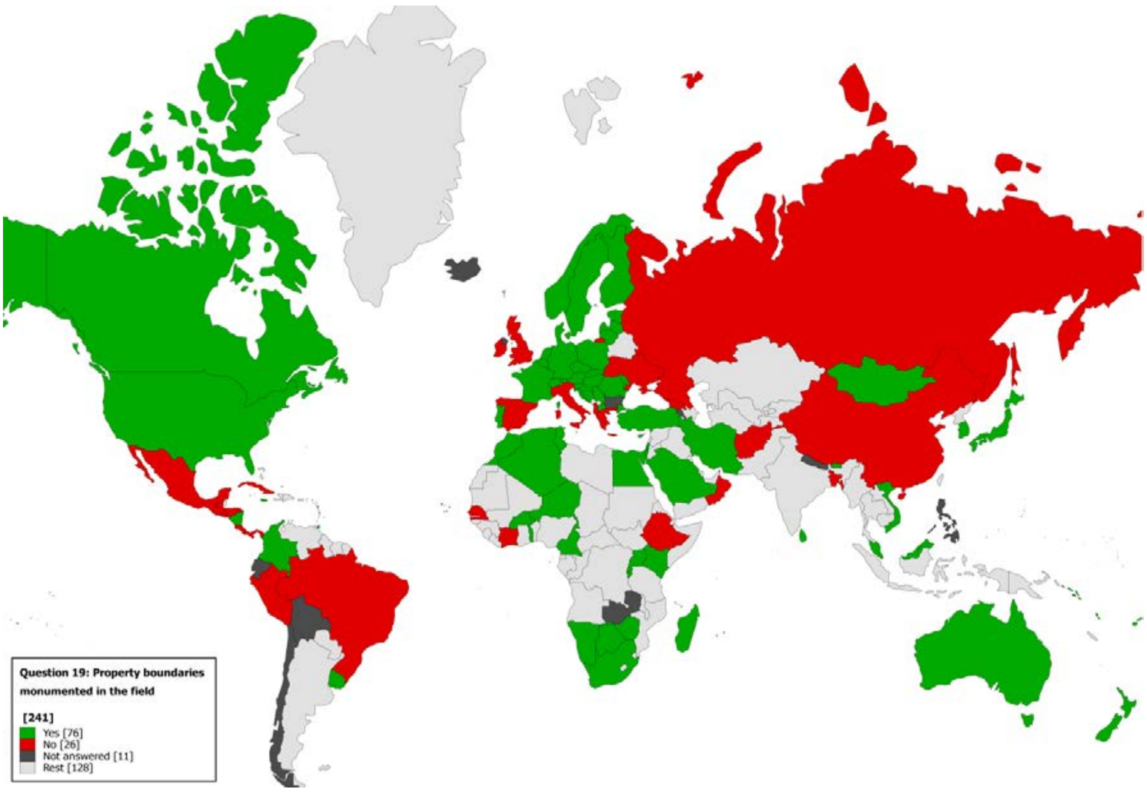


Figure 31: Question 19. Property boundaries monumented in the field

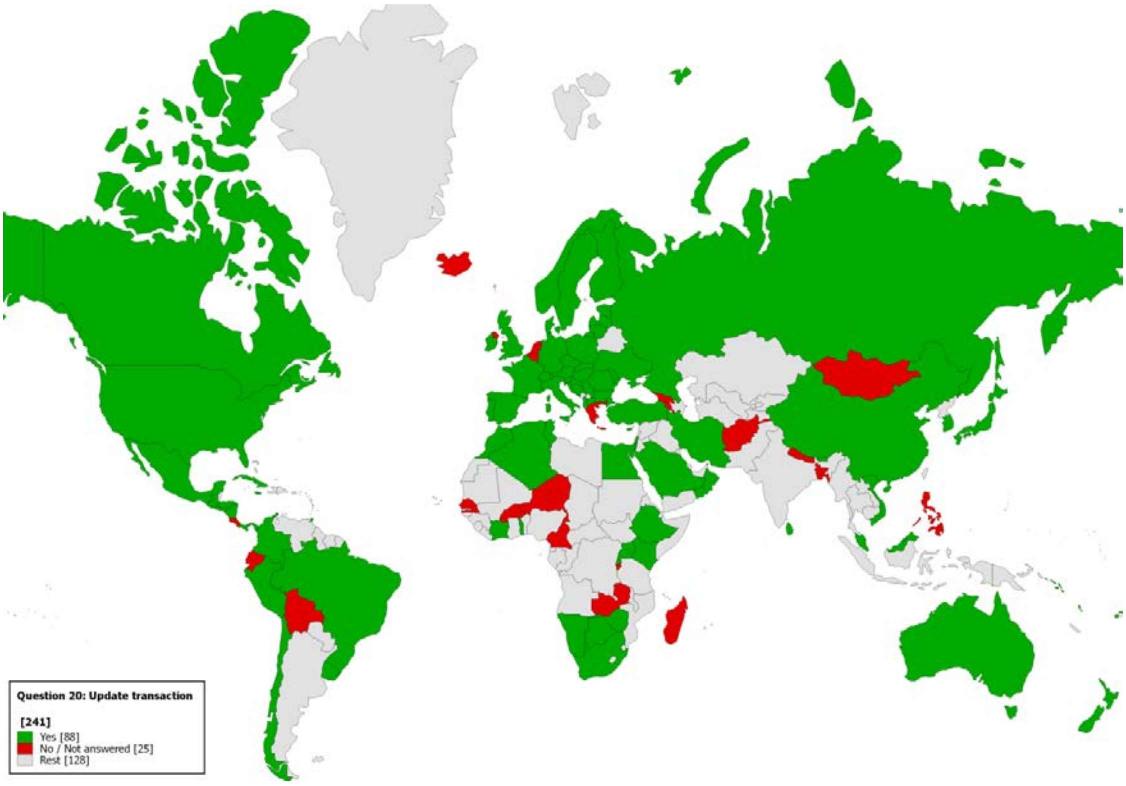


Figure 32: Question 20. Update transaction of property maps and/or data

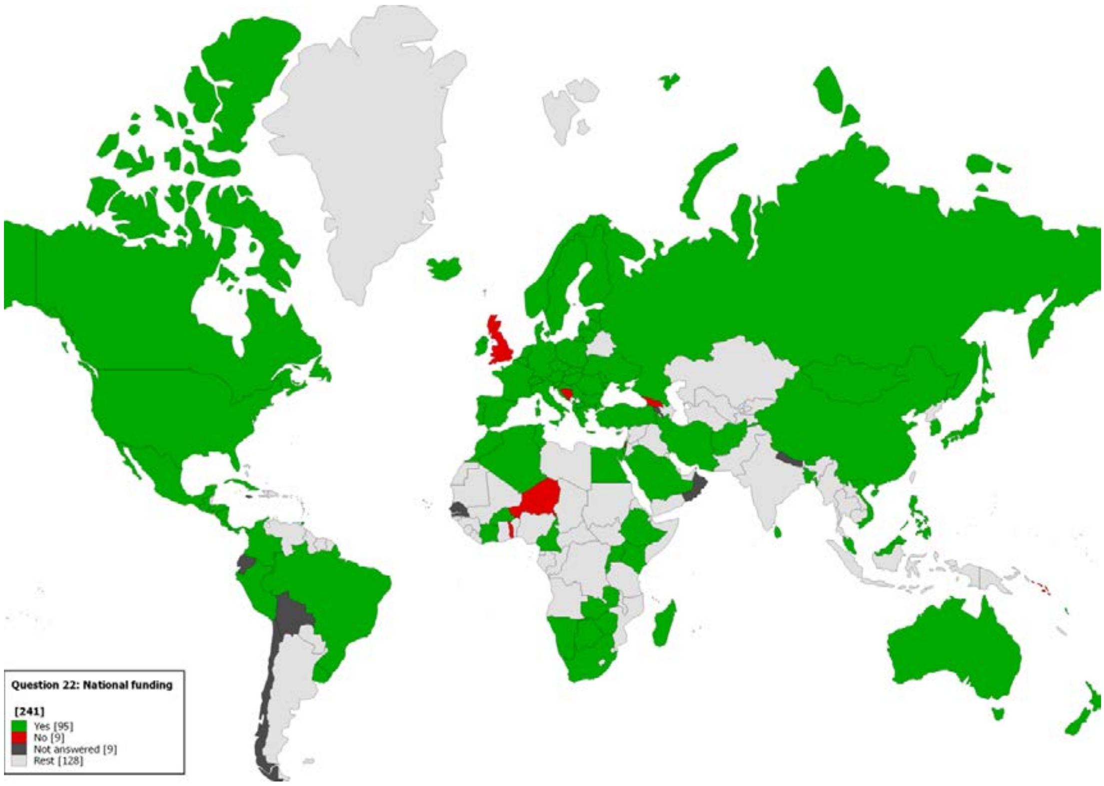


Figure 33: Question 22. National topographic mapping, imagery acquisition, surveying and cadastral programs funded by your national Government

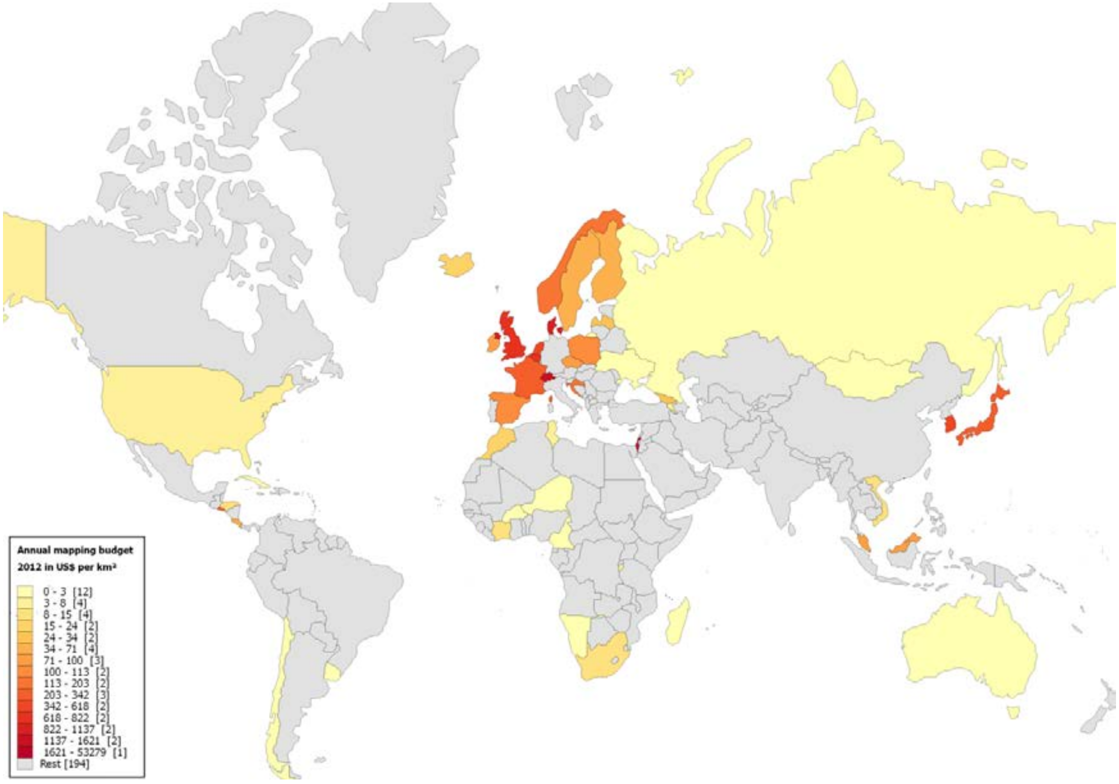


Figure 34: Question 23. Annual mapping budget of the National Mapping Organization converted to million US$ per square kilometre of the country area

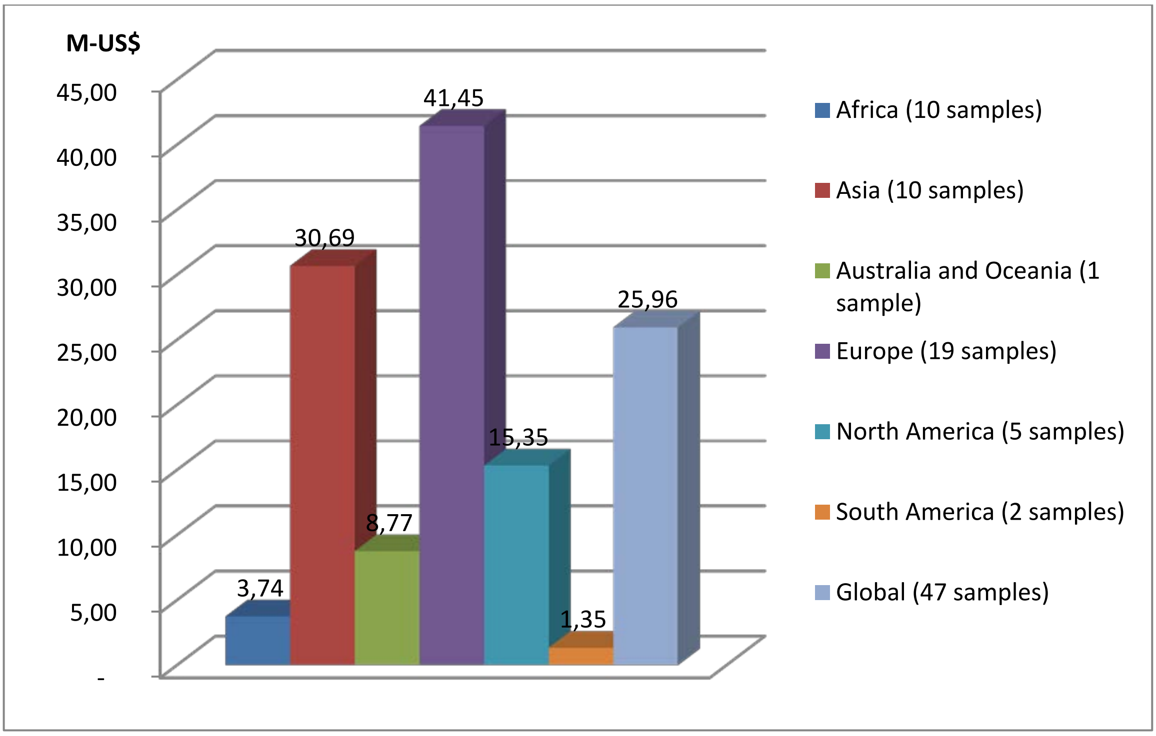


Chart 5: Question 23. Average annual budget 2012 per region converted to million-US$

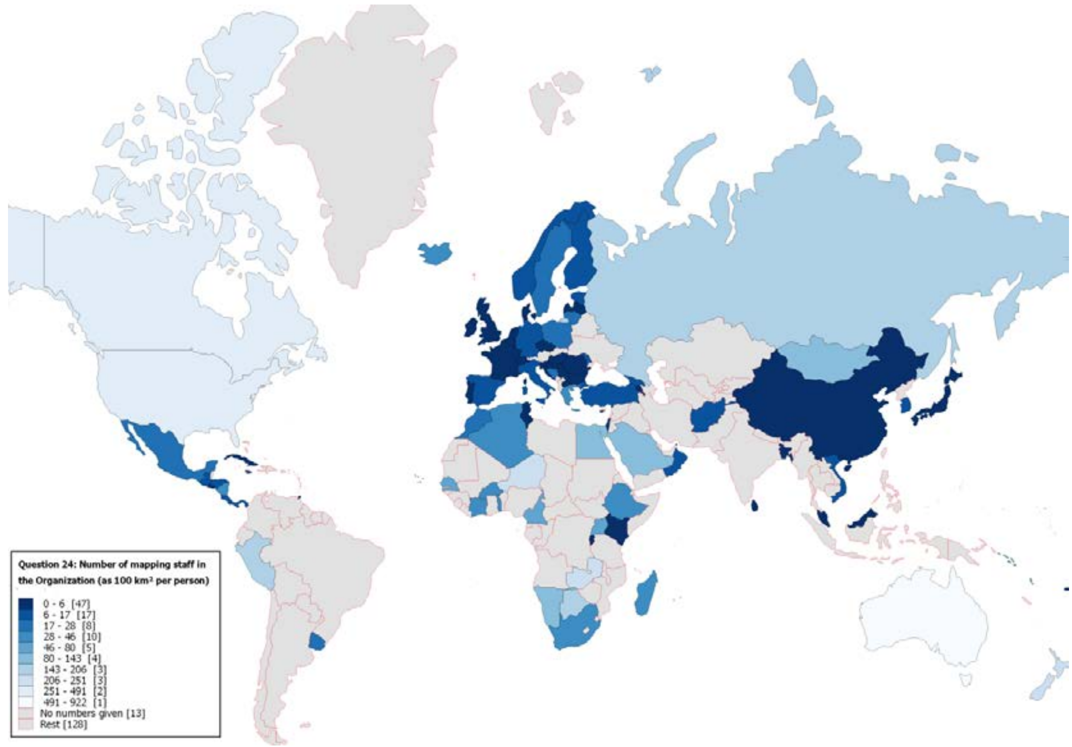


Figure 35: Question 24. Number of mapping staff in the organization as hundreds of square kilometres of country area per person

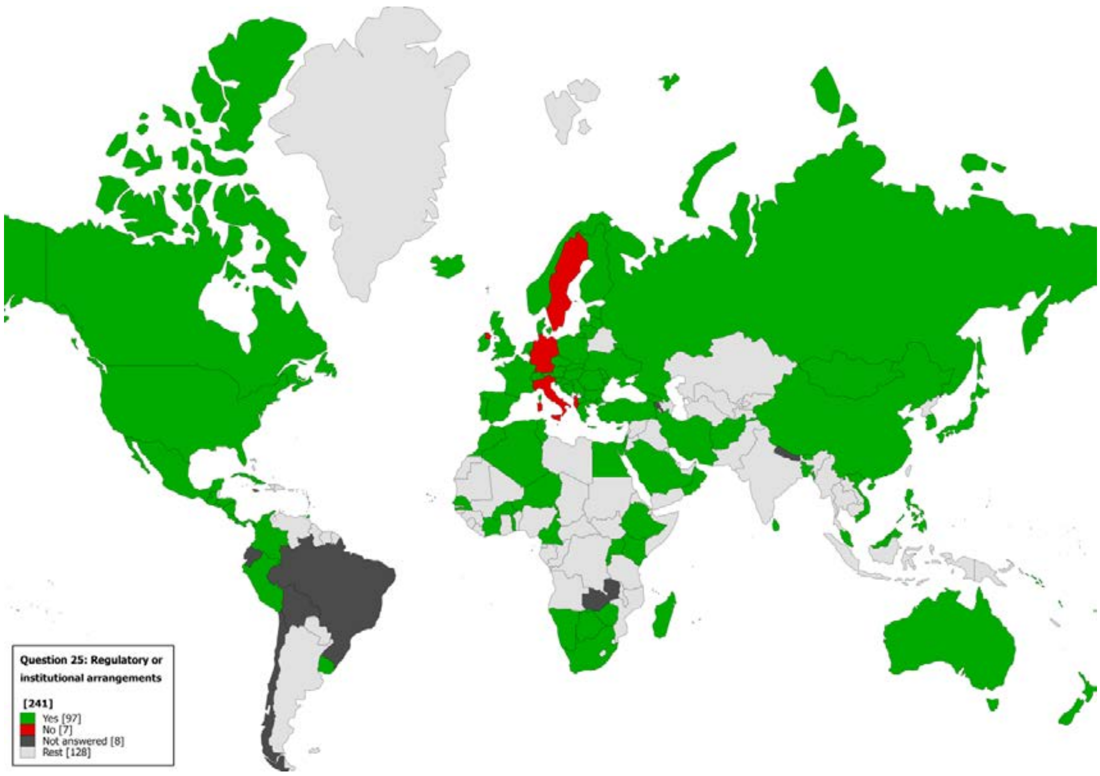


Figure 36: Question 25. Regulatory or institutional arrangements mandating the organization to fulfil its role as the lead mapping agency

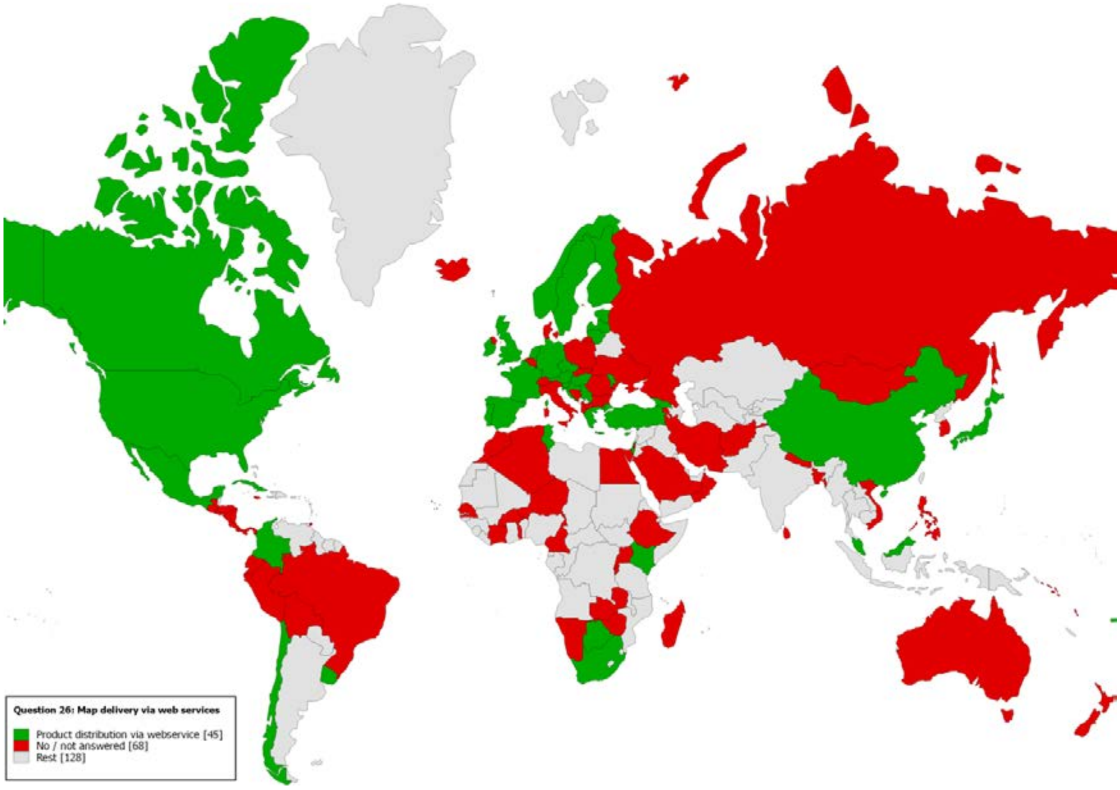


Figure 37: Question 26. Delivery of different map and data products via web services

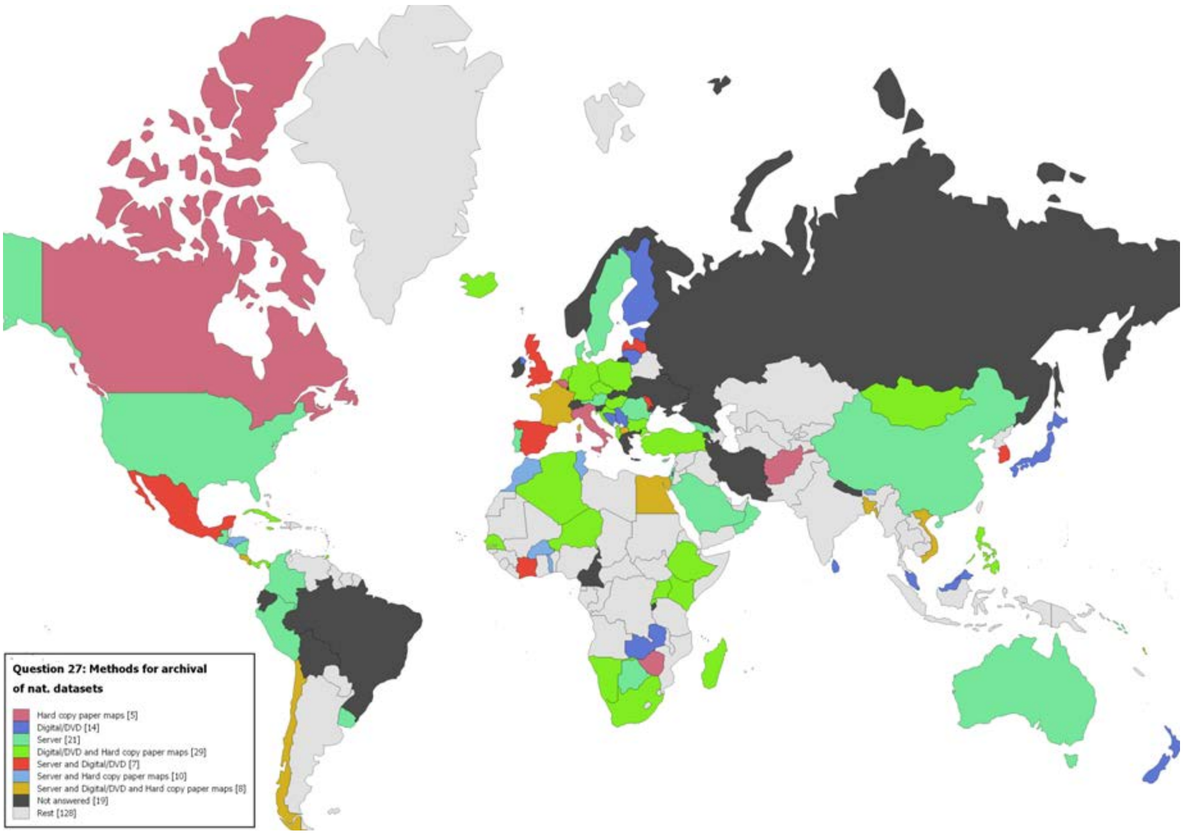


Figure 38: Question 27. Methods of archival for the national data sets

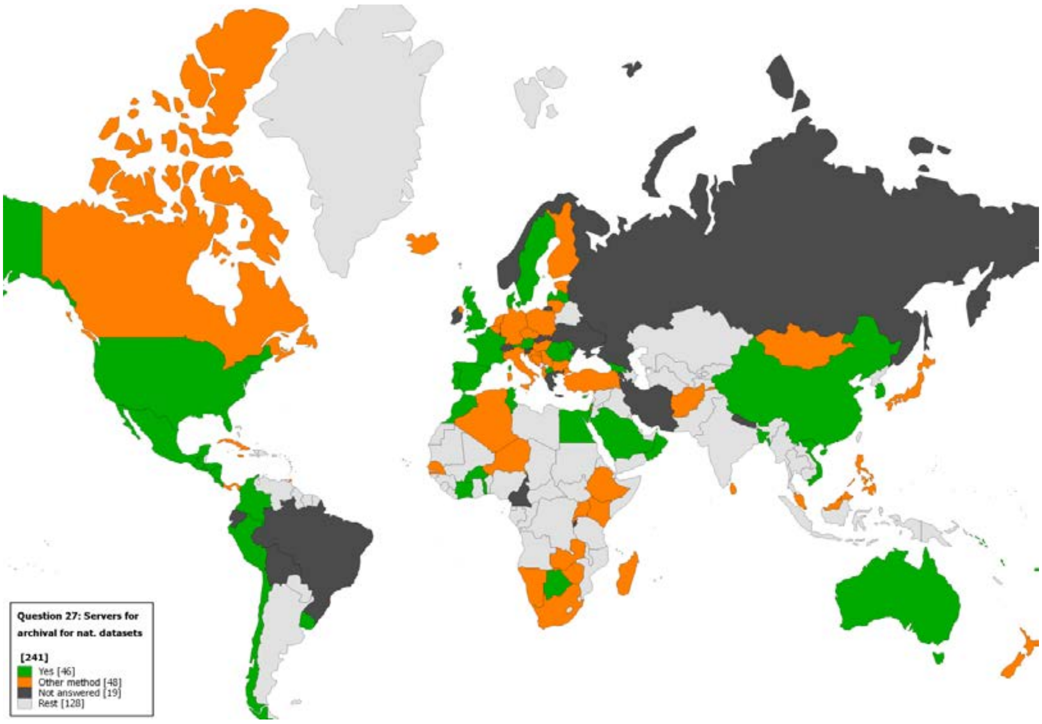


Figure 39: Question 27. Using servers/databases as method of archival for the national data sets

5 MAPPING CONTRIBUTIONS BY PRIVATE INDUSTRY

As has been demonstrated, official and authoritative mapping by governments provides a reliable geospatial infrastructure, which is used for many public and private applications, but which is costly, difficult and slow to maintain. For that reason private enterprises have succeeded to launch several initiatives to provide faster update solutions in areas, which require fast update solutions. These are based on different cost and accuracy models for specific applications, which require fast updates. These applications do not replace official authoritative cartography, but they supplement it, as all such efforts utilize official cartographic products as a base to start their value added operations.

5.1 Google

Google´s prime aim is to provide a location based information system for uses of the public. What the general user wants is quick orientation about how to locate a specific object, such as a landmark, a store, a restaurant or a service provider and how to drive to it.

Geometric accuracy within the context of the neighborhood topography is of lesser importance than the addressability and the access by roads or pathways. In general, business advertising provides for the revenue to establish and to maintain the system.

Google Inc. operates by different projects, of which the following are the most important from the cartographic point of view.

5.1.1 Google Earth

Existing orthophotography coverage with ground sample distances between 0.1 m and 0.5m as well as high resolution satellite imagery overages with ground sample distances (GSD) between 0.5 m to 2 m and beyond provide the geometric background image information, which can be interpreted by the user with respect to the searched objects, such as buildings, roads, vegetation, water surfaces. While ortho images have a high geometric accuracy related to ground features commensurate with the GSD, this is not so for building tops and tree tops. Geometric accuracy even deteriorates more for high resolution satellite imagery, since most of these images have been acquired with inclinations with respect to the vertical, unless stereo imaging permitted the generation of ortho imagery. The coverage is global for all land areas.
Nevertheless, despite some of these shortcomings with respect to official cartography, Google Earth can easily satisfy the geolocation demands for the uses Google Earth has been designed for.

5.1.2 Google Maps

Google Maps is a product usually derived, wherever possible, from authoritative cartography. It has been designed to supplement Google Earth with a cartographic output containing place names, road names and building addresses. It serves the ideal function of superimposing images with line graphics. Even though Google Maps may be derived from authoritative cartography, the feature content is much less elaborate and reduced to the intended geolocation function. The 3 models for creating Google Maps are shown in Figure 40: a) relying on authoritative data in North America, Europe, Australia as “Google Ground Truth” b) Map Maker outsourced, leaving the initiative of mapping using Google Earth to other companies (Africa, Middle East, India) c) “Video Rental” model offering Google Earth imagery to other countries for mapping use (Russia, China).

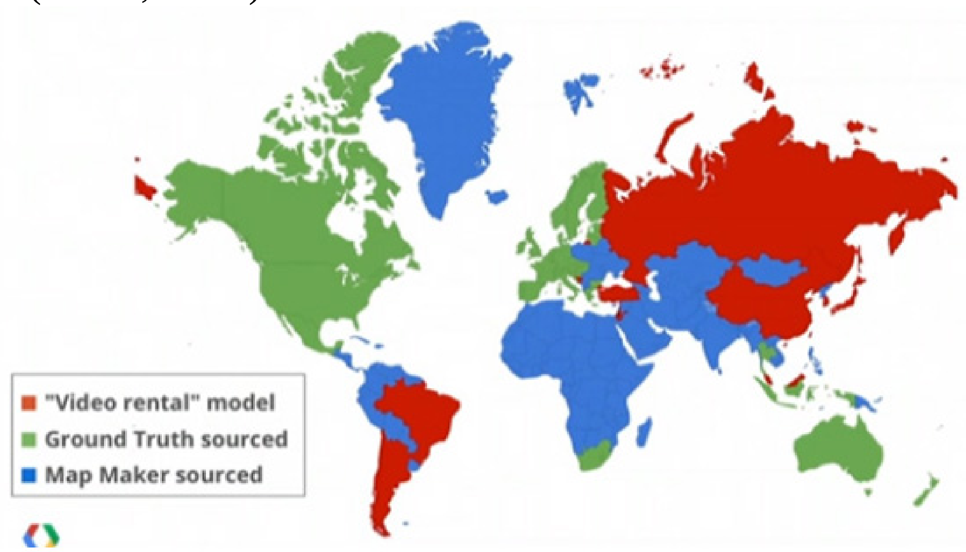


Figure 40: Google Maps

5.1.3 Google Street Map

Google Street Map has been developed as a tool to image buildings and streets with street furniture along urban roadways. This is done by vehicle based cameras, located by GNSS signals. In some communities the imaging of building facades has met resistance by some members of the population, which did not wish to show them to the public on the web. Nevertheless Google has pursued street mapping for the sole reason to update the Google Maps content as an internal operation.
In this manner Google Street Map has proved to be an effective tool to quickly update the Google Maps content for buildings and roads. The update of these features can generally be done much faster than by the regular update intervals for authoritative mapping without a reporting system in operation and without a multitude of fast survey options, rather than by a centralized mapping procedure. For coverage see Figure 41.

Figure 41: Google Street Map Coverage

5.1.4 Google Ground Truth

In the attempt not only to update the map content, but also to maintain a high level of geometric accuracy, the Google Ground Truth project has been launched for a number of countries in North America, Europe, Australia and South Africa, in which authoritative cartography has been merged with the results of high tech operations, such as Google Street Map, see Figure 42.

Figure 42: Google Ground Truth

As Google regards the progress of these projects as a confidential matter, it is not possible to make a more detailed account of the progress made.

5.2 Microsoft Bingmaps

Microsoft considered Google to be their strongest competitor, while Bingmaps has the same objectives as the Google efforts. Therefore care has been taken to achieve a higher resolution and a more accurate geometry than Google Earth.

This was possible by limiting the area of interest to the continental USA and to Western Europe, where there were no flight restrictions. Furthermore, the imagery used for Bingmaps consisted solely of digital aerial imagery flown by the company owned Vexcel Ultracam cameras.

The coverage of the countryside for the USA and for Western Europe was completed at 30cm GSD, and the urban areas were imaged at 15cm GSD. Whether the originally foreseen updates of every 3 years can be achieved as planned, is still an open issue. See Figure 43 (a,b,c,d).

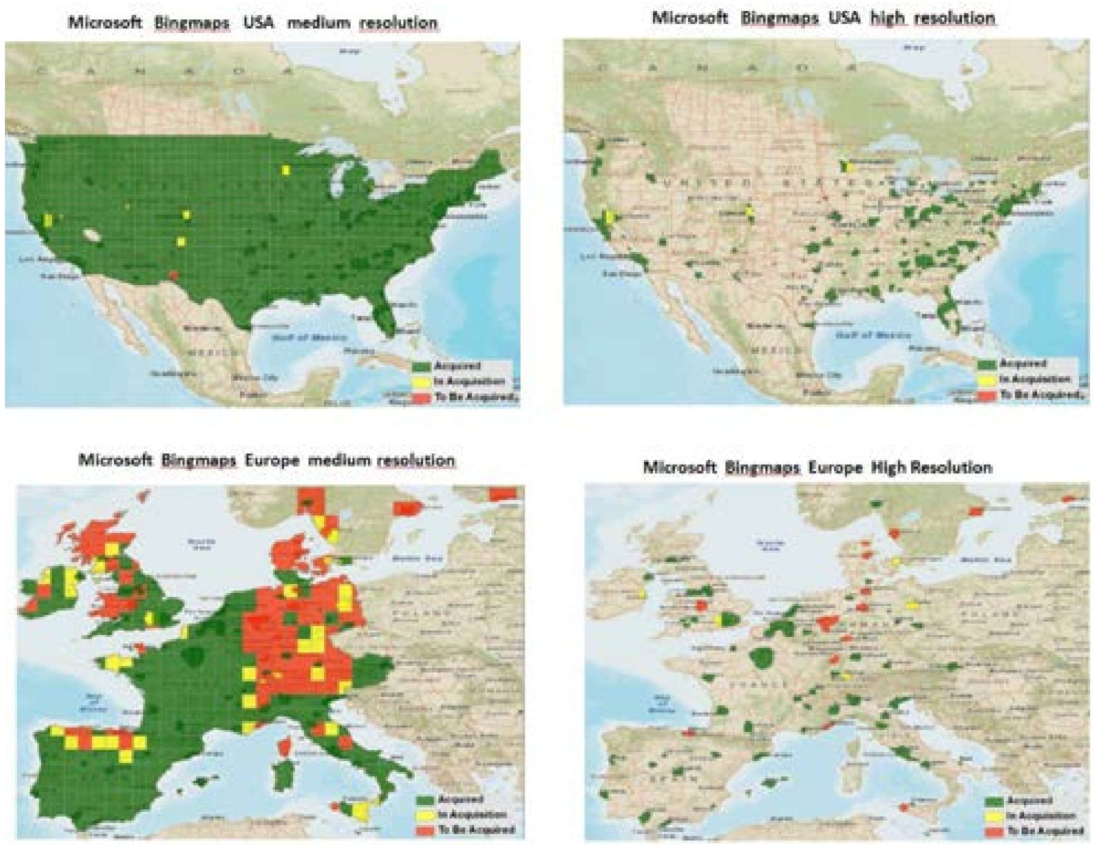


Figure 43: a,b,c,d: Bingmaps

5.3 Yandex

Another approach has been undertaken by Yandex in the Russian Federation, which was also applied in Turkey by the company Yandex.

Yandex has procured high resolution satellite imagery from Digital Globe for the entire territory of the Russian Federation at 0.5m GSD and at 1m GSD. The objects of interest were building blocks, single buildings, roads, creeks. They could be identified and mapped from the images. The geocoding of the mapped information was done by accuracy augmented GNSS code receivers with 2 to 3m accuracy on the ground. In this way Yandex succeeded to generate digital maps for about 300 urban conglomerations in Russia and Turkey.

Yandex, like international car navigation system suppliers, was also interested in car traffic routing, providing real time traffic congestion options for the agglomeration of Moscow.

5.4 HERE

When the Finish company Nokia bought Navteq, the global car navigation system efforts were continued by the subsidiary HERE.

HERE makes car navigation systems based on their own maps for 196 countries of the world, 116 countries of which have voice guided navigation and 44 countries of which with live traffic services.

Of interest are roads and points of interest. This also includes unidirectional restrictions of traffic flows.
In Europe 15% of the map´s content is updated every year, modifying or adding 1.1M km of roads, creating 700 000 new points of interest and adding 600 000 speed cameras.
In the Russian Federation 800 000 km of roads change after 6 months, and so do 120 000 street names, 22 000 turn restrictions, 3400 one way streets, 38 000 speed limits and 8700 directional street signs. See Figure 44:

Here (formerly Navteq)

Figure 44: HERE Global Coverage

5.5 TomTom

TomTom has road navigation coverage for 118 countries extending over North America, Brazil, Argentina, Europe, the Russian Federation, India, Indonesia, Thailand, Australia, New Zealand, West and South Africa. See Figure 45:

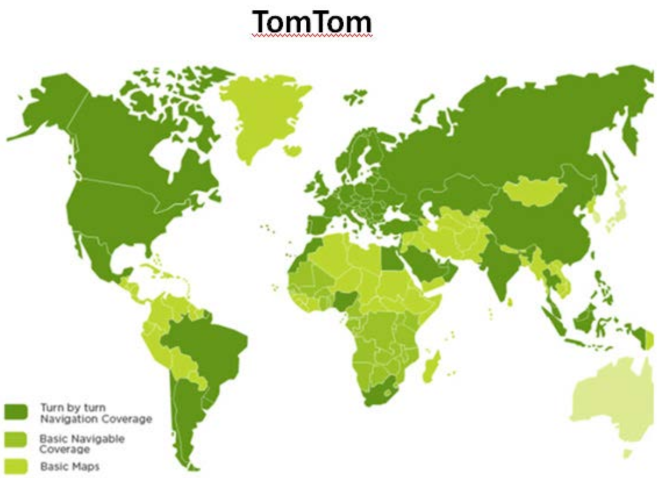


Figure 45: Tomtom Global Coverage

6 MAPPING BY MILITARY ORGANIZATIONS

Like it happened during the cold war period, when the US and the USSR military organizations considered it their goal to conduct mapping operations in what they considered to be crisis areas, this practice was recently revived by about 30 nations from Europe, North America, Australia, New Zealand, Japan, Republic of Korea and South Africa, when they launched the Multinational Geospatial Co-Production Program MGCP. The goal of this program is to generate up-to-date 1:50 000 digital maps for potential crisis areas of the globe in Asia, Africa, the Middle East, the West Indies and the Pacific Ocean. Benefitting from this activity is the UN cartographic section, which utilizes these maps to create information for crisis mitigation. See Figure 46:

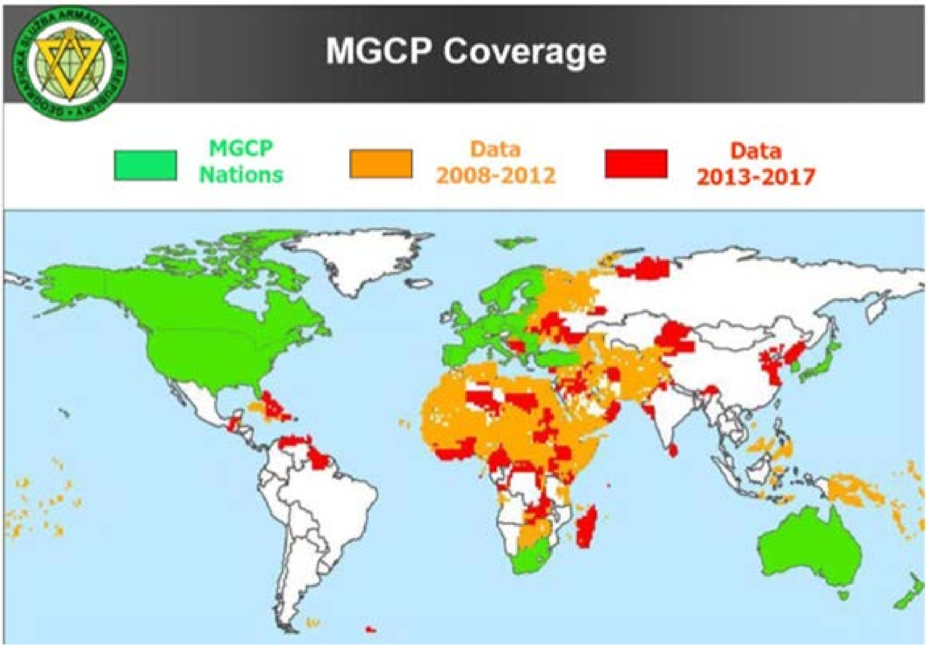


Figure 46: MGCP Mapping Coverage

7 SUMMARY OF RESULTS

- 113 UN Member countries have responded to the 2012-2014 UNGGIM-ISPRS Survey. It has been shown, that nearly all reporting countries have modernized their facilities to adopt modern GNSS, digital imaging and GIS technology in their operations, which are still handicapped by lack of funding and staff shortages.
- While in 1986 the world was basically covered by 1:250 000 maps, progress in technology has now made it possible to state that topographic mapping of the globe at 1:50 000 scale, relevant to sustainable development, has been reached.
- There are still gaps in providing updated information in developing countries. These need to be closed with a goal of no data to be older than 5 years.
- New technologies, such as those used by Google and by Yandex could help to reach this goal in priority areas.

8 FUTURE ACTIVITIES

- ISPRS has created Working group IV-2 to accompany the UNGGIM-ISPRS project.
- This working group has successfully provided the needed discussion forum for the task.
- It will be the future goal of this group to assure that the data collection and analysis will be sustainable by cooperating with UNGGIM and UN-GEO.
- A near goal will be the expansion of the work to include global land cover mapping as a task.

9 REFERENCES

UN Secretariat document E/CONF78/BP7 1986, prepared by A. J. Brandenberger & S.K. Ghosh, published in World Cartography XiX, 1990

UN Secretariat document E/CONF78/BP8 1986, prepared by G. Konecny, published in World Cartography XIX, 1990

UNRESOLVED ISSUES OF MAP UPDATING

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Commission IV, WG IV-2

KEY WORDS: topographic mapping, coverage, status, study, unresolved issues

1. The ISPRS-UNGGIM Study on the Status of Topographic Mapping in the World

ISPRS Working Group IV/2 has undertaken a global survey on the Status of Topographic Mapping in the World. Topographic Mapping is considered as the base for other type of mapping.

The results of the study have been posted on the Internet in the UNGGIM Knowledge Base: ggim.un.org/knowledgebase/KnowledgebaseCategory63.aspx.

ISPRS has also distributed a printed brochure of 64 pages. It is available on the Internet for download under:
http://www.isprs.org/documents/reports/The_Status_of_Topographic_Mapping_in_the_World.pdf.

A shorter version was published in 2016 in the Zeitschrift für Vermmessungswesen und Geoinformation ZFV (January 2016).

2. Results of the Study

1) The progress in global topographic mapping is scale dependent. The larger the scale range, the more detail needs to be mapped, and the more costly the mapping becomes. In 2012 the global land areas are covered to 33.5 % at the scale range 1:25 000, to 81.4 % at the scale range 1:50 000, to 67.5 % at the scale range 1:100 000 and to 98.4 % at the scale range 1:250 000.

2) Progress since the last UN Secretariat survey in 1986, that is within the last 26 years has been very good. The coverages for the 25 000 scale range were then 17.9 %, 49.3 % for 1:50 000, 46.4 % for 1:100 000, and 87.5% for 1:250 000. Chart 1 shows the development at these scale ranges since 1968.

3) Nevertheless the average age of maps in the world for 2012-2015 was 22.4 years for the 1:25 000 range, 26.3 years for 1:50 000, 31.2 years for 1:100 000 and 37.0 years for 1:250 000. Chart 2 shows the ages of maps for the different continents with

the best values for Europe (13.8 years for 1:25 000 in Europe) and for South America (9.8 years for the small mapped areas at 1:25 000). This is due to the fact, that the conventional technologies used for authoritative mapping are still relatively slow. Nevertheless, there has been an improvement since 1986, when the annual update rate was 3.2% for 1:25 000 (equivalent to an age of 31 years), 1.8% (56 years) for 1:50 000, 2.7% (37 years) for 1:100 000 and 3.6% (28 years) for 1:250 000.

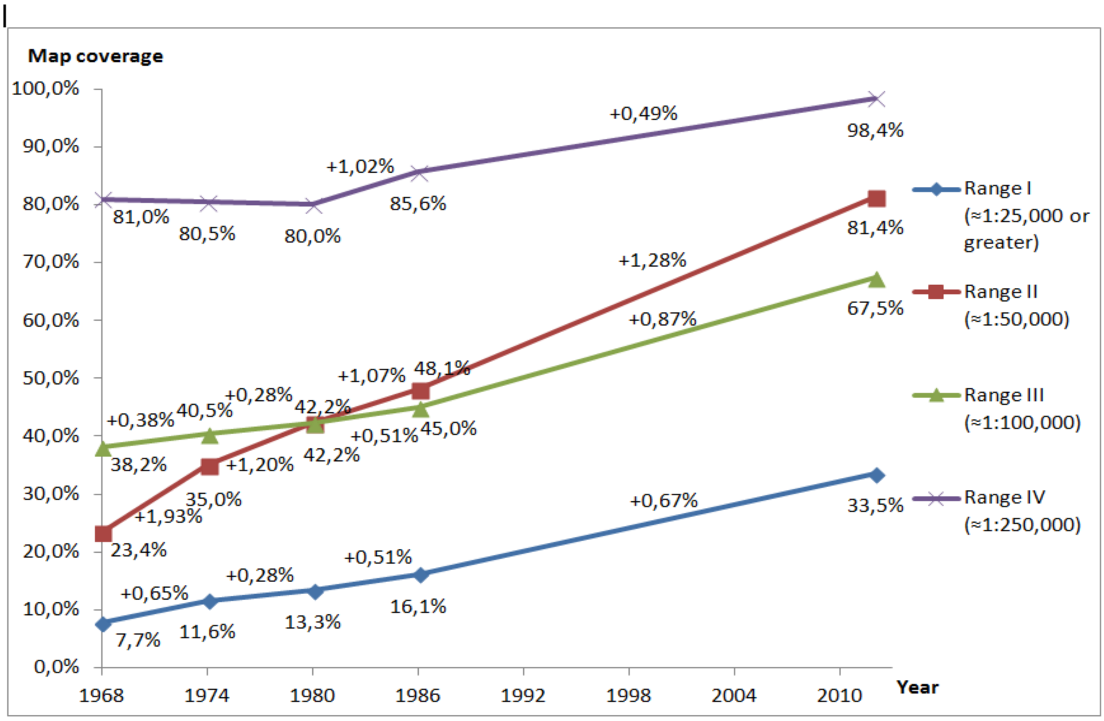
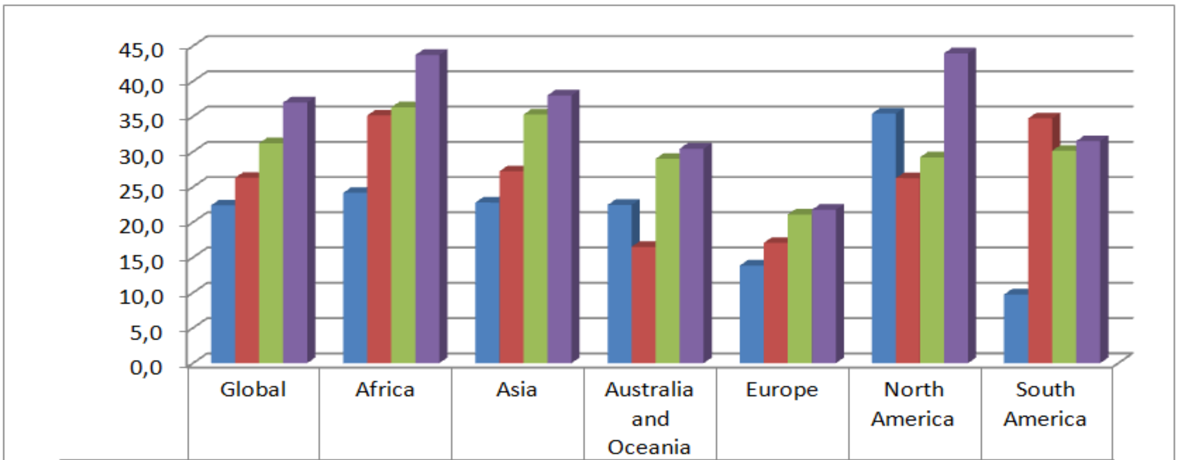


Chart 1: Percentages of total world area covered in each scale category, 1968-1974-1980-1986-2012

update rate 2012



	Global	Africa	Asia	Australia and Oceania	Europe	North America	South America
Range I	22,4	24,2	22,8	22,4	13,8	35,4	9,8
Range II	26,3	35,1	27,2	16,5	17,1	26,3	34,7
Range III	31,2	36,3	35,3	29,0	21,1	29,2	30,1
Range IV	37,0	43,7	38,0	30,4	21,8	44,0	31,5

Chart 2: Average map age in years counting from 2012

4) These studies have all been done for authoritative maps produced by governmental agencies, either by own production or by outsourcing. The possibilities to repeat the mapping effort for a map update were dependent on governmental funding reflecting demand and political decisions.

The important aspect of authoritative mapping has always been its reliability and its accuracy of geolocation. While governmental mapping agencies have always maintained their position as a civilian base data supplier to the user agencies, which enhanced the map and data content for their own purposes despite of their relatively slow mapping progress, the mapping efforts of the private sector have become noticeable. These efforts are less concentrated on accuracy and completeness, but they can diminish the time gap between map compilation and map completion.

5) Here especially high resolution satellite imaging and also progress in digital aerial imaging gave the private sector a head start. Google Earth, Google Maps and Bingmaps have been using this technology to derive geocoded image products very rapidly (Google Earth) and to even derive a limited number of features (roads, buildings) in vector form from the image products (Google Maps). Their feature content could even be verified and enhanced by mobile van terrestrial imaging (Google Street View, Cyclomedia).

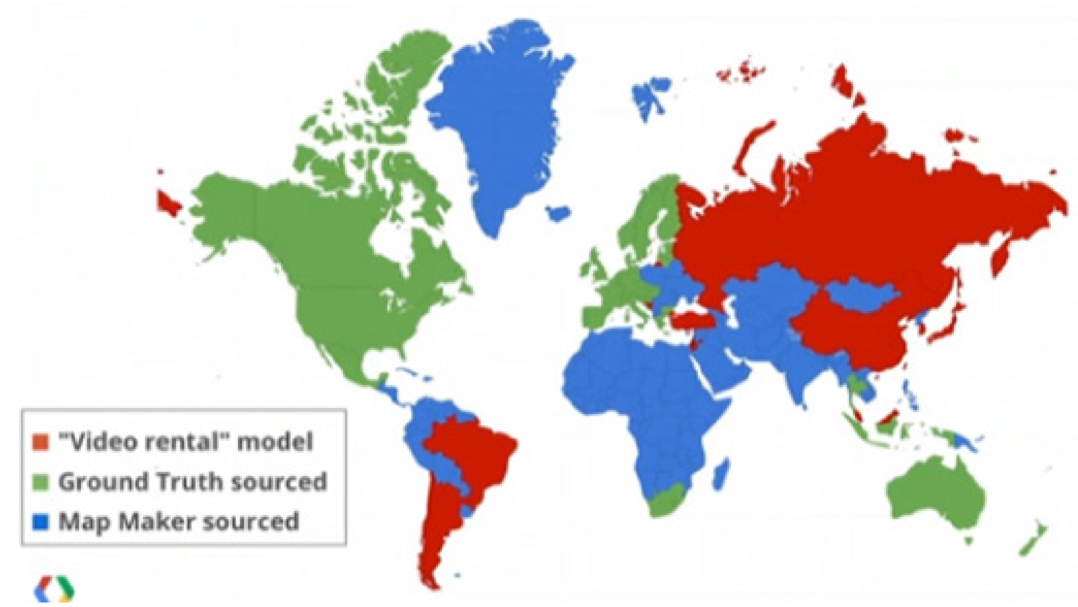


Figure 1: Google Ground Truth areas (green) use authoritative data as a base, the others use other means

Google Street Map

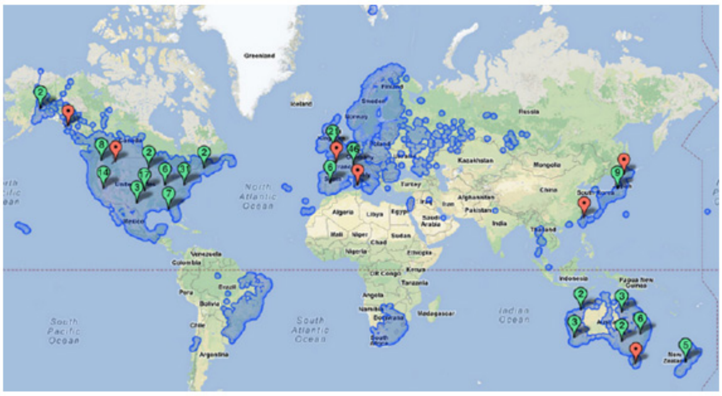
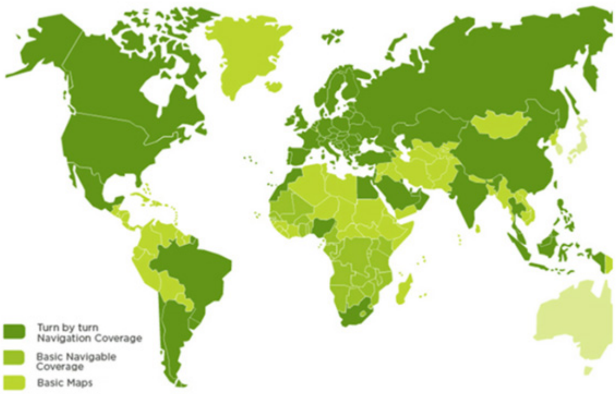


Figure 2: Google Street View is an efficient tool for updating map content

6) Further progress for limited features, such as roads and buildings has been introduced by navigation system providers, such as TomTom and HERE, which added traffic information to their transportation network data.

TomTom



Here (formerly Navteq)

7) Other interesting mapping efforts have been introduced by Yandex in Russia and Turkey, deriving vector information from a combined use of high resolution satellite imagery with ground based GNSS feature localization.

8) These methodological improvements have not only given a significant push to geoinformation technology per se, but they also have generated public use of their data. A recent map user survey made by the State Mapping Administration of the State of Lower Saxony LGLN in Germany has shown that authoritative geodata customers use Google and Tomtom or HERE products in parallel with authoritative data to check feature content and up-to-date status. They appreciate the existence of both public and private data.

9) Google, and to a lesser extent Bingmaps, are global operators. Google relies on the procurement of WorldView 3 or Pleiades images for updates, Bingmaps (now under responsibility of Uber) on Vexcel digital aerial images. Google has even the additional capability to crate local update information by the Skybox constellation of satellites using images or videos. Likewise Tomtom and HERE are global operators, mapping roadways in more than 190 countries.

10) But another more local initiative is the “Open Street Map”, for which map features are compiled by local private operators as their contribution to the user community. Naturally this effort cannot be systematic. It concentrates on a number of regions predominantly in Europe, America, Asia and Australia, but also in Africa.

11) It looks at present, that none of these systems will be able to replace authoritative mapping, but indeed there is a potential for private-public data exchanges for the sake of up-to-dateness and feature content verification.

12) One of the basic advantages, but also difficulties faced by governments in their authoritative mapping effort lies in the fact, that this mapping is the base for operating geographic or land information systems.

In doing so, the governments not only concentrate on the production of map features, but also on the possibility to link a wide range of attributes to the graphic features, such as point, lines and polygons. The analysis in these data systems can be well handled by relational data bases. One of the leading global GIS suppliers is ESRI with ArcGIS.

13) But if the maintenance of the geographic or land information system also requires changes in the feature geometry (new points, new lines, and new polygons) then the modification of relational data bases may become cumbersome, even though FME tools are available to permit a certain amount of object orientation for the data in the relational database, e.g. ArcGIS.

Such object oriented databases are advisable, if their features, such as buildings, parcels or roads need frequent updates, or if the updates are made by very different measurement tools.

The Ordnance Survey uses Oracle Spatial to maintain the object oriented data base for the topographic features at the 1:1200 scale. In the German Survey Administration the operation of a cadastral registration system ALKIS requires object orientation at the 1:1000 scale. But also the topographic database at the 1:5000 scale range level is modelled via UML in object orientation. These are highly sophisticated developments. Their definition and software effort required more than a decade to lead to implementation.

Countries, which do not have the monetary or the intellectual resources to introduce such systems for fast updating will achieve a faster and more effective topographic update possibility with ArcGIS with FME modifications, even if this may be less stringent.

On the other hand it is quite interesting, that GEO Star, a dual use object oriented and relational database has been developed in China.

14) There is rich material available in academic dissertations and publications on geodatabase modelling, but an international discussion of these issues and their importance has been greatly non-existent, even though it plays a role in solving the problem of updating map objects, rather than replacing map content patch by patch. Even Google has not offered an opinion on how to update their databases in public.