A New Approach of Map Quality Evaluation Applied to Khartoum State Survey Authority (Sudan)

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***Abstract*– This study was oriented to develop a new approach for evaluation map products. A new evaluation approach was developed according to existence and satisfaction of the map to the required mapping criteria. Khartoum state survey authority map products were aimed to be evaluated in this work. Map of Kafory block3 area that produced by Khartoum survey authority was selected to be a sample map. In order to apply this new approach, umber of evaluation criteria's were selected and adopting to kafory block3 map. Then, the proposed satisfaction factor was computed and was found to be about 36% of the ideal product. The new developed evaluation method was proved to be simple, easy and applicable by even non-specialist.**

***Keywords*– Map Standards, Quality Control, Quality Assurance and N-Satisfaction Factor**

I. INTRODUCTION

Maps are a graphical (symbolized) representation of geospatial data, that is refer to the location or the attributes of object or phenomena location on earth. Maps help their users to better understand geospatial relationship. Maps give information of distance, direction and area. Size can be retrieved, patterns revealed, and relation understood and quantified. Maps should be simple, clear and convey information efficiently. Map colours and overlays must be legible to the user. Maps should satisfy the basic elements requirements that include the following.

Descriptive Title that comprises a short description about the purpose of the mapand will include: council name/logo, title, name of map, and map sheet reference, which is a shortened form of the map identification number for each map. The title block provides the user with information about the map. The map title is the name of the map and the sheet number.

Legend which is the principal reference to the map symbols, subordinated to the title. However, this is still a key element for map reading describing all unknowns. Only the word "Legend" should be written on the map and not "Map Legend", or "Sudan Legend", etc. The legend should display all the categories of land that are used in that particular map series (e.g., all the zones used on the Land Zoning Map, regardless of whether all are shown on an individual sheet), but does not need to show zones or categories that are not adopted, The legend is set out on the left of the map template when every possible.

Scale, in which the standardized map tile scale will be shown as a unit measure (e.g., 1:40000@ A3) and as a graphic scale bar. Topographic maps of a scale of 1:40,000 are considered large-scale maps, whereas maps of a scale of 1:80,000 or greater are classed as small-scale maps. Large-scale maps show more geographic detail than small-scale maps and require more tiles to cover a geographic area. From a set of standard scales at A3 provided by the department, a selection of suitable scales will be determined by council based on the intensity of urban subdivision and the land use detail.

Projection that allows the map author to represent a portion of the 3-D curved surface of the earth on a flat (or 2-D) piece of paper. Map should include information about map projection used.

North Direction that should be oriented with north facing up the page.While there is no standard for north point. Simple north point, such as 'N' and arrow is preferred over the more ornate, such as a compass rose.

Locality Map which shows the location of areas covered by an individual sheet relative to the rest of a Local Governmental Area (LGA). The suburban LGA boundary should be outlined with a black line. Areas outside the LGA boundaries are to be shown uncoloured. The locality map should display the grids and indicate any map sheet references allocated for map sheets that do not exist at the time when the maps are being prepared. A thick red outline shall be inserted around areas covered by the subject map sheet. In most cases, the locality map should display the whole LGA. However, it is recognized that in some LGAs covering very large geographical areas, the map sheet reference may not be legible on the locality map.

Grid system that help the map user to find places on a map.

Map Index that must be clear and easily to the map user and it may vary from state to state.

Date, to represent the preparation date of individual map sheet.

II. QUALITY CONTROL AND QUALITY ASSURANCE

The definition of quality control (QC) and quality assurance (QA) has been re-framed and re-worded by different quality

experts from time to time. It also varies from industry to industry.

Quality control can be defined as the set of activities performed to ensure that the products or services meet the requirements as defined during the earlier process for assurance of quality. These activities are done during the manufacturing process and once the product is manufactured. Quality control is a detection system that uses a testing technique to identify errors or flaws in products and tests the end products at specified intervals. The main issue of using this system is that if the products are not subject to tests at regular intervals, the cost of tests will outweigh the benefits to the company.

Assurance of quality is a prevention system that predicts almost every thing about product safety, quality standards and legality that could possibly go wrong and then takes steps to control and prevent flawed products or services from reaching the advanced stages of the supply chain. Quality Assurance processes involve implementing real-time quality checks in every department of the company like designing, research, manufacturing and marketing. It is very necessary to treat quality control activities as different from the tasks of assurance of quality due to the following reasons:

- A product that is subject to regular quality control checks will not be entirely successful if the assurance processes that monitor the tests are not efficient.
- Another important fact is that QC and QA tasks must not be assigned to the same person. Since the activities of quality monitoring maintains a smooth progress of quality control functions, delegating these two jobs to one person will result in a conflict of interest.
- It is often found that while some companies concentrate more on quality control, others focus mainly on assurance of quality. For efficient running and quality products, both these processes must be subject to proper evaluation and management.
- To ensure a solid foundation for a well-managed and regulated company, it is essential to understand why it is important to implement quality control and quality assurance activities and how these activities can be successfully accomplished.

To implement quality control for an organization, it needs to identify the steps of the quality assurance process. Some of the major steps of this process are discussed below:

First and foremost, the project manager of the company has to create a team dedicated for quality control. This team will be responsible to evaluate and report on the evaluation regarding every part of the business. The team will be working neutrally and independently having authority and freedom of work, at each point of their operation. This team will be reporting to the senior management of the organization and keeping all results in safe file storage .

Once the team is formed, the main responsibility of the team will be to define the tasks and assign them to respective persons. Some of these responsibilities are to review the products, tools, services as per the requirements, standards and guidelines, audit project processes, suggest various methods, standards or tools to be used in the project, report the outcome of the evaluation etc.

The quality control team then defines the plans for the quality assurance process. Depending upon the nature of business the details of the plan might change, however the basis of the plan remains common for most of the businesses. Mostly the list includes quality objectives, defining the tests and verification activities, process evaluation, defining the individual responsibility of the team member, identifying training requirements, budgeting and funding for quality control jobs, scheduling all activities, documenting and tracking etc.

The next step of this process is to generate the testing procedures, checklists and related activities to explain the way quality control will be performed.

The quality control team now has to perform according to the plan to ensure the next step of quality assurance process.

By acquiring the resources to perform the procedures, the team starts evaluating the project. Tools required for this evaluation are identified depending on the nature of the project.

Any non conformance with the standards or requirement are notified and reported to the appropriate department. The problems are then corrected and again sent for testing to the quality control team. This way, testing and correcting goes on, till the project is proven to be in conformance with the standard.

The next step of quality assurance process is to identify the training requirement for the team members to perform the evaluation processes as specified in the quality control plan.

The performance of the quality control team should be monitored regularly by the project manager against the quality control plan, schedule and budget. In case the progress of the quality control team does not satisfy, then corrective actions should be taken.

The quality control activities and results are reviewed by the senior management of the organization and their stakeholders on regular intervals. Any non compliance or unsolved issue for the quality control procedure is taken care of by the senior management at this point of time.

The team collects review information from various sources. Suggestions for improvement at any step of quality assurance process is accepted and implemented in the next session, if it satisfies the various limitations. Recommendations are accepted from any level of business for future use.

The team refines the total process to give it a defined structure with quality control process descriptions, templates and checklists. This structure can be reused as a model for future or might become an example to other organization

III. SIGNIFICANCE OF QUALITY ASSURANCE/ QUALITY CONTROL

QA/QC is an integral factor in the data collection task and cannot be sacrificed to expediency or false economy.

A relatively limited QA/QC effort is usually directed toward field tests to verify the quality of final mapping products. As a consequence, credible judgment must be exercised by both mapper and user in designing a mapping

project so that the accuracy of the final output adheres to reliable tolerances.

Quality control should be the watchword of the mapper who is obligated to institute professional quality control procedures. Quality assurance should be ascertained by the user who is committed to performing quality assurance assessment measures.

IV. SUDAN NATIONAL STANDARD FOR SPATIAL DATA ACCURACY

The Sudan National Standard for Spatial Data Accuracy (NSSDA) implements a statistical and testing methodology for estimating the positional accuracy of points on maps and in digital geospatial data, with respect to georeferenced ground positions of higher accuracy testing methodology and reporting requirements.

The NSSDA uses root-mean-square error (RMSE) to estimate positional accuracy. RMSE is the square root of the average of the set of squared differences between dataset coordinate values and coordinate values from an independent source of higher accuracy for identical points.

Accuracy reported at the 95% confidence level means that 95% of the positions in the dataset will have an error with respect to true ground position that is equal to or smaller than the reported accuracy value.

Accuracy test guidelines according to an independent source of higher accuracy are the preferred test for positional accuracy. Consequently, the NSSDA presents guidelines for accuracy testing by an independent source of higher accuracy. The independent source of higher accuracy shall the highest accuracy feasible and practicable to evaluate the accuracy of the dataset. The data producer shall determine the geographic extent of testing. Horizontal accuracy shall be tested by comparing the planimetric coordinates of well-defined points in the dataset with coordinates of the same points from an independent source of higher accuracy.

Vertical accuracy shall be tested by comparing the elevations in the dataset with elevations of the same points as determined from an independent source of higher accuracy. Errors in recording or processing data, such as reversing signs or inconsistencies between the dataset and independent source of higher accuracy in coordinate reference system definition, must be corrected before computing the accuracy value.

NSSDA also has its own requirements and standards for cartographic work including map design and layout.

V. A NEW EVALUATION APPROACH

This new evaluation approach is simply based on identifying the suggested map requirements and their criteria's first according to whatever specification in hand. Then, applying evaluation criteria's to the map product under evaluation. As a result, three cases may expected; first; existence of the map requirement according to the specification criteria, i.e., satisfying the map standards. The second case may arise is the case of existence of the map requirement but unsatisfying the map standards. Finally, the third expected case is the complete absence of the map requirement. In order to numerically describe these three cases, 2, 1 and 0 points are suggested to be given to each case successively.

Table 1: Sudan National mapping Standard

Map Scale	Horizontal Accuracy RMSE (m)	Vertical Accuracy (m)	Contour Interval (m)
1:50	0.0125	0.0020	0.0125
1:100	0.025	0.0042	0.025
1:200	0.050	0.008	0.050
1:250	0.063	0.016	0.063
1:500	0.125	0.020	0.125
1:1,000	0.25	0.042	0.250
1:2,000	0.50	0.083	0.50
1:2,500	0.625	0.104	0.625
1:5,000	1.25	0.208	1.25
1:10,000	2.50	0.417	2.50
1:25,000	6.25	1.25	6.25
1:50,000	12.5	2.083	12.5
1:100,000	25.0	4.00	25.0
1:250,000	62.5	12.5	62.5
1:500,000	125.0	25.0	125.0
1:1,000,000	250.0	50.0	250.0
1:4,000,000	1200.0	200.0	1200.0

Final evaluation can be done by computing a factor suggested to be called N-satisfaction factor. This factor is a percentage ratio of the summation of the map points to the points of the ideal case.

Acceptance and rejection criteria are based on the level of N-satisfaction factor that assigned by mapping agency.

VI. MEASUREMENTS AND RESULTS

This research work was oriented to evaluate the Khartoum survey authority maps products compared with national survey authority standard applying the new developed approach. In order to do this, a part of Khartoum map covering Kafory block3 was selected to be a sample map. Requirements for number of map elements were selected, studded, and evaluated. These elements included horizontal accuracy, layout, cartography information, and map design.

To evaluate the accuracy of the map, ten well distributed identifiable points were selected on the map to be as check points. Their map coordinates were measured in the office directly from the digital map. The actual ground coordinates were then measured in the field using Trimble 5800 GPS receiver applying real time kinematic technique. Results of office and field observation are listed as shown in Table 2:

Table 2: Measure and actual coordinates

Point	E map	N map	E exist	N exist
1	453986.972	1731106.865	453986.182	1731102.865
2	453952.872	1731096.865	453953.170	1731096.666
3	453952.872	1731116.865	453952.872	1731116.865
4	453669.372	1731401.865	453670.267	1731399.440
5	453733.399	1731361.910	453735.636	1731359.628
6	453945.375	1731406.880	453945.560	1731407.052

7	454006.361	1731472.030	454008.693	1731474.269
8	453845.393	1731321.862	453846.671	1731321.701
9	453845.343	1731541.864	453845.553	1731539.626
10	454028.880	1731641.890	454029.159	1731641.518
RMSE X		1.166m		
RMSE Y		1.932m		
RMSE XY		3. 792m		
NSSDA map tolerance		0.5m		

The other stage is to evaluated cartographic work of the maps under study. In order to do this, eighteen map elements were selected and evaluated. These map elements include the cartography maps stander such as north direction, title, legend ... etc. Suggested point grading was applied as shown in Table 3:

Table 3: Evaluation criteria and its points

No.	Evaluation criteria	Points
1	NSSDA accuracy scale	0
2	Map Title	2
3	North Arrow	2
4	Scale	2
5	legend	1
6	Georeference	1
7	Colour	1
8	sheet Number	0
9	Map Index	1
10	Grid	0
11	Overlapping	1
12	Reliability	1
13	Elevation	0
14	Glossary	0
15	Conversion of elevation	0
16	Magnetic declination	0
17	Lettering	1
18	Source of data	0
Total points		13
Ideal points		36
N-Satisfaction Factor		**36%**

VII. CONCLUSION

Quality control requirespointing out reference standard criteria's then, applying a specificevaluation method. By referring to the new evaluation method developedand applied to Khartoum state survey authority and results obtained, the following conclusions can be pointed out:

- The new mapping evaluation method based on a percentage N-satisfaction factor proved to besimple, easy to understand, successfully applied.
- Khartoum survey authority map products represented by Kafory block3 map provide 36% N-satisfaction factor according to NSSDA standards.
- About 40% of the map requirements do not presented on the map.
- Only about 38% of the map requirements are presented but do not satisfy national specification.
- Absent of mapping quality control section in Khartoun survey authority negatively affecting map products.

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