Spatial Data Quality Model for "Fit- For- Purpose" Methodology in Colombia

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Key words: Land Administration, Fit for Purpose, data quality, positional accuracy

SUMMARY

In Colombia the modernization of the Land Administration starts with the Peace Agreement in 2016. At the same time new policies given by the national government around cadaster, land tenure and land titling has been produced in order to have updated information in these topics.

In this way, the Spatial Data Infrastructure for Land administration is created, to standardize and to support the administration of the land information of the country (ICDE-AT, 2017). Therefore, one of the challenges is to have standardized data with the quality required according the technical specifications.

The Universidad Distrital of Bogotá (Colombia) through the research group NIDE has been working together with Kadaster and ITC (University of Twente of Netherlands), to test the Fit for Purpose (FFP) methodology in 2 municipalities in Colombia focused on land titling. In this way and aiming that different users can access and use the spatial data of the boundaries of the rural parcels acquired in field using FFP, It is important to determine the quality of this data.

Due the fact the FFP methodology still does not have technical specifications that fit in the Colombian cadastral requirements and standards and support data quality measurement, it is essential to build a FFP spatial data quality model in order to ensure the reliability of the information.

The aim of this paper is to present the FFP spatial data quality model, that includes the Technical Specification profile, to measure the positional accuracy criterion of the parcel boundaries data, acquired with "Fit for Purpose" methodology, focused on land titling in Colombia and based in the standard ISO 19157:2013.

The products of the project are the FFP quality data model that includes a profile of technical specifications for FFP in Colombia, and the results of the measurement the positional accuracy of the spatial boundary data collected in the field.

RESUMEN

En Colombia, la modernización de la Administración de Tierras comienza con el Acuerdo de Paz en el año 2016. Al mismo tiempo, el gobierno nacional generó nuevas políticas sobre el catastro, la tenencia y la titulación de la tierra con el fin de tener información actualizada sobre estos temas tan importantes para el desarrollo del país.

De esta manera, se da inicio a la creación de la Infraestructura de Datos Espaciales para la Administración de Tierras ICDE –AT, para estandarizar y apoyar la administración de la información de la tierra del país. Por lo tanto, uno de los desafíos es tener datos estandarizados con la calidad requerida de acuerdo con las especificaciones técnicas.

La Universidad Distrital de Bogotá (Colombia) a través del grupo de investigación NIDE ha estado trabajando junto con Kadaster y el ITC (Universidad de Twente de Holanda), para probar la metodología *Fit for Purpose* (FFP) en 2 municipios en Colombia, enfocados en la titulación de tierras. De esta manera y con el objetivo de que diferentes usuarios puedan acceder y utilizar los datos espaciales de los límites de las parcelas rurales adquiridas en el campo utilizando FFP, es importante determinar la calidad de estos datos.

Debido al hecho de que la metodología FFP todavía no tiene especificaciones técnicas que se ajusten a los requisitos y estándares del catastro colombiano, que respalden la medición de la calidad de los datos, es esencial construir un modelo de calidad de datos espaciales FFP para garantizar la confiabilidad de la información.

El objetivo de este trabajo es presentar el modelo de calidad de datos espaciales generados con la metodología FFP, el cual incluye el perfil de especificación técnica, para medir el elemento de calidad de exactitud posicional, de los datos de límites de parcelas, adquiridos con la metodología "*Fit for Purpose*", con fines de la titulación de tierras en Colombia y basado en la norma ISO 19157: 2013.

Los productos del proyecto son el modelo de datos de calidad de FFP que incluye un perfil de especificaciones técnicas para FFP en Colombia y los resultados de la evaluación de la calidad de la exactitud posicional del conjunto de datos espaciales.

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1. INTRODUCTION

The Colombian national policies related to land tenure in the last 20 years has been inadequate then the country nowadays has a weakened cadaster, which main aim is the fiscal approach. Therefore, in last two years the government has been working in the development of new policies focused on the creation of the multi-purpose cadaster, that supports the formalization of property and the adoption of effective procedures for land data acquisition, to solve the problems of land titling in a flexible and low-cost way, particularly in rural areas (CONPES 3859, 2016, p. 4).

The peace agreement in Colombia produced an international interest in supporting this process and in contributing to peace-building, especially in the areas affected by the conflict. In this way some methodological proposals are put forward to support the policies, established regarding peace, one of them is "Fit for Purpose" (FFP).

In the Colombian context, the Fit for Purpose (FFP) methodology has been implemented through several pilot projects, where governmental organizations such as Instituto Geográfico Agustín Codazi (IGAC), Agencia Nacional de Tierras (ANT), Superintendencia de Notariado y registro (SNR) and academic institutions as the Universidad Distrital Francisco José de Caldas have been join efforts, for testing this methodology in the Colombian reality, taking into account that they are the responsible for the decision making procedures regarding the management and legislation on the use and ownership of land in the country. This implementation has been leading by Kadaster of Netherlands in the frame of a MoU between them and the Universidad Distrital Francisco José de Caldas.

Nevertheless, a problem arises in the implementation of FFP in countries such Colombia that has rigid rules regarding data acquisition procedures for land administration, especially in the terms of quality of data. For this reason, it is necessary to determine how to monitor and measure the quality of the data generated by FFP methodology Lemmen, C., Enemark, S., Clifford Bell, K., & McLaren, R. (2014), to ensure the accomplished of the technical specifications given by IGAC for cadastral survey in Colombia.

The objective of this paper is to show the results of the creation of a quality model for FFP methodology in Colombia, and the measurement of the positional accuracy for the data collected in the Vereda Los Mandarinos (Apartadó, Antioquia), based on the ISO 19157 standard, to meet the requirements of the Spatial Data Infrastructure for Land administration in Colombia.

2. DATA QUALITY AND FFP

FFP methodology includes the application of gradual quality upgrades, which must guarantee the integrity of the total coverage of cadastral data with adequate quality, “completeness of Land Administration coverage with adequate quality must prevail over partial coverage with high land registration quality”. Therefore, the capture and recording land information must be maintained permanently and if it is possible gradually reaching the highest levels of quality (Saers, Meijer, & Molendijk, 2017).

According to Saers and Others, FFP considers five levels of quality: Quality Level 1, Recording of Land Interest; Quality Level 2, Recording of Land Claim; Quality Level 3, Recording of Recognition; Quality Level 4, Registered Land right: Quality Level, Published Land Right.

In Colombia FFP is focused to Land Titling, for this reason it is possible start with basic quality in the levels one to four and in level five make improvements in order to get the optimal quality.

3. PRODUCT LIFE CYCLE

The spatial quality model of FFP is based on the NTCA_01002, which defines the product life cycle as an important component of the quality of the product, and comprises five stages as follows: (Figure 1) (Comisión Interdepartamental Estadística y Cartográfica, 2011)

- Conceptualization stage. It is related with the definition of needs and demands of the desire product and describes the general product features.
- Design stage. Define the product as a whole, including checking its effectiveness the definition of the quality model, guiding processes, production methods and control.
- Production stage. based in the Product Specifications (Technical specifications)
- Stage of preparation for exploitation. Definition of the activities for the before the exploitation of the product itself.
- Exploitation stage. define the activities after the production, it refers to the use to geographic information or to the product itself.

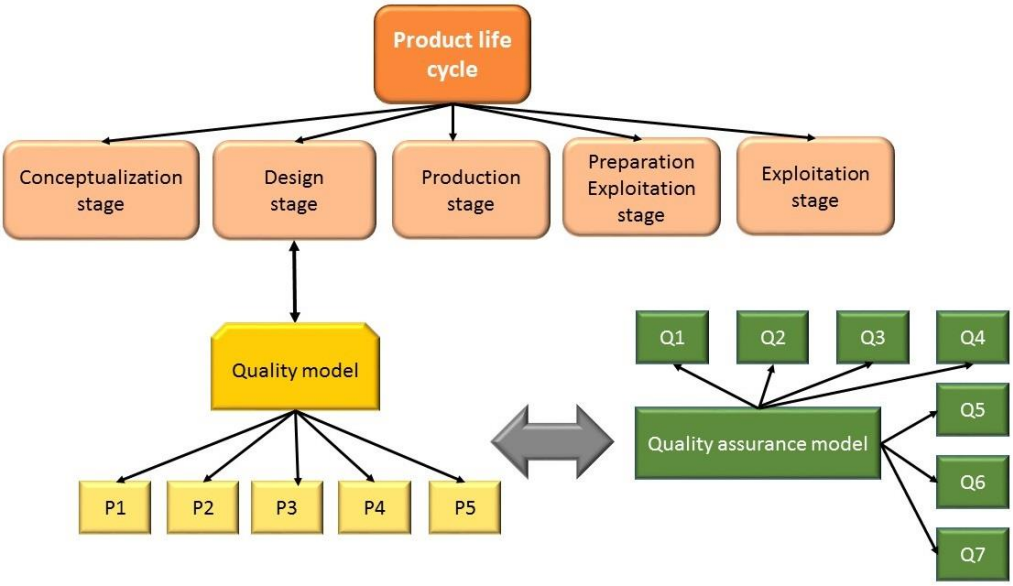


Figure1: Product life cycle
Source: Model of quality assurance of Andalucia

For FFP we consider the product as the data collected in field, focused to land titling. In this way the information is basically parcel boundaries and the legal rights. The product must be created based on the LADM-Col profile defined by IGAC for the multipurpose cadaster of Colombia.

4. FFP QUALITY MODEL

The FFP quality model is defined as a model of describing the quality of spatial data set, according to the technical specifications, applying at the Colombian cadaster and based on ISO 19157:2013 standard. The conceptual model of FFP quality model includes three components according to ISO 19157:2013: requirements, conformance and evaluation process (Figure 2).

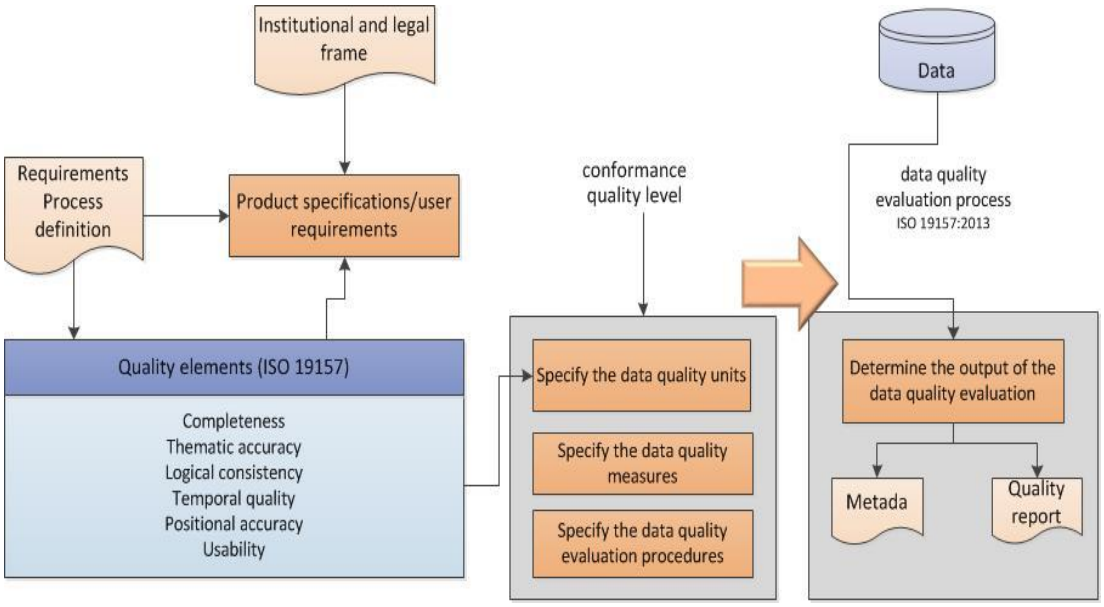


Figure 2: Data quality model
Source: (ICDE, 2017)

In the same way, the quality assurance model comprises of five types of conformance:
Q1, Q2 and Q3: Conceptual quality assessment
Q4: Internal product evaluation
Q5: Evaluation against the real world
Q6. Evaluation of user satisfaction in the exploitation of the product
Q7: Evaluation of the effective use of the results of the previous levels in the improvement of the product over time

Table 1 shows the types of conformance applied in the FFP quality model assurance, for this part of the project, we do not consider the Q5, Q6 and Q7 evaluations.

Table 1: Types of conformance and FFP

Types of conformance	Description	FFP quality model
Q1	Compliance with general guidelines and strategies	Fit for Purpose approach Multipurpose cadaster: (Ley 1753 de 2015, art. 104) CONPES 3958
Q2	Compliance with the basic model	Profile ISO19152 LADM for FFP pilots
Q 3	Compliance against specific requirements	Fit for Purpose approach Technical specifications for cadastral survey IGAC (positional accuracy) (IGAC 2019)
Q4	Internal product compliance	Technical specifications for cadastral survey IGAC (positional accuracy) Quality assessment implementation guide - ICDE (positional accuracy) (ICDE, 2017)
Q5	External product compliance	N/A
Q6	Compliance in exploitation	N/A
Q7	Conformity in continuous improvement	N/A

5. Technical Specifications Profile "Fit For Purpose" methodology

To measure the quality of the positional accuracy element, it was created the profile of the technical specifications for the "Fit For Purpose" methodology, based on ISO 19152: 2013 and using the guide established by ICDE for this purpose (ICDE 2017). The first version of the profile is a component of the quality model of the FFP methodology and from this specification; it is possible to measure the quality of FFP data. Following are presenting the most relevant elements of this profile (ICDE, 2017):

Title	Technical Specifications of "FIT FOR PURPOSE" methodology in Colombia
Spatial representation	Vector
Spatial Reference System	WKID::4686 GCS_WGS_1984 Datum: D_WGS_1984
Spatial Data quality	DQ_Positional Accuracy, ISO 19157 Absolute External Positional Accuracy ISO 19157
Conformance quality level	A,B,C,D
Data quality measure	CE90, ECPM
Data quality evaluation procedures	Internal Direct Evaluation
Result Scope	Conformance Result: Boolean, True or False

6. Quality evaluation process

Since one of the most important concern, for the multipurpose approach in the Colombian cadaster, is the evaluation of the accuracy of the data; in this project we implement the data quality evaluation process, applying ISO 19157:2013 standard, for the "absolute positional accuracy element" of the spatial data set regarding the vereda los Mandarinos (Apartadó-Antioquia) using FFP methodology (Figure 3).

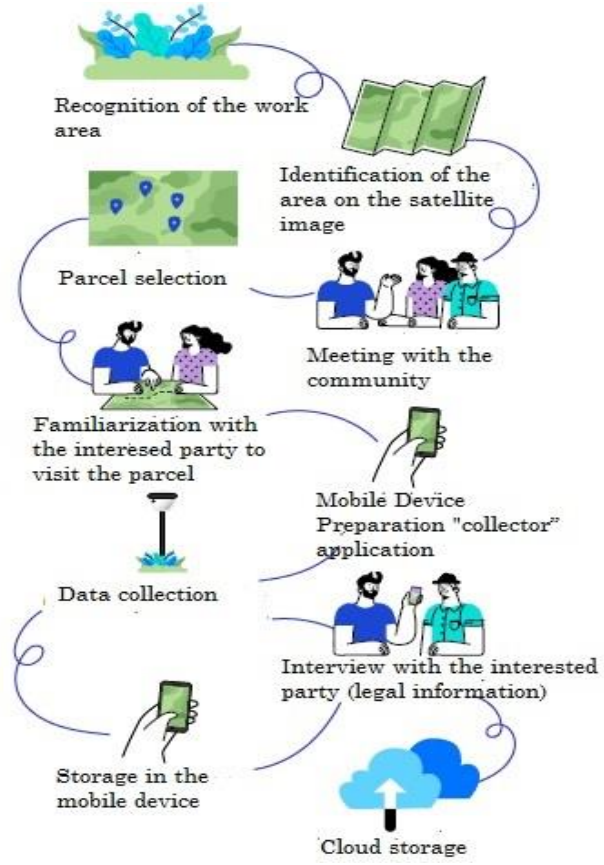


Figure 3: FFP methodology
Source: Cartilla metodología FFP

6.1 Quality evaluation procedure for Positional Accuracy

The quality evaluation procedure to measure the positional accuracy for FFP data, is the following:

- Selection from the databases the raw data and the topologically structured data of “Los Mandarinos” (Figure 4).

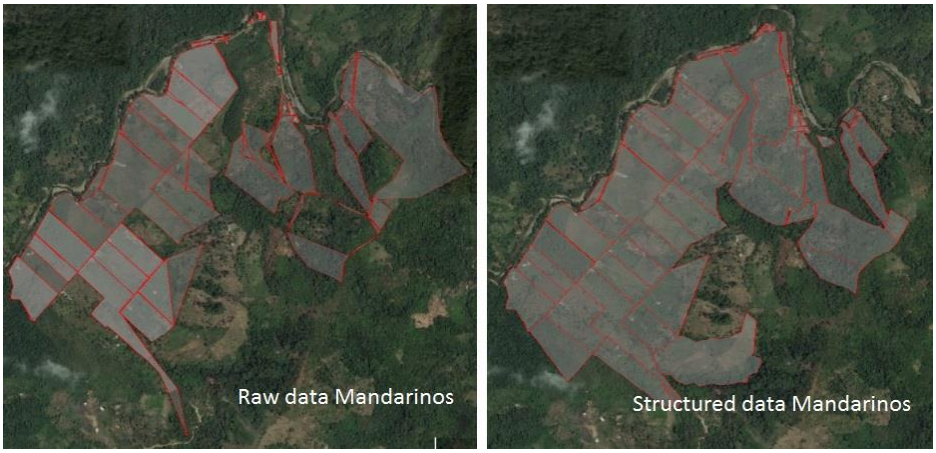


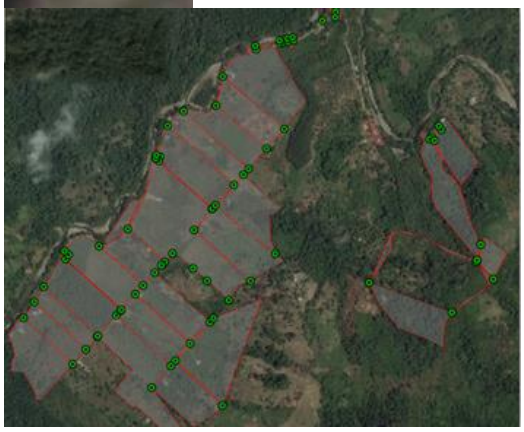
Figure 4: Spatial data set of Los Mandarinos

- Sampling Criteria

Boundary points adquired by field measurements. (Excluding points, were edited or captured using another different source).

At least 1 point (vertex) consisting of minimum 2 measurements

The Data of the sampling is distributed homogeneously in the data set



- Projecting the points of the sample, to Cartesian coordinate system Gauss-Krüger

- Apply quality measures for each edge point “CE90” y “ECPM”, ISO 19157:2013. This procedure was applied to 52 boundary points.

$$\sigma_x = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_{mi} - x_{ti})^2} \quad \sigma_y = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(y_{mi} - y_{ti})^2}$$

$$\frac{2{,}146}{\sqrt{2}}\sqrt{\sigma_x^2 + \sigma_y^2}$$

CE90 - Source: (Comité Técnico AEN/CTN 148, 2014

$$\sigma = \sqrt{\frac{1}{n}\sum_{i=1}^{n}\left[(x_{mi} - x_t)^2 + (y_{mi} - y_t)^2\right]}$$

ECPM Fuente: Comité Técnico AEN/CTN 148, 2014

- Classify the border points according to following classes (Table 2):

Table 2: Classes ECMP and R

Class	ECMP (m)	Radio (m)
A	[0-0,30]	[0-0,50]
B	[0,30-0,60]	[0,50-1]
C	[0,60-1,5]	[1-2]
D	[1,5-3]	[2-3]

East_Xti	North_Yti	East_xmi	North_ymi	ECMP	R	CLASS R	CLASS ECMP
1053220,625	1370541,887	1053220,789	1370542,068	0,211936887	0,321603873	A	A
1053220,625	1370541,887	1053220,525	1370541,746				
1053011,044	1370440,833	1053011,141	1370440,936	0,122247493	0,185504599	A	A
1053011,044	1370440,833	1053011,004	1370440,742				

- Conformance Result

  It is established for each point that meets the characteristics of the previously established classes. The Control method and non-parametric statistical base, allow to support or reverse the hypothesis and is based on proportions, percentiles and error counting.

  Classes A, B, C and D establish a quality classification to discriminating different levels of data quality. In this way, at least the 90% of the points must have a classification so the data set can be considered reliable and conforming (Table 3).

Table 3: Conformance Result

East_Xti	North_Yti	East_Xmi	North_Ymi	ECMP	R	CLASS R	CLASS ECMP	CONFORMANCE	CONFORMANCE
1053220,625	1370541,887	1053220,789	1370542,068	0,211936887	0,321603873	A	A	TRUE	96,154%
1053220,625	1370541,887	1053220,525	1370541,746						
1052497,006	1369517,562	1052497,655	1369517,192	1,031437744	1,565156393	C	C	TRUE	
1052497,006	1369517,562	1052495,982	1369518,284						
1052750,082	1369380,767	1052750,869	1369379,815	1,290192076	1,957803452	C	C	TRUE	
1052750,082	1369380,767	1052749,298	1369381,857						
1052677,53	1369302,062	1052678,861	1369299,588	2,530324987	3,839644568	FALSO	D	FALSO	
1052677,53	1369302,062	1052679,654	1369301,43						

The result of the evaluation of the data quality of Los Mandarinos, indicates the 96.154% of 52 boundary points achieve the established level of conformance (90%), therefore the product is conforming.

CONCLUSIONS

The purpose of describing the quality of FFP data is to show how the data set, best suited to application needs or requirements of the standards for multipurpose cadaster in Colombia. In this way the data quality model for FFP approach was successfully created, and allows to evaluate how well a data set meets the criteria of the product specification.

The technical specification profile for the positional accuracy quality element was an important issue for the project and permitted to evaluate the quality of the dataset according to the national standards and the ISO 19152 and ISO 19157.

The result of the quality evaluation of the FFP data set was very successful and showed that the accuracy of the FFP data set meets the requirements of the technical specifications for positional accuracy for cadastral survey in Colombia. For further research could be important the evaluation of the other quality elements of the 19157 ISO standard.

The FFP data quality model, is essential for the implementation of the FFP methodology in Colombia, because is the tool to control the quality of the data. It also helps to normalize the data, in order meet the Land Administration Spatial data infrastructure necessities and to ensure the access and usability of this information by the national organizations related to the land in Colombia.

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BIOGRAPHICAL NOTES

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