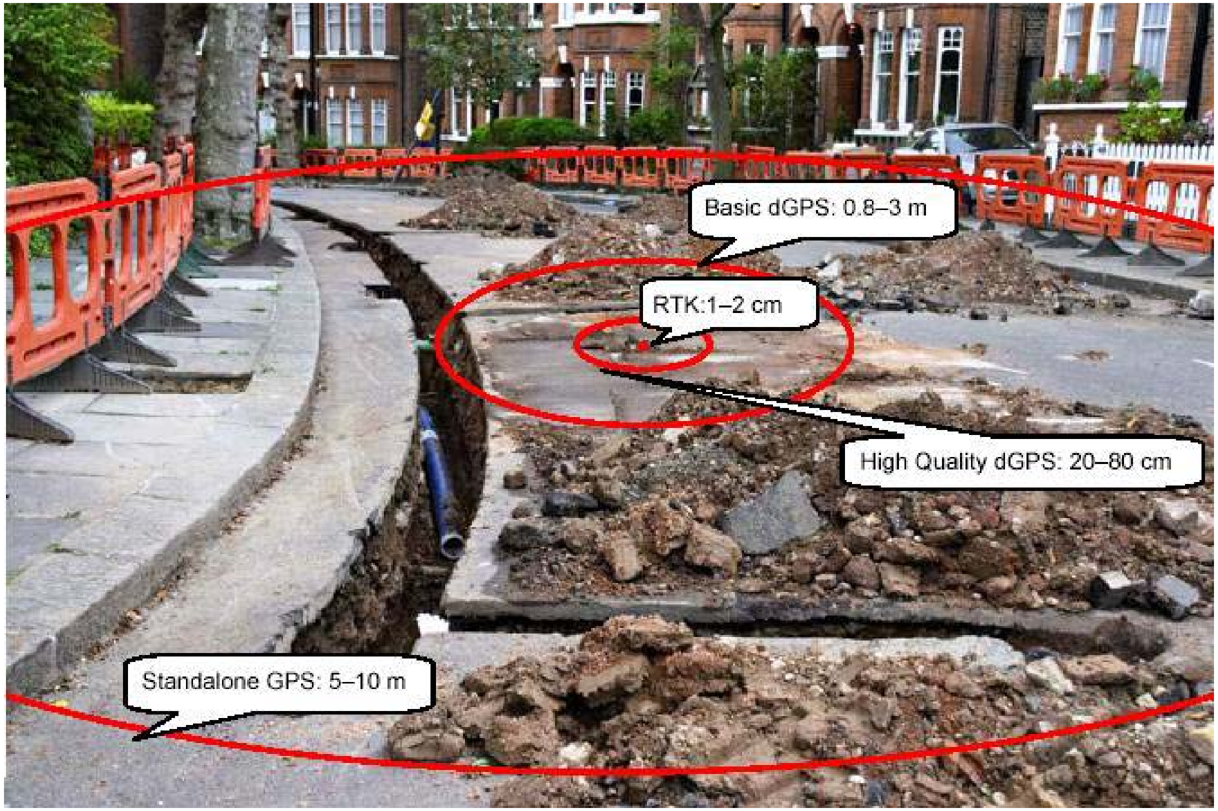

eurogeographics

PLENARY MEETING OF THE QUALITY KNOWLEDGE EXCHANGE NETWORK

Madrid October, 2015

Presentation of the proposal of the Spanish Standard UNE 148002 for Positional Accuracy Control


norma española

UNE 148002

Septiembre 2014

TÍTULO

Información Geográfica

Control de calidad posicional de datos espaciales

Asociación Española de Normalización

Comité Técnico Normalización 148

Información Geográfica

AENOR

AEN/CTN 148

Speaker

Francisco Javier Ariza López

fjariza@ujaen.es
953 212 469
Universidad de Jaén
www.ujaen.es
Departamento de Ingeniería Cartográfica, Geodésica y Fotogrametría
Escuela Politécnica Superior / Campus de las Lagunillas S/N / 23.071 Jaén

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Objectives

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- Why? —> Why we introduce a new method?
- How ?—> How this new method works?. We Present the relevant issues of the method (ISO 2859, coupled model…)
- What ?—> What is proposed by this new method. We present the relevant issues of the proposal (UNE 148002)

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Content / Program

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- **Introduction & concepts**
- **Analysis of Positional Accuracy Assessment Methods (PAAMs) (Problems)**

Why?

- **Objectives for the new method**
- **ISO 2859-1 & ISO 2859-2**

  Iso 2859-1 & ISO 2859-2

- **Adaptation for dealing with positional errors**

  Two examples: lot by lot, isolated lot

  Pros & Cons of the adoption of ISO 2859-1 e ISO 2859-2

How?

- **The proposal 148002**
- **Future works**

What?

Importance

Importance of position/location

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Positional accuracy is now of great importance

In general:

- Increase of use of GI implies increasing demand of quality.
- SDI need interoperability.
- GNSS allow everybody to get coordinates.

Demanding applications:

- Intelligence.
- Military applications (eg weapons and missiles)
- Unmanned vehicles (UA).
- Navigation.
- Precision farming.
- Etc.

Importance

Importance of position/location

- Renewed importance due to positioning techniques (GNSS, GPS, INS, etc.).→ Precise positioning.
- Importance of new surveying techniques (LIDAR, etc.).→ Precise capture, non normally distributed data.
- Importance of interoperability requirements.→ Data integration and precise uses.
- Seamless continental applications. → Absolute positioning.

REACTION:

→ **Positional accuracy improvements programs (PAI):**
Germany, Australia, EEUU, France, UK, Switzerland …

→ **Revision of the PAAM and standards.**

Concepts

What means position?

- Way of referring to the location of objects in space.
- Here we are interested in what is called "direct positioning" or “by coordinates" (ISO 19111), as opposed to "indirect positioning" or “by geographical identifiers" (ISO 19112).
- In this case a system to refer the coordinates (datum, ellipsoid, longitude, etc.) it is needed.

Many times the position of spatial objects has error when recorded in spatial data sets

—> CONTROL IS NEEDED <—

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Concepts

Error and uncertainty

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Error and uncertainty are key concepts.

Error: The discrepancy between two values that are supposed to be equal.

$$e_{x_i} = x_{t_i} - x_{m_i} \qquad e_{y_i} = y_{t_i} - y_{m_i} \qquad e_{z_i} = z_{t_i} - z_{m_i}$$

Possible errors:

- Blunders or Mistakes —> elimination and the use of methods that reduce the possibility of occurrence, etc.
- Systematic or bias (constant or variable) —> detection and correction, models...
- Random —> are not removable, MODELS are used to model such errors.

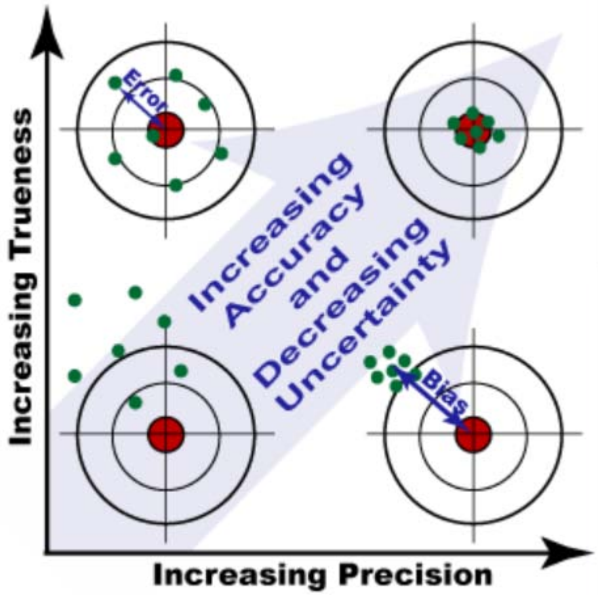
Concepts

Error and uncertainty

Uncertainty: Non-negative parameter characterizing the dispersion of the quantity values being attributed to a measurand, [VIM, 2007].

Error: The difference between a measured value of a quantity and a reference value (conventional value or true value) [VIM 2007]

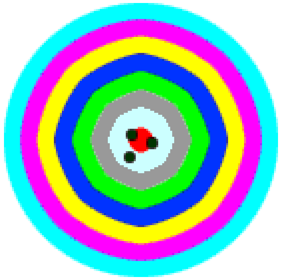
Accuracy: The closeness of agreement between a test result and the accepted reference value. [ISO 3534-1]



Accuracy = Trueness + precision

Bias component **Random component**

Trueness: The closeness of agreement between the average value obtained from a large series of test results and an accepted reference value.



Ideal situation

Precision: The closeness of agreement between independent test results obtained under stipulated conditions.

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Concepts

Error and uncertainty

In each PAAM a statistical base model for error is supposed

For majority of cases: The Gaussian or Normal model is assumed

Many studies point that this is WRONG. This hypothesis is NOT true.

Other base models for positional uncertainty in SDS

- *LIDAR (Maune, 2007): Without a parametric model (distribution free)*
- *Manual digitizing (Bolstad et al 1990): Bimodal*
- *Digitizing (Tong & Liu, 2004): p-norm (Normal + Laplace)*
- *Geocodification (Cayo and Talbot 2003; Karimi and Durcik 2004, Whitsel et al. 2004): Log normal*
- *GNSS Observations (Wilson, 2006; Logsdon, 1995): Raleigh, Weibull*
- *Other models that are mentioned: Folded Normal, Half Normal, Gamma*

PAAM

Analysis of PAAMs

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How is controlled the positional accuracy? —> PAAMs

There are many positional accuracy assessment methods (PAAMs) available:

- **National Map Accuracy Standard (1947) by USBB.**
- **Accuracy Standards for Large Scale Maps (1990) by ASPRS**
- **Engineering Map Accuracy Standard (1983) by ASCE**
- **National Standard for Spatial Data Accuracy (1998) by FGDC**
- **STANAG 2215 by NATO.**
- **ASPRS Positional Accuracy Standards for Digital Geospatial Data (2014)**
- **Etc.**

United States National Map Accuracy Standards

With a view to the utmost economy and expedition in producing maps which fulfill not only the broad needs for standard or principal maps, but also the reasonable particular needs of individual agencies, standards of accuracy for published maps are defined as follows:

1. **Horizontal accuracy.** For maps on publication scales larger than 1:20,000, not more than 10 percent of the points tested shall be in error by more than 1/30 inch, measured on the publication scale; for maps on publication scales of 1:20,000 or smaller, 1/50 inch. These limits of accuracy shall apply in all cases to positions of well-defined points only. Well-defined points are those that are easily visible or recoverable on the ground, such as the following: monuments or markers, such as bench marks, property boundary monuments; intersections of roads, railroads, etc.; corners of large buildings or structures (or center points of small buildings); etc. In general what is well defined will be determined by what is plottable on the scale of the map within 1/100 inch. Thus while the intersection of two road or property lines meeting at right angles would come within a sensible interpretation, identification of the intersection of such lines meeting at an acute angle would obviously not be practicable within 1/100 inch. Similarly, features not identifiable upon the ground within close limits are not to be considered as test points within the limits quoted, even though their positions may be scaled closely upon the map. In this class would come timber lines, soil boundaries, etc.
2. **Vertical accuracy,** as applied to contour maps on all publication scales, shall be such that not more than 10 percent of the elevations tested shall be in error more than one-half the contour interval. In checking elevations taken from the map, the apparent vertical error may be decreased by assuming a horizontal displacement within the permissible horizontal error for a map of that scale.
3. **The accuracy of any map may be tested** by comparing the positions of points whose locations or elevations are shown upon it with corresponding positions as determined by surveys of a higher accuracy. Tests shall be made by the producing agency, which shall also determine which of its maps are to be tested, and the extent of the testing.
4. **Published maps meeting these accuracy requirements** shall note this fact on their legends, as follows: "This map complies with National Map accuracy Standards."
5. **Published maps whose errors exceed those aforestated** shall omit from their legends all mention of standard accuracy.
6. **When a published map is a considerable enlargement** of a map drawing (manuscript) or of a published map, that fact shall be stated in the legend. For example, "This map is an enlargement of a 1:20,000-scale map drawing," or "This map is an enlargement of a 1:24,000-scale published map."
7. **To facilitate ready interchange and use of basic information for map construction** among all Federal mapmaking agencies, manuscript maps and published maps, wherever economically feasible and consistent with the uses to which the map is to be put, shall conform to latitude and longitude boundaries, being 15 minutes of latitude and longitude, or 7.5 minutes, or 3-3/4 minutes in size.

Issued June 10, 1941
Revised April 26, 1943
Revised June 17, 1947

U.S. BUREAU OF THE BUDGET

PAAM

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Analysis of PAAMs

Table 1. Summary of Reviewed Aspects of Analyzed Positional Accuracy Assessment Methodologies

Name: name of the standard	NMAS (1a)	EMAS (2a)	ASLMS (3a)	MILSTD 60001 (4a)	NSSDA (5a)	STANAG (6a)
Origin: organization	USBB (1b)	ASCE (2b)	ASPRS (3b)	DOD (4b)	FGDC (5b)	NATO (6b)
Date: year of publication	1947	1985	1990	1990	1998	2002
Formal aspects: adherence of the document to a conventional structure of a standard. The following levels are assigned: null=0; very scarce=1; scarce=2; medium=3; appropriate=4; very complete=5	1	2	2	3	4	5
Sheet, lot of sheets or a series: indication of the type of element to which the control is applied	Map	Area	Sheet	Area	Area	Area
Isolated/flow: whether the control is supposed on isolated elements (e.g., sheet or lot) or in a continuous process (e.g., lot by lot process)	—	—	—	—	—	—
Scales: if there is a distinction or recommendation based on scales	All	>20,000	>20,000	All	All	<25,000
Control elements: if there is an explicit indication to use point elements as control elements	Yes	Yes	Yes	Yes	Yes	Yes
Sample size: recommended minimum size for the control sample	—	20	20	—	20	167
Typology of control points: if there is an indication of the typology of the control elements	—	—	—	—	—	Yes
Spatial distribution: if there is a guide about the appropriate spatial distribution of the control sample	—	—	Yes	—	Yes	Yes
Sub-regions: if there is a proposal for using subregions in the event of diverse accuracies	—	—	—	—	—	Yes
Precision of the sampling: suggested precision needed for the control sample	—	3x	3x	—	3x	5x
Absolute accuracy: consideration of this quality subelement	Yes	Yes	Yes	Yes	Yes	Yes
Relative accuracy: consideration of this quality subelement	—	—	—	Yes	—	Yes
Basic hypothesis testing: if there is an indication to perform these tests	—	—	—	—	—	—
Implicit normality: if the normality (Gaussian distribution) is assumed	Yes	Yes	Yes	Yes	Yes	Yes
Outliers: if there is an indication concerning their elimination or how to deal with them	Yes	Yes	Yes	—	Yes	Yes
Bias: if there is an indication of how to deal with it	—	Yes	—	Yes	—	Yes
RMSE: if the root mean squared error is the proposed uncertainty measure	—	—	Yes	—	Yes	—
Mean and deviation: if the mean and standard deviation are the proposed measures	—	Yes	—	Yes	—	Yes

M.Francés
ISO 3951
Elipse,
Etc

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Analysis of PAAMs

Table 1. Summary of Reviewed Aspects of Analyzed Positional Accuracy Assessment Methodologies

Name: name of the standard	NMAS (1a)	EMAS (2a)	ASLMS (3a)	MILSTD 60001 (4a)	NSSDA (5a)	STANAG (6a)
Planimetry: if the application to the horizontal component is considered	Yes	Yes	Yes	Yes	Yes	Yes
Altimetry: if the application to the vertical component is considered	Yes	Yes	Yes	Yes	Yes	Yes
3D: if the application to 3D cases is considered	—	—	—	—	—	Yes
XY displacement for *Z*: if a planimetric shifting for altimetric adjusting is possible	Yes	—	Yes	—	—	—
Circular/linear: if planimetric components (*XY*) are analyzed together (circular) or independently (linear)	L	L	L	C	C	C
Categories: if the use of accuracy categories is proposed	—	—	Yes	Yes	—	Yes
DEM: if there is an explicit consideration of the application of the method to digital elevation models	—	—	—	—	Yes	Yes
Expression of results: type of report to indicate results (pass/fail=1; classification=2, value=3)	1	1	2	3	3	3
General information: an indication of the information included in the specification and in the presence of recommendations, examples, calculation examples, etc. The following scale is used: null=0; very scarce=1; scarce=2; medium=3; appropriate=4; very complete=5	1	2	2	4	4	5
Probability of the result: the probability level considered for the result of the assessment	90	≈90	≈90	90	95	90
Uncertainty of the method: if there is an indication of the uncertainty of the control methodology itself	—	—	—	—	—	Yes (10%)
Global valuation: a global score evaluation following the scale: very bad (1); bad (2); functional (3); good (4); and very good (5), assigned by the authors of the work as a subjective global evaluation of the method	2	3	3	5	4	5

Note: Blank spaces indicate that the standard analyzed did not deal with this aspect. 1a=National Map Accuracy Standard, 1b=U.S. Bureau of the Budget; 2a=Engineering Map Accuracy Standard; 2b=American Society of Civil Engineers; 3a=accuracy standard for large scale maps; 3b=American Society of Photogrammetry and Remote Sensing; 4a=military standard; 4b=U.S. Department of Defense; 5a=National Standard for Spatial Data Accuracy; 5b=Federal Geographic Data Committee; 6a=standard agreement; 6b=North Atlantic Treatment Organization.

Bias: if there is an indication of how to deal with it	—	Yes	—	Yes	—	Yes
RMSE: if the root mean squared error is the proposed uncertainty measure	—	—	Yes	—	Yes	—
Mean and deviation: if the mean and standard deviation are the proposed measures	—	Yes	—	Yes	—	Yes

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ISO 3951
Elipse,
Etc

Analysis of PAAMs

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The PAAMS can be considered from two perspectives:

From the quality point of view:

- ***Estimators for the quality assessment: The quality of a product (population) is determined by means of a sample. An outcome (estimation) without trial for acceptance or rejection occurs.***
- ***Acceptance rules for quality control: determine whether the quality of the product reaches specifications. A judgment is given on whether to accept or reject the product.***

From a statistical perspective:

- ***Estimation: reliable determination of a value .***
- ***Contrast: reliable determination of whether a condition is met.***

Analysis of PAAMs

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Base model for errors (uncertainty)

- *The assumed model is the Gaussian (NORMAL)*
- *Some times explicitly and others implicitly.*

Other required hypotheses are:

→ *randomness*

→ *no outliers*

→ *independency between error components*

In general, nobody test these hypotheses!!!

PAAM

Analysis of PAAMs

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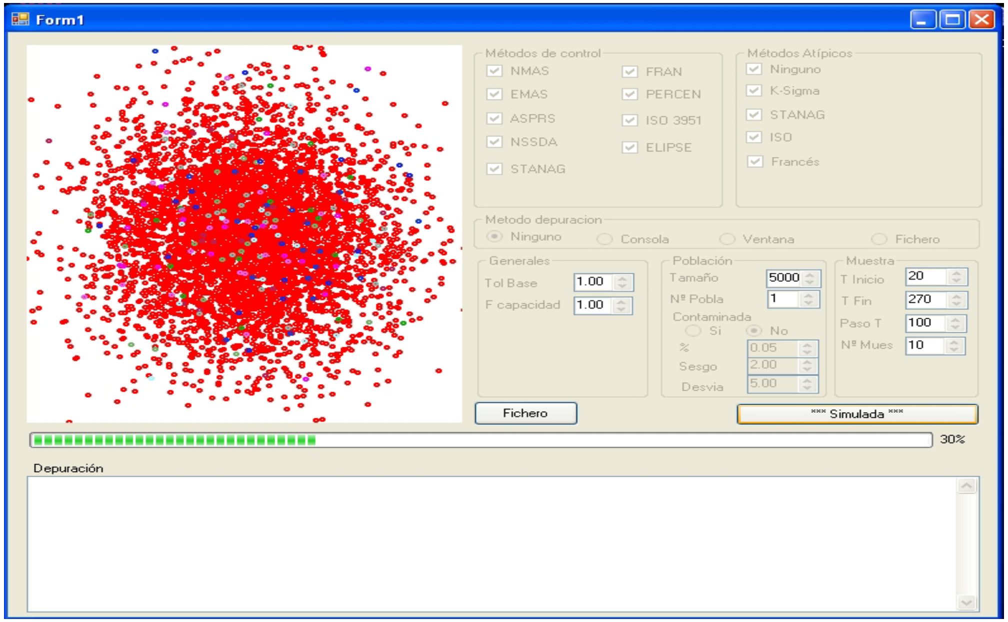
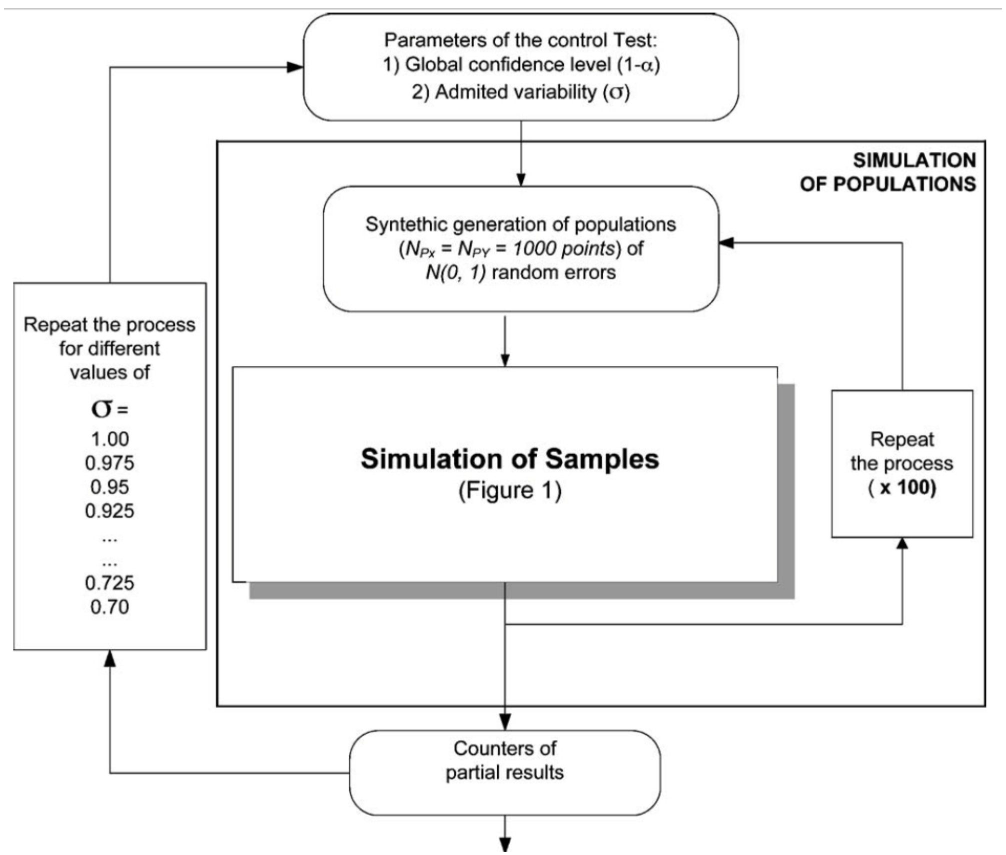
We have tested many of the PAAMs by **Simulation**

- We worked with synthetic data.
- Values from a N(0,1).
- Controlled correlation.
- Controlled contamination.
- Spatially well distributed.

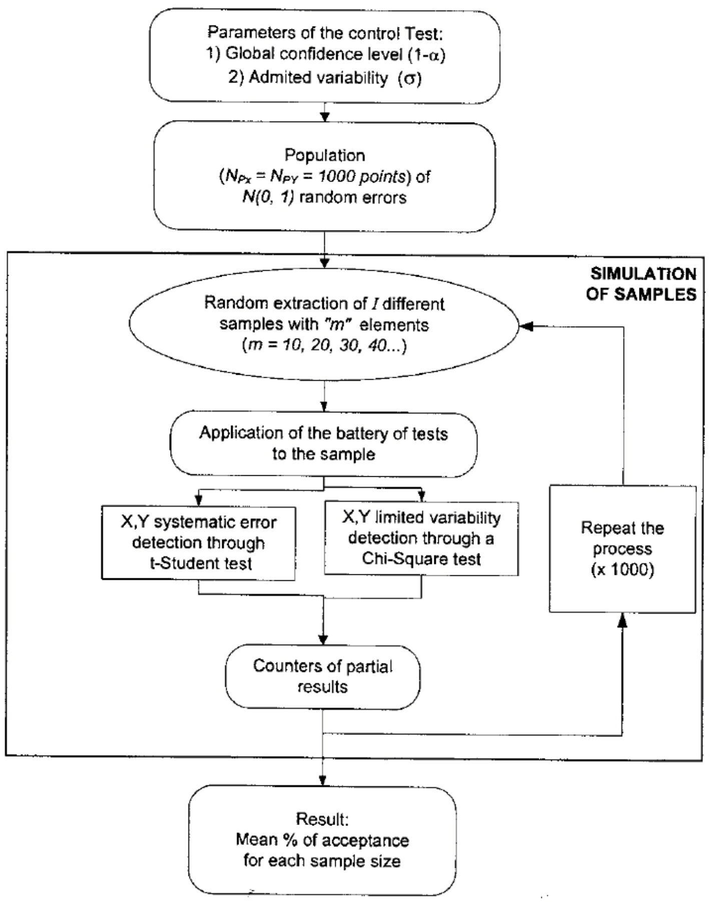


Analysis of PAAMs

Simulation of populations



Simulation of samples



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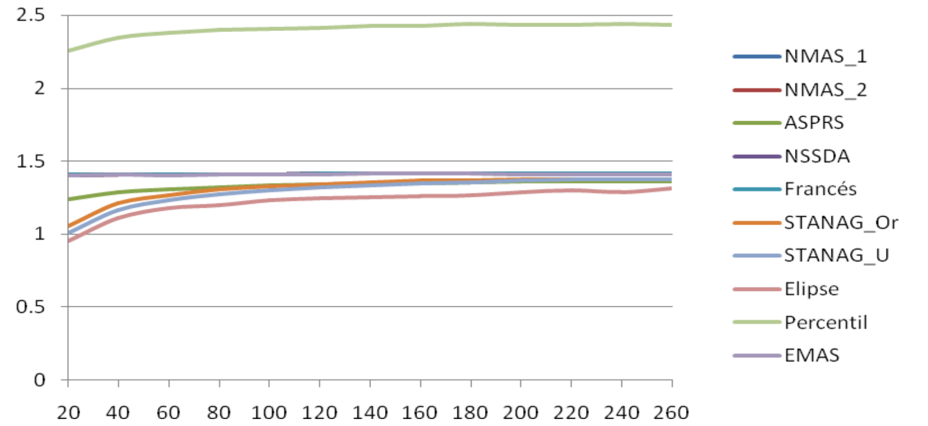
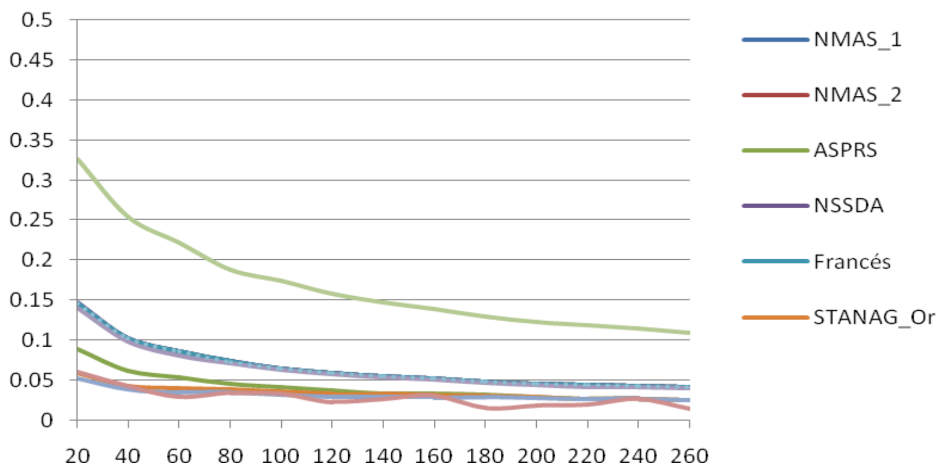
PAAM

Analysis of PAAMs





Estimation

For each analyzed method the figure presents:

- The standard deviation estimation σxy for the cases that pass the control (Y-axis in meters, X-axis is sample size) (100samplesx20Populations)
- Precision of the estimation of the standard deviation σxy for the cases that pass the control (Y-axis in meters, X-axis is sample size)

They work in a very similar fashion

Attention: estimation requires large sample sizes

PAAM

Analysis of PAAMs

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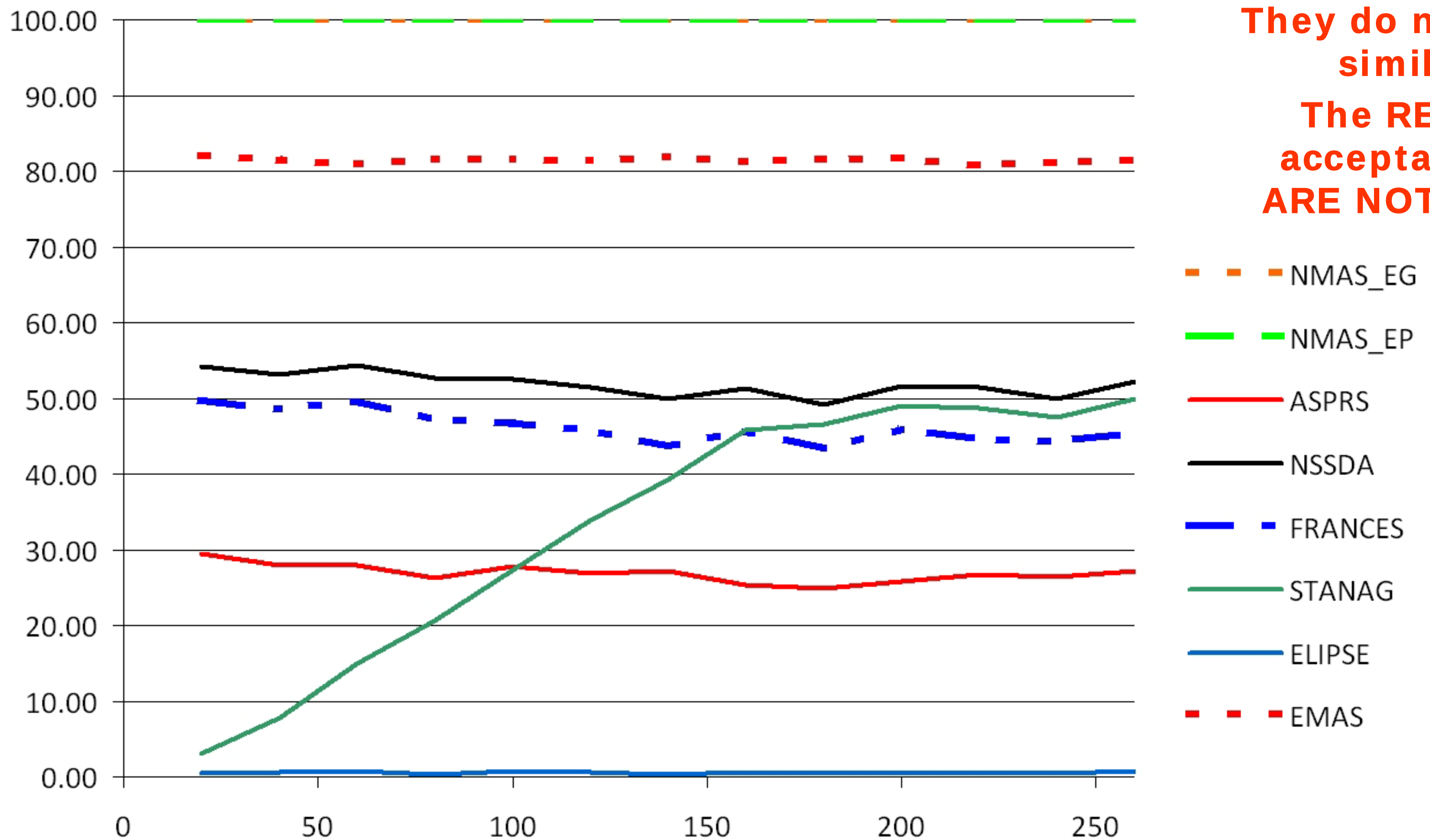


Comparison of some PAAMs working as acceptance/rejection methods (Y-axis acceptance probability, X-axis sample size)

(100Mx20P, Ninguno)

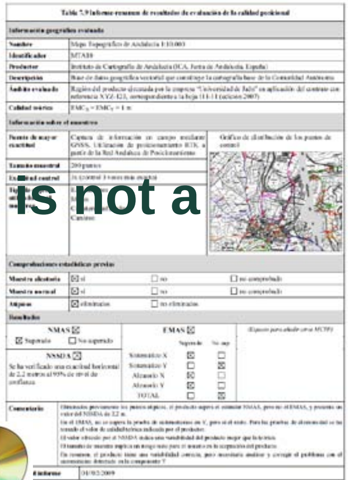
Control

They do not work in a similar fashion.

The RESULTS of acceptance / rejection ARE NOT COMPARABLE

PAAM

Analysis of PAAMs



IN SUMMARY, PAAMS HAVE PROBLEMS:

- **Metadata → Scarce, Non adequate to the process, there is not a standardized report.**
- **Control elements → only well defined points**
- **Operational procedure → only control of isolated SDS**

- **Statistical problems:**
  - **The main underlying assumption is the normality of the errors. This assumption has disastrous results if not satisfied (e.g. ISO 3951)**
  - **Another common underlying hypothesis is the equality (or near equality) of error distributions in all components (ie σx=σy).**
  - **As indicated in numerous studies, positional errors do not always follow a normal distribution.**
  - **Outliers should be removed as they affect the results, but do not exist uniform criteria.**

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Goals

Goals for the new method

Our goals were to develop:

- A simple statistical method.
- A suitable method for any error model (parametric or non-parametric)
- A method that runs on the population and not on parameters of the population.
- A method valid for 1D, 2D and 3D data and any kind of geometries (e.g. points, line strings, etc.).
- A method based on international standards

ISO 2859

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The main idea of the new method

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UNE 148 002 basically makes two contributions:

- **It proposes the use of ISO 2959 for the statistical part of the control process**
- **It proposes a set of specific rules for managing positional control processes spatial data**

ISO 2859

Introduction

Consists of the following parts, under the general title Sampling procedures for inspection by attributes:

- ✔ **ISO 2859-1:1999**

  Sampling procedures for inspection by attributes -- Part 1: Sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection

  More details »

- ✔ **ISO 2859-2:1985**

  Sampling procedures for inspection by attributes -- Part 2: Sampling plans indexed by limiting quality (LQ) for isolated lot inspection

  More details »

- ✔ **ISO 2859-3:2005**

  Sampling procedures for inspection by attributes -- Part 3: Skip-lot sampling procedures

  More details »

- ✔ **ISO 2859-4:2002**

  Sampling procedures for inspection by attributes -- Part 4: Procedures for assessment of declared quality levels

  More details »

- ✔ **ISO 2859-5:2005**

  Sampling procedures for inspection by attributes -- Part 5: System of sequential sampling plans indexed by acceptance quality limit (AQL) for lot-by-lot inspection

  More details »

Geomatics Sector:

- **ISO 19157**
- **Land Parcel Identification System in Europe (JRC)**
- **Geological data in China**
- **National Topographic Hydrographic Authority in New Zealand.**
- **Etc.**

ISO 2859

Introduction

Some concepts:

- A **lot** is a set of elements. Lots should be homogeneous, which means that the units in the lot should have a common origin (the same processes, machines, operators, etc.). Examples of lots are:
  - •Set of images.
  - •Set of maps sheets.
  - •Set of metadata records .
  - •Set of geographic features.
  - •Set of well defined points.
  - •Etc.
- **Sampling plan**: A lot-sentencing procedure in which a decision about an entire lot of size *N* is taken from the result of a random sample of size n selected from the lot. The decision is taken by comparing the accounted number of defects that are present in the sample with an acceptance number c. Thus, if the lot size is *N* a sampling plan is defined by *{n, c}.*
- **AQL** (acceptable quality level/acceptance quality limit). The AQL represents the worst or poorest level of quality for the production process that the consumer would consider to be acceptable as a process average.
- **Limiting quality** (LQ). A quality level which for the purposes of sampling inspection is limited to a low probability of acceptance.

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ISO 2859

Introduction

ISO 2859 schema of application:

Determine the appropriate "Part " to be applied:

Case 1: A sequence (>=10) of lots → Part 1: Sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection.

-Determine the appropriate Inspection Level to be applied:

Special inspection levels: S-1, S-2, S-3, S-4

General inspection levels: I, II, III

-Within the established inspection level (do not change it¡¡), apply the switching rules between levels of severities in inspection in order to assure user and producer risk.

Case 2: An isolated lot or less than 10 lots in the sequence → Part 2: Sampling plans indexed by limiting quality (LQ) for isolated lot inspection.

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ISO 2859

ISO 2859-1

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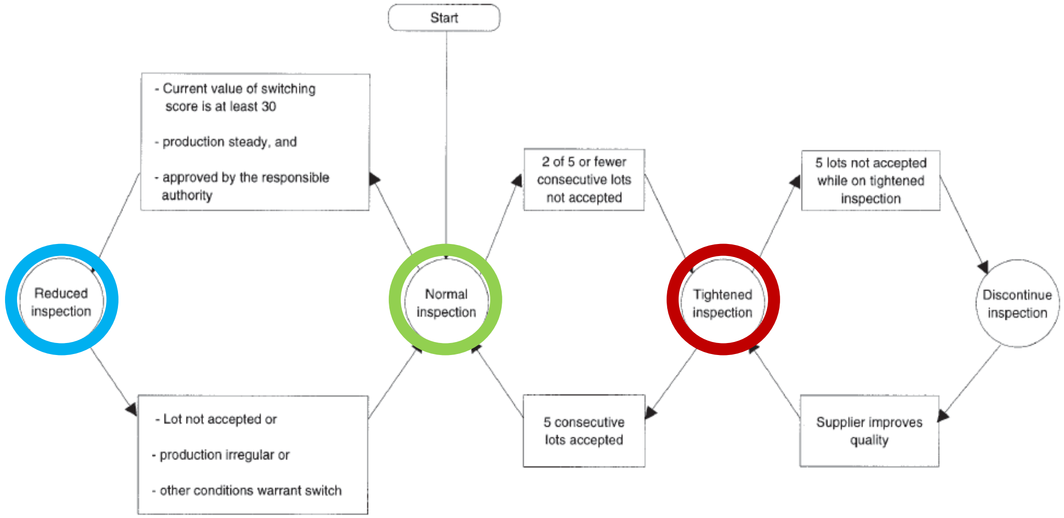
Severities levels in inspection ← → switching rules:

- **Normal.** The acceptance criterion has been devised to secure the producer a high probability of acceptance when the process average of the lot is better than the AQL.
- **Tightened.** The acceptance criterion is tighter than that for the corresponding plan for normal inspection and is invoked when the inspection results of a predetermined number of consecutive lots indicate that the process average might be poorer than the AQL.
- **Reduced.** The sample size is smaller than that for the corresponding plan for normal inspection and with an acceptance criterion that is comparable to that for the corresponding plan for normal inspection. Reduced inspection is at the discretion of the responsible authority.



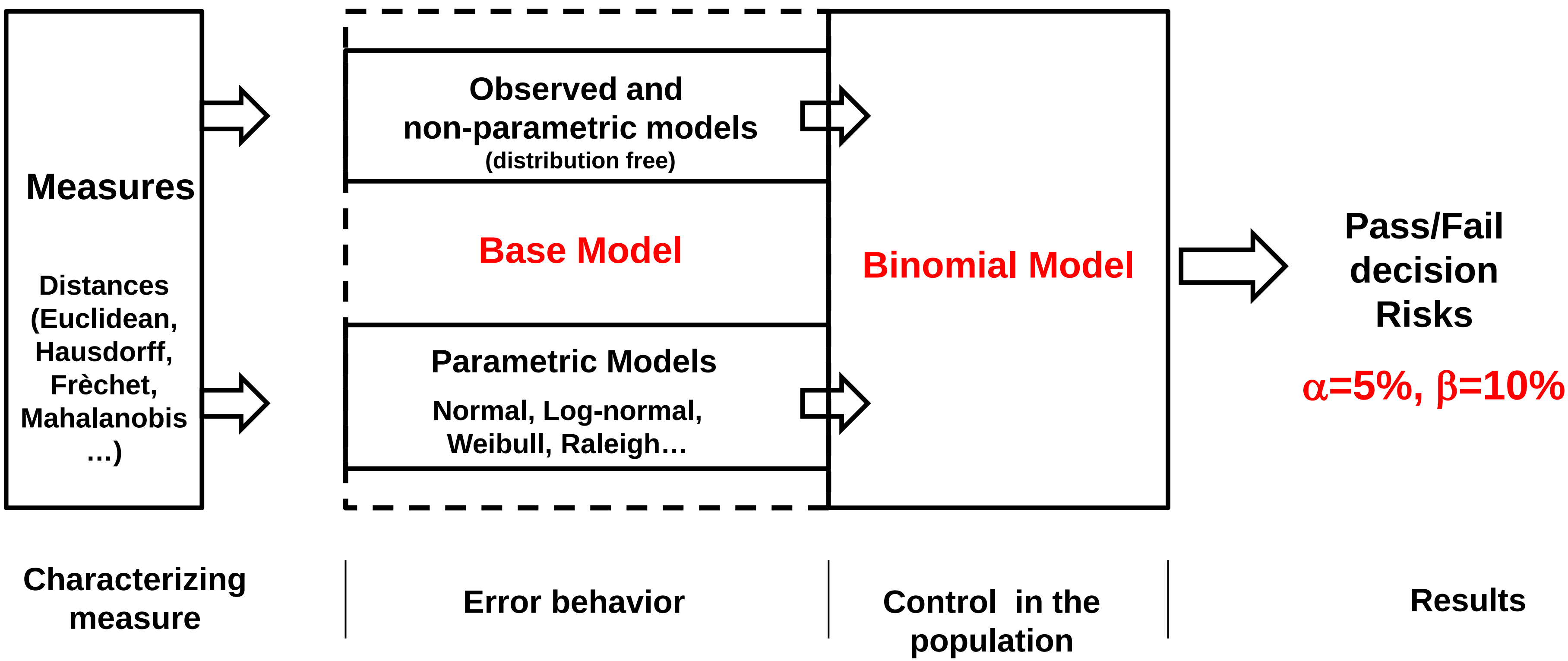
Objective → **To ensure the established risk levels α=5%, β=10%**

ISO 2859

ISO 2859 for positional quality control

Based on the "Coupled Model"

$$CM = BiM(n, \pi | \pi \sim BaM)$$



ISO 2859

ISO 2859 for positional quality control

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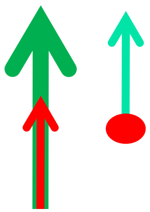
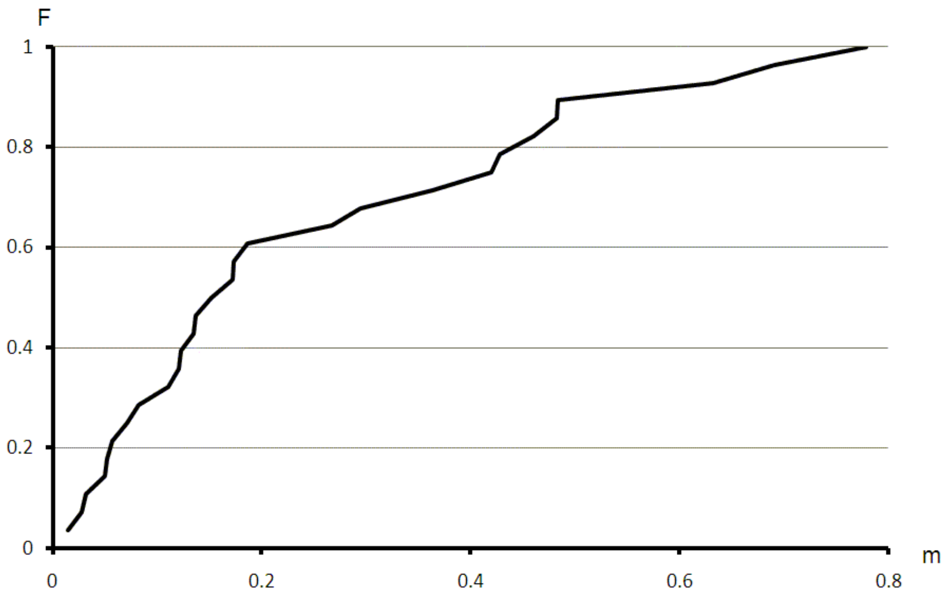
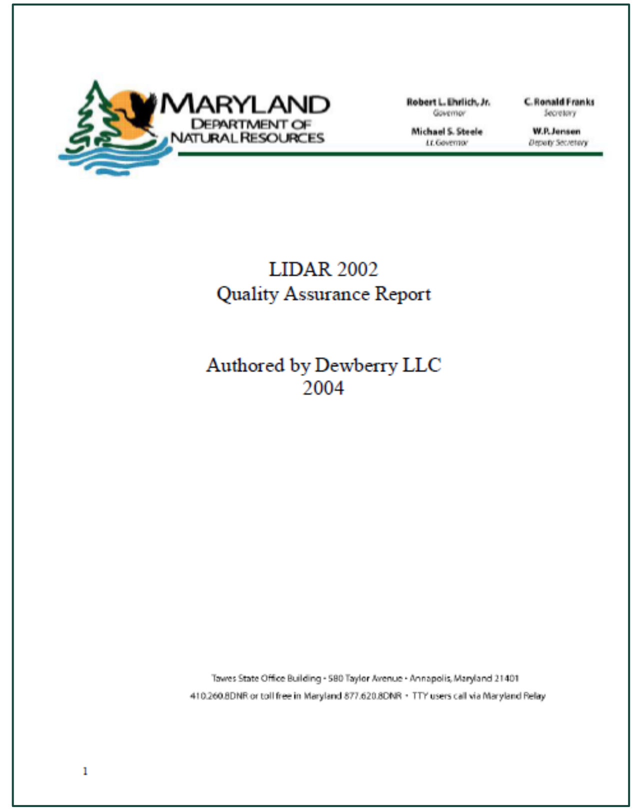
Examples of some base models



Case 1D





MARYLAND
DEPARTMENT OF
NATURAL RESOURCES

Robert L. Ehrlich, Jr.
Governor

C. Ronald Franks
Secretary

Michael S. Steele
Lt. Governor

W.P. Jensen
Deputy Secretary

LIDAR 2002
Quality Assurance Report

Authored by Dewberry LLC
2004

Tawes State Office Building • 580 Taylor Avenue • Annapolis, Maryland 21401
410.260.8DNR or toll free in Maryland 877.620.8DNR • TTY users call via Maryland Relay

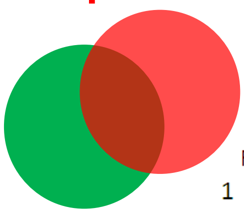
1

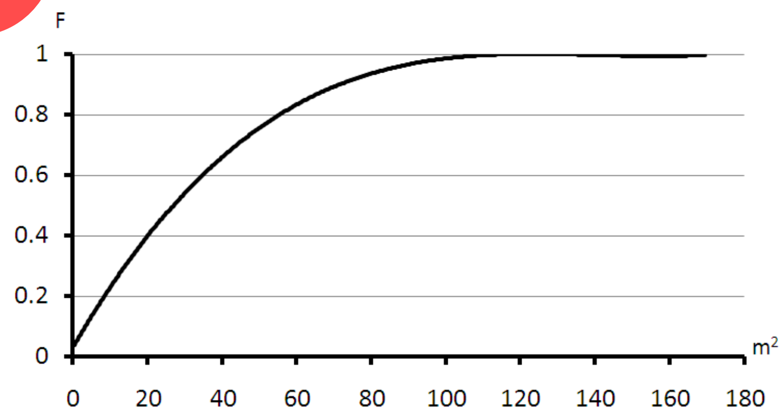
Source. Dewberry, (2004). Worcester County LIDAR 2002 Quality Assurance Report. Maryland Department of Natural Resources.

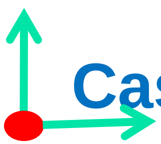
ISO 2859

ISO 2859 for positional quality control

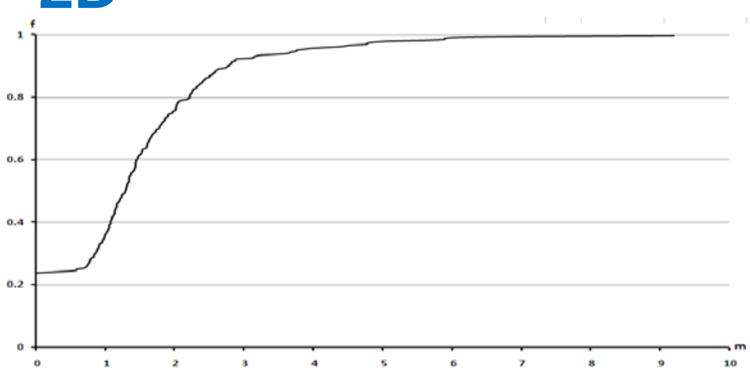
Examples of some base models

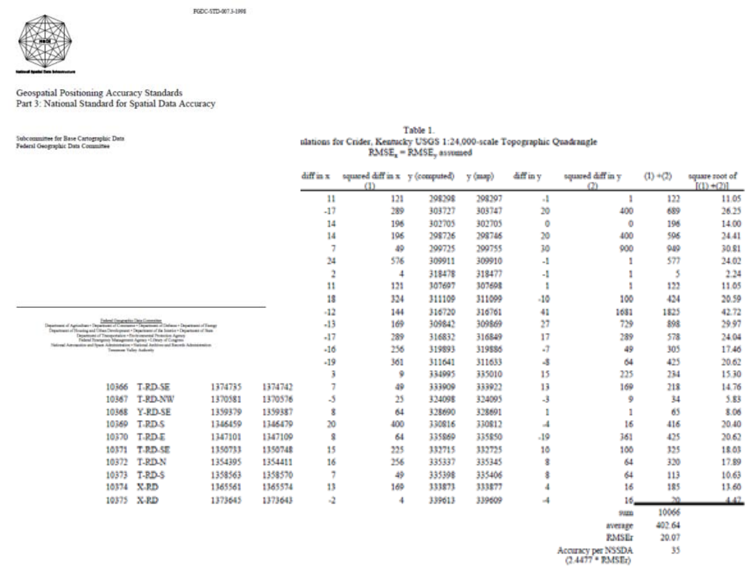






Case 2D





FGDC-STD-007.3-1998

Geospatial Positioning Accuracy Standards
Part 3: National Standard for Spatial Data Accuracy

Subcommittee for Base Cartographic Data
Federal Geographic Data Committee

Table 1.
…ulations for Crider, Kentucky USGS 1:24,000-scale Topographic Quadrangle
$RMSE_x = RMSE_y$ assumed

				diff in x	squared diff in x (1)	y (computed)	y (map)	diff in y	squared diff in y (2)	(1) +(2)	square root of [(1) +(2)]
				11	121	298298	298297	-1	1	122	11.05
				-17	289	303727	303747	20	400	689	26.25
				14	196	302705	302705	0	0	196	14.00
				14	196	298726	298746	20	400	596	24.41
				7	49	299725	299755	30	900	949	30.81
				24	576	309911	309910	-1	1	577	24.02
				2	4	318478	318477	-1	1	5	2.24
				11	121	307697	307698	1	1	122	11.05
				18	324	311109	311099	-10	100	424	20.59
				-12	144	316720	316761	41	1681	1825	42.72
				-13	169	309842	309869	27	729	898	29.97
				-17	289	316832	316849	17	289	578	24.04
				-16	256	319893	319886	-7	49	305	17.46
				-19	361	311641	311633	-8	64	425	20.62
				3	9	334995	335010	15	225	234	15.30
10366	T-RD-SE	1374735	1374742	7	49	333909	333922	13	169	218	14.76
10367	T-RD-NW	1370581	1370576	-5	25	324098	324095	-3	9	34	5.83
10368	Y-RD-SE	1359379	1359387	8	64	328690	328691	1	1	65	8.06
10369	T-RD-S	1346459	1346479	20	400	330816	330812	-4	16	416	20.40
10370	T-RD-E	1347101	1347109	8	64	335869	335850	-19	361	425	20.62
10371	T-RD-SE	1350733	1350748	15	225	332715	332725	10	100	325	18.03
10372	T-RD-N	1354395	1354411	16	256	335337	335345	8	64	320	17.89
10373	T-RD-S	1358563	1358570	7	49	335398	335406	8	64	113	10.63
10374	X-RD	1365561	1365574	13	169	333873	333877	4	16	185	13.60
10375	X-RD	1373645	1373643	-2	4	339613	339609	-4	16	20	4.47
									sum	10066	
									average	402.64	
									RMSEr	20.07	
									Accuracy per NSSDA (2.4477 * RMSEr)	35	

Source: FGDC (1998). FGDC-STD-007: Geospatial Positioning Accuracy Standards, Part 3. NSSDA. FGDC, Reston, USA.

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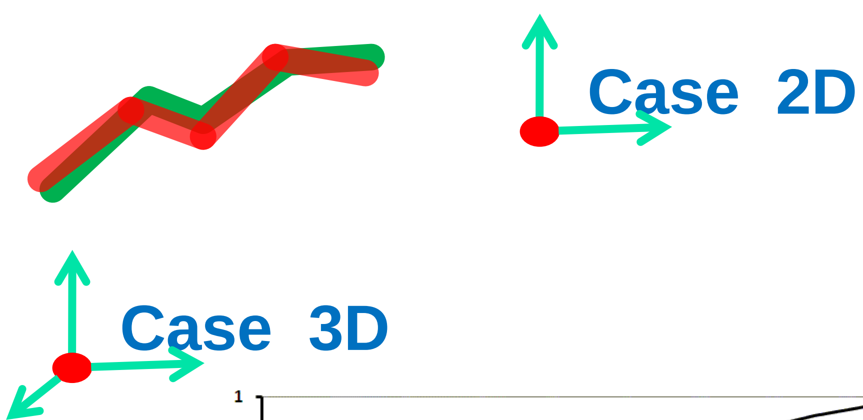
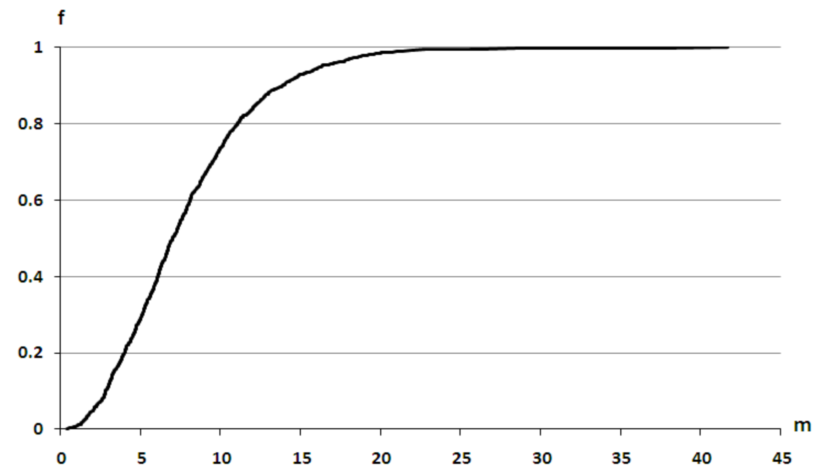
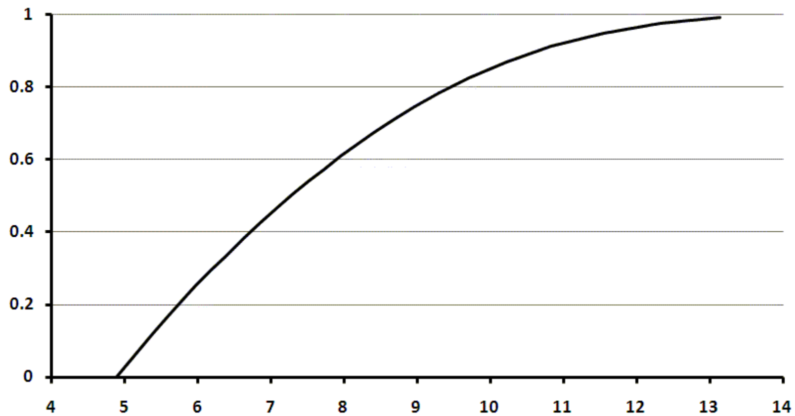
ISO 2859

ISO 2859 for positional quality control

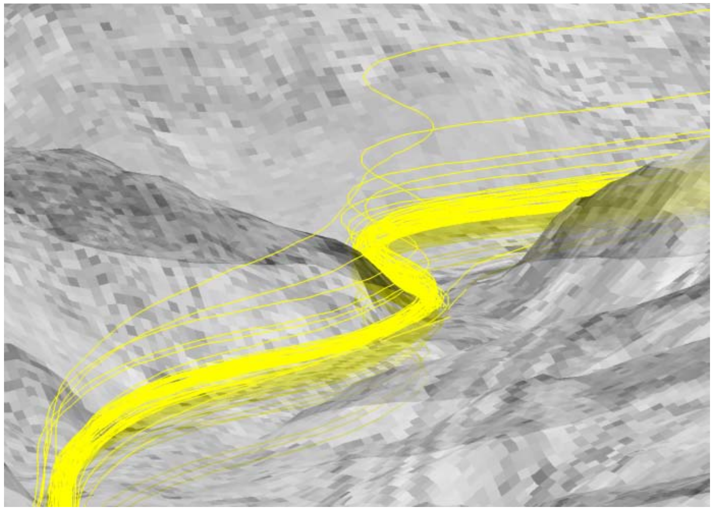
Examples of some base models





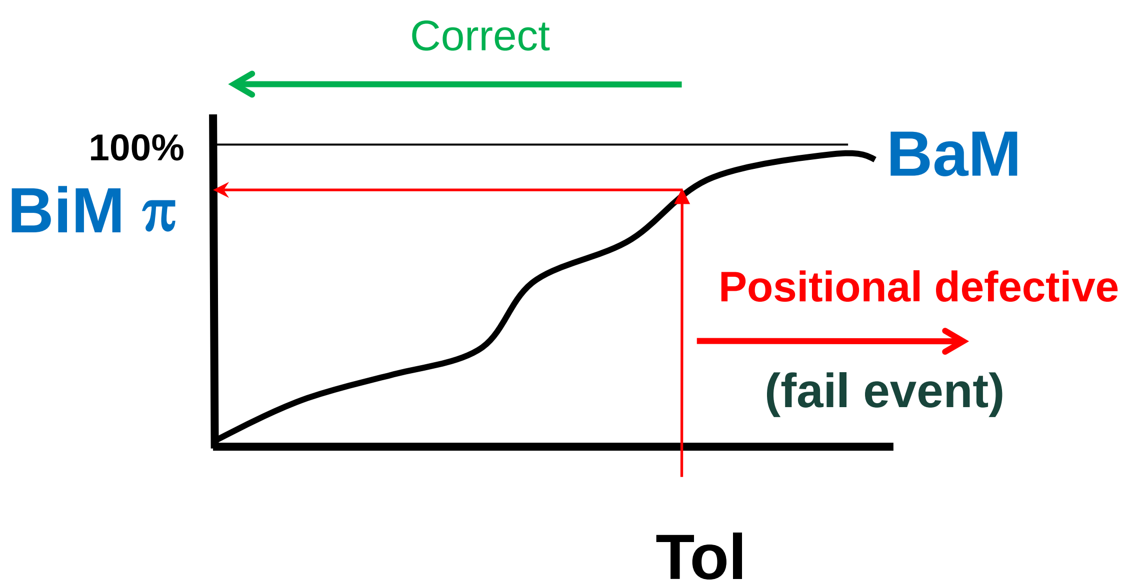


Source: Ariza-López F.J, García-Balboa J.L, Ureña-Cámara M.A, Reinoso-Gordo F.J. (2012). Metodología para la evaluación de la calidad de elementos lineales 3D. En X Congreso TOPCART 2012, 16-19 Octubre, Madrid.



ISO 2859 for positional quality control

Positional defectives —> the cases to be counted¡¡¡



$$E_i > Tol$$

$$\pi = P[E_i > Tol]$$

π → **proportion of positional defectives in the BaM established By the given Tol**

$$P[F > mc \mid F \rightarrow B(n,\pi)] = \sum_{k=mc+1}^{n} \binom{n}{k} \pi^k (1-\pi)^{n-k}$$

ISO 2859

ISO 2859 for positional quality control

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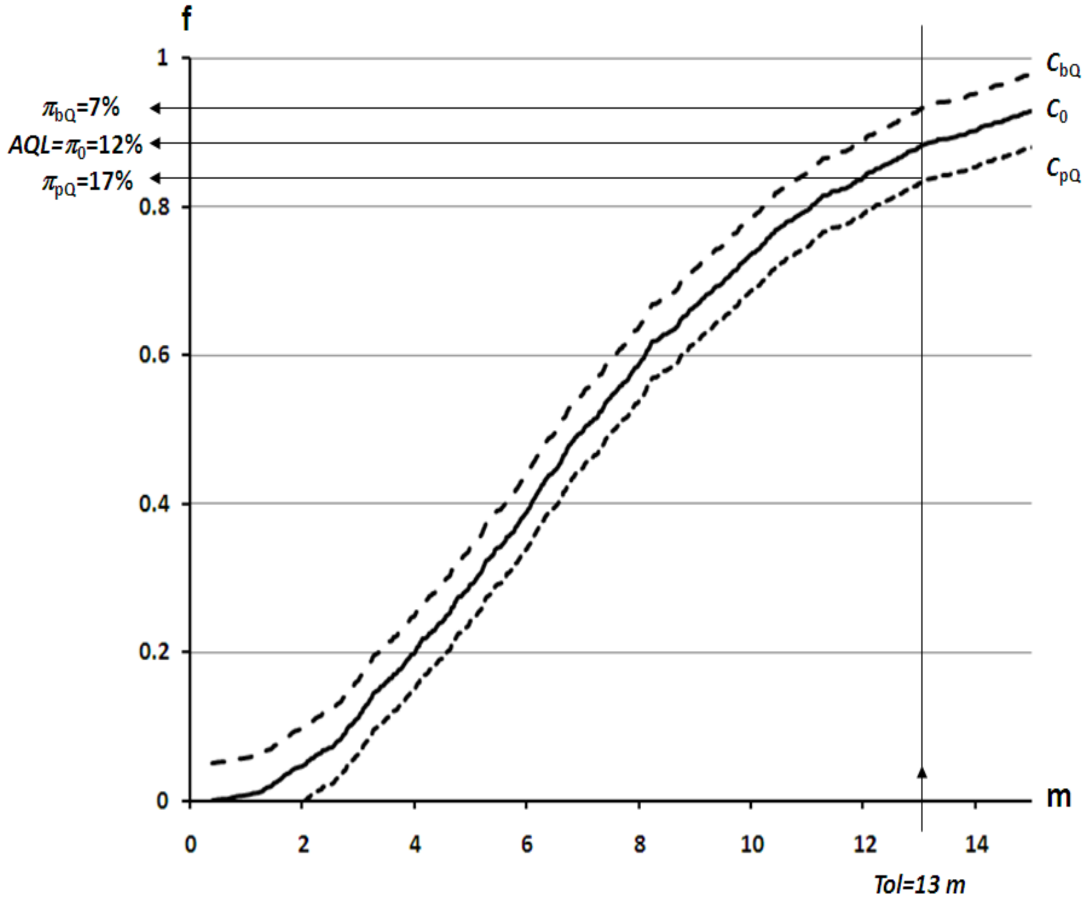
Relation between AQL and the Base Model



BaM of best quality

BaM

BaM of poor quality

$$AQL \geq \pi$$

Quality requirements expressed by the pair:

$$\{Tol, \pi\}$$

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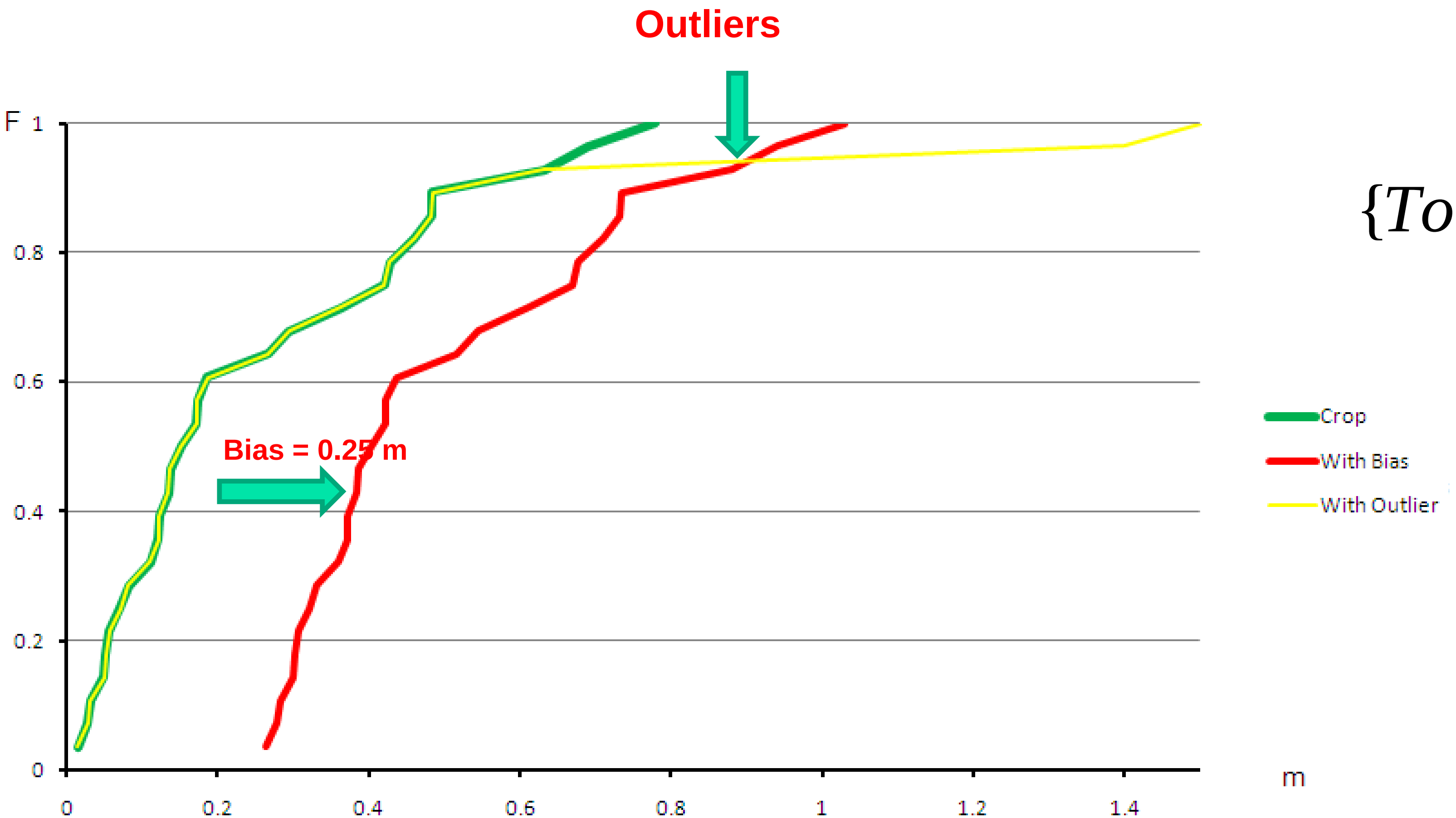
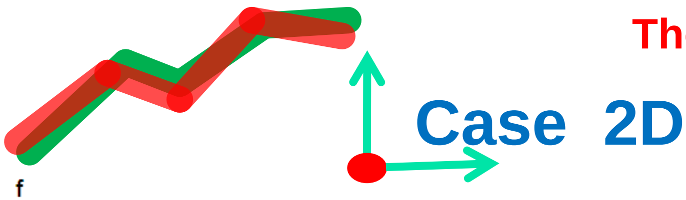
Bias and outliers in the Base Model

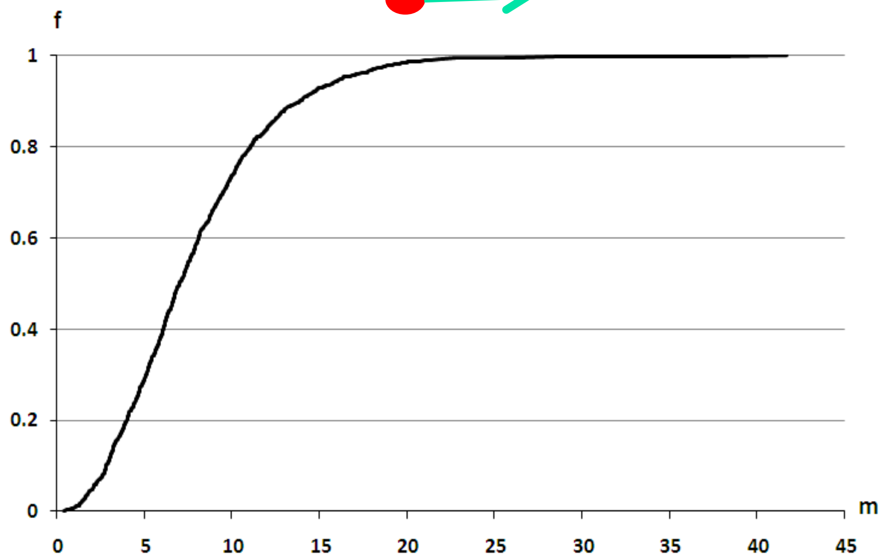


$$\{Tol, \pi\}$$

ISO 2859

Example 1: lot by lot (ISO 2859-1)





The Base Model

Principal characteristics of the product-axes and GPS-axes.

Characteristics	MTA10v product subset	GPS field survey
Total length	1210 Km	1210 Km
Total cases	1254 road segments	1254 road segments
Mean length	965 m	965 m
Standard deviation of the length	1671 m	1671 m
Total points involved	28,823 points	122,467 points
Mean points per road segment	22.98 points/road segment	97.66 points/road segment
Mean distance between points	41.98 m	9.88 m
Standard deviation of points distance	28.49 m	3.19 m
Mean speed kinematic survey	–	35.56 Km/h
Positional accuracy	10.65 m (95%)	1.41 m (95%)

(Hausdorff Distance)

Lot = Set of road segments
Segment = defined following some criteria
Size ∊ [91, 150]
[Tol=16.13 m ; AQL = 6.5%]

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ISO 2859

Example 1: lot by lot (ISO 2859-1)

Lot size	Special inspection levels S-1	S-2	S-3	S-4	General inspection levels I	II	III
2 to 8	A	A	A	A	A	A	B
9 to 15	A	A	A	A	A	B	C
16 to 25	A	A	B	B	B	C	D
26 to 50	A	B	B	C	C	D	E
51 to 90	B	B	C	C	C	E	F
91 to 150	B	B	C	D	D	F	G
151 to 280	B	C	D	E	E	G	H
				E	F	H	J
				F	G	J	K
				G	H	K	L
				G	J	L	M
				H	K	M	N
				J	L	N	P
				J	M	P	Q
				K	N	Q	R

Acceptance quality limit, AQL, in percent nonconforming items and nonconformities per 100 items (normal inspection)

Sample size code letter	Sample size	0,010 Ac Re	0,015 Ac Re	0,025 Ac Re	0,040 Ac Re	0,065 Ac Re	0,10 Ac Re	0,15 Ac Re	0,25 Ac Re	0,40 Ac Re	0,65 Ac Re	1,0 Ac Re	1,5 Ac Re	2,5 Ac Re	4,0 Ac Re	6,5 Ac Re	10 Ac Re	15 Ac Re	25 Ac Re	40 Ac Re	65 Ac Re	100 Ac Re	150 Ac Re	250 Ac Re	400 Ac Re	650 Ac Re	1 000 Ac Re
A	2	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↓	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	30 31
B	3	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	30 31	44 45
C	5	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	30 31	44 45	↑
D	8	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	30 31	44 45	↑	↑
E	13	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	30 31	44 45	↑	↑	↑
F	20	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑	↑	↑	↑
G	32	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑	↑	↑	↑	↑
H	50	↓	↓	↓	↓	↓	↓	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑	↑	↑	↑	↑	↑
J	80	↓	↓	↓	↓	↓	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑	↑	↑	↑	↑	↑	↑
K	125	↓	↓	↓	↓	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
L	200	↓	↓	↓	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
M	315	↓	↓	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
N	500	↓	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
P	800	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
Q	1 250	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
R	2 000	↑	↑	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑

If positional defectives <= 3 → Accept
If positional defectives >=4 → Reject

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ISO 2859

Example 1: lot by lot (ISO 2859-1)

	Positional defectives (**bold**):		*NCA*=6.5%	
Lot	cases of measured errors [m] greater than Tol = 16.13 m	N	Ac-Re	D
1	1.38; 8.43; 7.49; 11.7; 8.76; 5.43; 7.25; 7.65; 10.74; 2.72; 10.51; 1.57; 6.77; 7.41; 8.76; 3.25; 12.05; 4.65; 4.66; 9.59	0	3-4	A

Lot ID (sequential)

Observed errors in the sample

Count of positional defectives in the sample

Acceptance and rejection values

Decision about the lot

Example 1: lot by lot (ISO 2859-1)

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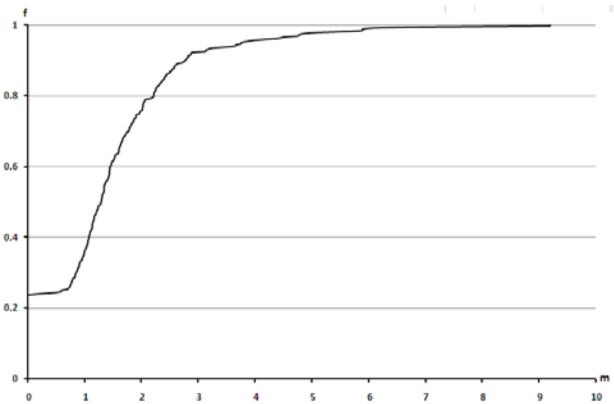
	Positional defectives (**bold**):		*NCA*=6.5%	
Lot	cases of measured errors [m] greater than Tol = 16.13 m	N	Ac-Re	D
1	1.38; 8.43; 7.49; 11.7; 8.76; 5.43; 7.25; 7.65; 10.74; 2.72; 10.51; 1.57; 6.77; 7.41; 8.76; 3.25; 12.05; 4.65; 4.66; 9.59	0	3-4	A
2	6.31; 4.85; 10.28; 4.09; 4; 10.47; 7.38; 6.16; 1.81; 7.6; 11.12; 6.58; 1.62; 5.47; 5.71; 3.05; 4.99; 3.54; 9.62; 2.67	0	3-4	A
3	13.14; 6.57; 6.26; 3.63; 11.58; 8.01; 3.25; 1.85; 8.5; 4.64; 8.01; 2.72; 11.88; 10.31; 5.63; 11.28; 4.04; 9.47; 6.35; 6.21	0	3-4	A
4	7.75; 3.6; 7.05; 10.18; 4.05; 1.33; 8.19; 4.42; 3.77; 8.73; 1.88; **17.22**; 11.58; 5.89; 10.53; 8.23; 4.24; 10.72; 11.71; 5.35	1	3-4	A
5	10.24; 9.52; 3.08; **17.97**; 22.8; 6.94; 11.05; 3.54; 2.98; **19.46**; 11.43; 11.43; 4.09; 7.25; 1.12; 9.05; 9.01; **15.77**; 5.92; **18.02**	4	3-4	R
6	5.81; 3.04; 5.63; 5.98; 3.8; 2.81; 8.71; 3.2; 7.84; 4.4; 12.87; 11.83; 9.79; 7.02; 2.36; 10.62; 6.74; 12.62; 6.74; 6.83	0	3-4	A
7	**19.52**; 2.71; 2.84; 6.63; 9.63; 2.94; 4.11; 21.86; 2.05; 11.19; **16.22**; 9.85; 7.14; 2.61; **27.17**; 4.76; 10.53; 11.07; **17.71**; 2.92	4	3-4	R
8	0.83; 5.89; 10.17; 6.04; 6.21; 4.65; 9.79; 3.39; 7.39; 3.49; 4.23; 7.2; 12.05; 4.14; 7.52; 4.63; 10.37; 1.63; 8.03; **17.57**	1	2-3	A
9	2.05; 1.1; 3.07; 9.19; 7.02; 8.96; 7.6; 7.62; 4.56; 7.9; 3.26; 7.75; 10.28; 9.02; 6.47; 3.7; 8.16; 6.02; 7.27; 7.55	0	2-3	A
10	10.6; 8.25; 9.33; 2.6; 9.51; 9.26; 6.14; 14.86; 3.26; 10.6; 2.15; 5.12; 9.69; 12.97; 5.89; 11.14; 6.08; 2.94; 1.56; 3.46	0	2-3	A
11	2.3; 16.22; 14.59; 5.69; 3.91; 4.63; 14.25; 6.82; 8.56; 5.2; 3.73; 15.46; 4.87; 1.77; 7.17; 5.78; **16.42**; 2.79; 5.1; 4.74	1	2-3	A
12	4.38; 8.23; 10.24; 3.61; 11.81; 7.25; 2.03; 8.92; 2.93; 10.43; 13.89; 3.92; 5.23; 11.87; 1; 5.44; 7.03; 6.74; 2.08; 8.38	0	2-3	A
13	9.82; 11.98; 4.07; 3.05; 6.7; 8.25; 6.06; 5.99; 3.05; 8.17; 2.01; 7.12; 1.56; 7.38; 5.09; 8.73; 2; **16.42**; 10.09; 9.85	1	3-4	A
14	7.92; 6.24; 6.32; 6.69; 4.72; 7.05; 7.82; 14.31; 3.04; 10.09; 14.32; 5.85; 3.25; 5.24; 6.69; 0.72; 9.37; 2.96; 5.7; 4.63	0	3-4	A
15	14.17; **17.38**; 1.45; 7.58; 6.32; 5.78; 5.43; 13.89; 3.03; 5.96; 3.85; 1.71; 10.79; 9.79; 5.25; 1.43; 4.96; 6.34; 4.84; 13.14	1	3-4	A

ISO 2859

Example 2: isolated lot (ISO 2859-2)



Size ∊ [281, 500]

[Tol=3.75 m ; AQL = 6.5%]

Lot size		Limiting quality in percent (LQ)									
		0,5	0,8	1,25	2,0	3,15	5,0	8,0	12,5	20	32
16 to 25	*n*	→	→	→	→	→	25 [1]	17 [1]	13	9	6
	Ac						0	0	0	0	0
26 to 50	*n*	→	→	→	50 [1]	50 [1]	28 [1]	22	15	10	6
	Ac				0	0	0	0	0	0	0
51 to 90	*n*	→	→	90 [1]	50	44	34	24	16	10	8
	Ac			0	0	0	0	0	0	0	0
91 to 150	*n*	→	150 [1]	90	80	55	38	26	18	13	13
	Ac		0	0	0	0	0	0	0	0	1
151 to 280	*n*	200 [1]	170 [1]	130	95	65	42	28	20	20	13
	Ac	0	0	0	0	0	0	0	0	1	1
281 to 500	*n*	280	220	155	105	80	50	32	32	20	20
	Ac	0	0	0	0	0	0	0	1	1	3
501 to 1 200	*n*	380	255	170	125	125	80	50	32	32	32
	Ac	0	0	0	0	1	1	1	1	3	5
1 201 to 3 200	*n*	430	280	200	200	125	125	80	50	50	50
	Ac	0	0	0	1	1	3	3	3	5	10
3 201 to 10 000	*n*	450	315	315	200	200	200	125	80	80	80
	Ac	0	0	1	1	3	5	5	5	10	18
10 001 to 35 000	*n*	500	500	315	315	315	315	200	125	125	80
	Ac	0	1	1	3	5	10	10	10	18	18
35 001 to 150 000	*n*	800	500	500	500	500	500	315	200	125	80
	Ac	1	1	3	5	10	18	18	18	18	18
150 001 to 500 000	*n*	800	800	800	800	800	500	315	200	125	80
	Ac	1	3	5	10	18	18	18	18	18	18
> 500 000	*n*	1 250	1 250	1 250	1 250	800	500	315	200	125	80
	Ac	3	5	10	18	18	18	18	18	18	18

Errors in the sample taken from the lot:

{1.01; 0.79; 2.18; 0.0; 2.01; 1.23; 0.0; 0.85; 0.0; 1.01; 1.34; 2.44; 1.61; 1.42; 1.49; 1.69; 0.95; 2.21; 9.19; 2.5}

PROS and cons of the statistical method

Here a brief summary of major PROS:

- Normally is not required
- No underlying model is required —> All models are treated in the same way
- It is a statistical test.
- Sample size is smaller than in estimation processes
- Provides user's and producer's risk.

PROS and cons of the statistical method

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- I is applicable to points, lines and any geometry.
- Applicable to any dimension
- Applicable on any metric and measure.

- Positional quality is expressed in a very simple way.
- Positional quality is expressed in the same way as other elements of spatial data quality.
- The same framework applies to control other aspects of quality (eg, thematic, completeness, logical consistency), which is a very desirable to facilitate the analysis of the quality, management and reporting of the quality circumstances.

- The method can be applied to various types of supplies (isolated, lot to lot, etc.).

- It is based on well-known and widespread international standards -> same language.

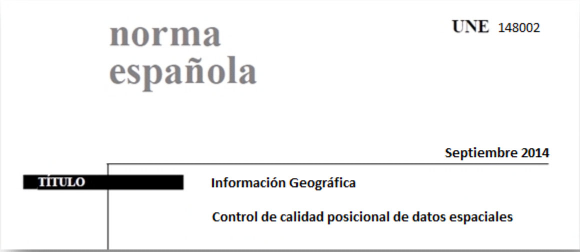
pros and CONS of the statistical method

- Significant change in paradigm
- Resistance to change.

AEN/CTN 148

UNE 148002 (proposal)

Alignments


norma española

UNE 148002

Septiembre 2014

TÍTULO

Información Geográfica

Control de calidad posicional de datos espaciales

With ISO 19157:

- metaquality
- Scope (data quality unit)
- Use of ISO 2859

With ISO 3534-1:

- Terms related to accuracy (Trueness + precision)

With ISO 2859-1,2:

- Control method

Objectives

- Simplicity
- Universality
- Compatible with other controls over spatial data

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1. SCOPE

1. This standard is specifically designed to:
   - Establish guidelines for acceptance control processes of spatial data by positional quality.

2. This standard is based on the principles of quality of Geographic Information of ISO 19157, and also adopts general principles of quality management (ISO 9000: 2008).

3. This standard focuses on the positional component of spatial data so its adoption does not affect other tasks that the organization may have.

4. This standard allows the producer to ensure that the products passing the test achieve the required positional quality, no matter if the products come from the organization itself or are coming from external supplies, totally or partially. This method provides significant advantages over traditional methods of positional quality control (see Annex J).

5. This standard requires the creation of evidence from evaluation processes of positional quality, which must be used effectively in quality improvement processes as a means of quality assurance over time.

6. The way to manage quality records is beyond the scope of this standard.

7. The ways to report the processes related to positional quality control are aligned with ISO 19157 and ISO 19115-1 standards.

8. This standard does not establish compliance levels for positional accuracy of any product. The consumer can set requirements against particular applications of interest. For information purposes, Appendix C contains some requirements of scale and positional accuracy values in engineering and architecture, as well as how to determine positional accuracy requirements in the case of applications and geomatics systems.

9. This standard is only applicable to spatial data sets and establishes conformance testing for verification.

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2. CONFORMANCE

10. Compliance to this standard is only related the process of positional quality control. Any positional quality control process claiming conformance to this standard shall pass all the requirements described in the abstract test suite presented in annex A.

5. POSITIONAL QUALITY CONTROL OF SPATIAL DATA SETS

14. This standard establishes a method for controlling the positional quality (acceptance/rejection) of spatial data sets (SDS) that is valid for 1D, 2D, 3D and n-dimensional data. The standard is based on hypothesis testing in order to achieve a statistically valid result. Given a metric conformity level (MCL) for the positional errors, the goal is to reject and accept SDS when they are exceeding the MCL or not, established as an average of errors over time (Acceptance Quality Limit, AQL). The acceptance and rejection occurs within a framework where consumer and producer risk are known.

15. The perspective adopted in this standard is on the consumer side. The standard is only interested in verifying whether the SDS is consistent or not. The product may or may not be characterized by the producer, but the control process is independent of this. The producer may have interest in obtaining a better understanding of why a given situation occurs, however this standard does not have this objective.

16. The standard can be applied to SDS submitted for positional control in isolation, but also for the case of sequential submissions (batch to batch type), which can occur in large mapping projects.

17. The control method is valid for 1D, 2D, 3D, and generally, nD, SDS; and does not require any underlying assumptions about the behavior of positional uncertainty (e.g. normality of errors).

18. This standard can be applied to any element of positional accuracy (e.g. absolute, relative, gridded).

19. This standard is independent of the uncertainty parameter being used to establish the MCL.

20. The standard does not establish quality levels. It will be the consumer/producer who must establish these levels depending on the application purpose and/or the process of creating the SDS. For information purposes, Appendix C contains some scale/resolution requirements in engineering and architectural work and how to determine the

6. POSITIONAL QUALITY CONTROL METHOD

21. For this standard, the positional quality control (PQC) is a process of statistical hypothesis testing that determines the acceptance or rejection of a spatial data set of 1D, 2D, 3D or nD, compared with the pair {MCL, AQL|LQ} by means of a base model.

22. The statistical foundation of the PQC is presented in Appendix F. The application of this method allows for a common framework for all kinds of statistical models representing positional uncertainty, whether statistical parametric distribution functions or observed distribution functions (distribution free).

23. The PQC achieves a statistically based decision on the acceptance or rejection of an SDS versus a base model, and this decision is important for the consumer, with regard to applications, and for the producer, in order to ensure quality supplies.

24. In this standard positional quality must be specified by means of two values, the MCL and the AQL or the LQ, as appropriate. The MCL is a value serving as error tolerance. Any positional error observed exceeding the MCL is considered defective in position. AQL is suitable for sequentially evaluated SDS and is expressed as a percentage. For a given MCL, the AQL refers to the worst average quality that we are willing to accept in a batch to batch delivery. The relationship between AQL and MCL is provided by the base model (see Appendix F). LQ refers to a quality with very low probability of acceptance in the control of an SDS evaluated in isolation.

25. For this standard, the PQC is a direct external process (ISO 19157) based on statistical sampling.

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26. Prior to any PQC the user should:

- Preferably, have knowledge of the base model. Annex G provides a methodology for estimation.
- Determine the scope or scopes for the control.
- Have pre-established the MCL to apply (in Annex C there are some guidelines on requirements for positional accuracy).
- Have pre-established the AQL to apply (in Annex F the relation between AQL and metric behavior is presented).
- Have an independent control source (control SDS) at least 3 times more accurate than the controlled SDS (in Annex D this requirement is justified).
- Have ensured the positional interoperability between the control and the controlled spatial data sets (datum, ellipsoid, projection).

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27. The PQC can be carried on:

- Isolated SDS (a separate lot). In this case there is a single supply, or it is a sporadic supply far apart in time from other supplies, or the parties wish to consider it so. In this case the international standard ISO 2859-2 (procedure A) must be applied. This standard is intended to ensure consumer's and producer's risk at 10% and 5%. respectively (see nonconforming elements and afterwards comparing this account to the acceptance value indicated in Table A of ISO 2859-2 for a given lot size. Annex I presents an example of the application of ISO 2859-2.
- Sequence of SDSs (delivery batch to batch). In this case there is a continuous flow of supply deliveries of SDSs that must be subjected to positional acceptance controls. In this case the international standard ISO 2859-1 must be applied. This standard is intended to ensure consumer's and producer's risk at 10% and 5% respectively (see Annex E). For this standard to adequately protect the parties, the minimum supply should consist of 10 or more lots and switching rules of ISO 2859-1 must be applied. If the supply does not reach more than 10 lots ISO 2859-2 applies. Acceptance or rejection will be based on counting the number of nonconforming elements (positional defectives) and comparing, lot by lot, this value with the acceptance/rejection value shown in Tables 2, 3 and 4 of the standard for the lot size, severity and sampling type. If considered appropriate, one may apply multiple sampling plans offered by this international standard. Appendix H presents an example of application of ISO 2859-2.

7. SCOPE OF A POSITIONAL QUALITY CONTROL

28. In alignment with the international standard ISO 19157, this standard links the PQC process described in Chapter 6 to a particular scope by means of the data quality unit. For this standard, the scope of a PQC process is the determination of a set of constraints (e.g. temporal, spatial, geometric, thematic, logical, etc.), determining clearly and unequivocally a set of geographic objects (universe of discourse) whose positional component is being controlled. These constraints determine the population under control and on which to inform.

29. In relation to the aspect of the geometry of the elements to control, it can be any (point, line, surface, volume, etc.), provided that the particular control metrics and the evaluation method applied will be the same for all the geometries involved.

    Note 1: You cannot mix different metrics, for example, you cannot work together with Euclidean distances and Hausdorff distances.
    Note 2: Still working with the same metric (e.g. Euclidean) there cannot be mixed estimates derived from different methods.

30. In relation to the thematic aspect of geographical objects whose position is controlled, it is possible to assess various thematic categories, jointly or separately, according to convenience, if this is properly reflected in the scope.

31. With regard to the fuzziness shape definition aspect of some geographical objects, different types can be assessed jointly or separately, according to convenience, if this is properly reflected in the scope. It is not recommended to jointly assess fuzzy elements and well defined elements (crisp elements).

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32. In the case of a large SDS (e.g a series), or an SDS with a great diversity of contents, assessment by categories or geometries is recommended, but always with a utilitarian orientation (e.g. for navigation, for general location, etc.), or based on the source (e.g. grouping data by sources of the data supply).

33. In any case the consumer must be informed of the selection criteria (e.g. geometric, thematic, etc.) applied in order to clearly identify the type of objects evaluated. The scope should appear in the report of the PQC.

34. An independent quality report should be used to report the results and metaquality. Annex B proposes a scheme for this report.

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8. SAMPLE FOR THE CONTROL

35. For PQC processes sampling techniques should be applied as required in ISO 2859-1 and ISO 2859-2.

36. In PQC processes the sample size *n* is determined as indicated in ISO 2859-1 and ISO 2859-2, as appropriate.

37. The sample will be materialized by a selection of items registered on the SDS to evaluate that, within the scope established, are also present in the reference.

38. It should be ensured that the sample provides an adequate representation of the population and for this distribution conditions may be imposed on the scope (e.g. spatial or thematic).

39. In the case that the geographical area covered by the SDS is rectangular and survey methods are considered homogeneous, the recommended distribution for the control sample is indicated in Figure 1 (average distance between control elements is in the order of 1/10 of the diagonal dimension and a distribution of at least 20% of the control elements in each quadrant). In the case where the SDS covers an area whose shape is determined by a geographic feature of interest (e.g. road, rail, river, etc.) a spatial distribution that adequately covers the element of interest entirely should be taken.

40. The sample selection will be carried out by a randomized and automated process on all those items that meet the conditions specified in the preceding paragraphs.

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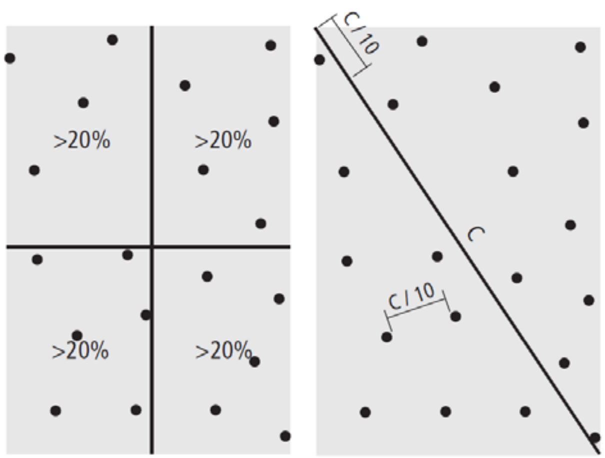
41. Since the existence, access, etc., of the control elements of a random sample taken on an SDS cannot always be ensured, the initial sample size n may be increased, according to the experience of the executor, in order to ensure that eventually there are sufficient valid sampling units.

42. In the case of samples used for the PQC in supply contracts, it is recommended to obtain the approval of the spatial distribution by the purchaser prior to the execution of the work.



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9. REFERENCE SET

43. The PQC requires access to an independent external source (reference SDS) and in the execution of work some requirements are needed in order to ensure confidence in the results.

44. The PQC requires comparing elements of the SDS under control (controlled elements) with homologous elements in the reference SDS (control elements). The reference SDS may come from an *ad hoc* capture/survey from the real world through fieldwork, or from any other data set that meets the following requirements:
    a) Independence. The reference SDS should not share common processes with the controlled SDS. Independent processes are performed at different times, by different working groups, with different instruments, etc. In case of doubt statistical techniques may be applied to demonstrate and prove independence.
    b) Greater accuracy. The reference SDS should be at least three times better than the controlled SDS (see Annex D). To ensure this requirement it is necessary to know the controlled SDS production methods, and design and implement a method for the reference SDS.
    c) Completion. The reference SDS must cover 100% of the declared scope for the controlled SDS; otherwise it shall specify the scope and clearly indicate that it does not match the controlled SDS entirely.

45. This standard recommends reference SDS coming from *ad hoc* processes based on the most accurate field work.

10. METAQUALITY IN THE PROCESS OF PQC

46. Metaquality is a set of quantitative and qualitative statements about a quality evaluation and its result. The knowledge about the quality and the suitability of the evaluation method, the measure applied, and the given result may be of the same importance as the result itself. This standard adopts the metaquality elements of ISO 19157:

- Confidence. Trustworthiness of data quality results.
- Representativity. Degree to which the sample used has produced a result which is representative of the data within the data quality scope.
- Homogeneity. Expected or tested uniformity of the results obtained for a data quality evaluation.

47. In this standard confidence in the results of a PQC process is determined by two complementary aspects:

- Qualitative. The rigorous application of the methods is the main guarantee of trust from a qualitative perspective. This aspect must be ensured by the participation of experts in quality of geographic information in work teams and by the requirements stated in section 9 of this standard.
- Quantitative. Effective enforcement of the following aspects is the basis of trust from the quantitative perspective: sample size, randomness, independence of control process and greater accuracy of the reference SDS. These aspects should be insured by compliance with the requirements of sections 8 and 9 of this standard.

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48. In this standard homogeneity of the results of a PQC is determined by:

- Production of the controlled SDS. The homogeneity of the controlled SDS is beyond the scope of this standard; however it should be noted that it can be a critical aspect in the case of SDS where numerous persons or organizations have intervened, where diverse backgrounds, knowledge, skills, etc. concur, or different work methodologies (e.g. OpenStreetMap) are applied.
- The extension of the control process. For PQC processes dilated in space or in time appropriate quality management measures shall be taken in order to ensure homogeneity of the PQC process at all times. Key elements necessary to ensure homogeneity are, among others: documented procedures, the establishment of standards in education and training of personnel involved, including verification mechanisms to ensure consistent processes, etc.

49. In this standard representativity of the result of a PQC should be evaluated from multiple perspectives. Since the assessment is based on sampling, the representativity should be:

- Considered in relation to the following aspects:
  - Space. The spatial representativeness of the sample by its effective spatial distribution compared to the actual spatial distribution of the population.
  - Time. The temporal representativeness of the sample by its effective temporal distribution compared to the actual temporal distribution of the population.
  - Theme. The thematic representativeness of the sample by its effective thematic distribution of categories and attributes compared to the actual thematic distribution of the population.
  - Participation. In the case of works with the participation of various organizations (e.g. national series) or individuals (e.g. OpenStreetMap), this has the same sense as previous cases but related to the participation issue in the population.
  - Global. Refers to global representativeness as an interpretation of all the partial representativeness given above being considered in a specific PQC.
- Evaluated by appropriate techniques, some techniques are applicable:
  - Visual comparison of histograms and distribution functions of the sample and the population.
  - Adherence tests between the curves representing the distribution functions of the sample and the population (e.g. by means of the Kolmogorov-Smirnov test for continuous cases and Chi2 for discrete cases).

(c) Francisco Javier Ariza López / fjariza@ujaen.es

11 STANDALONE QUALITY REPORT

50. A standalone quality report must be used for reporting on the implementation and results of PQC process developed as established in this standard.

51. The standalone quality report is a free-content report but must at least include the contents specified in Annex A. Annex B provides a sample template.

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Annex A

ANNEX A

(Normative)
Abstract test suites

A.1. General Conformance
A.1.1. Test case identifier: Standalone quality report
a) Test purpose: To verify that a standalone quality report exists.
b) Test method: Check whether a standalone quality report has been included.
c) Reference: Clause 11.
d) Type: Basic.

A.1.2. Test case identifier: Data quality unit
a) Test purpose: To verify that at least one data quality unit exists.
b) Test method: Check whether the standalone quality report includes at least one data quality unit.
c) Reference: Clause 7.
d) Type: Basic.

A.1.3. Test case identifier: Positional quality requirements
a) Test purpose: To verify that a statement exists about the positional quality requirements as required in this rule.
b) Test method: Check whether the standalone quality report includes a statement about the MCL and AQL or LQ, as appropriate.
c) Reference: Clause 5.
d) Type: Basic.

A.1.4. Test case identifier: Positional interoperability between the controlled data set and the control data set.
a) Test purpose: To verify that the controlled data set and the control data set are interoperable in position.
b) Test method: Check whether the controlled data set and the control data set truly share datum, ellipsoid and projection.
c) Reference: Clause 6.
d) Type: Basic.

Gen. conformance: 5 tests
Req. For the CDSt: 3 tests
Req. For the sample: 2 tests
Red. For MetaQ: 3 tests.

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A.1.5. Test case identifier: Applicability of ISO 2859-1
a) Test purpose: To verify that the main condition of applicability of ISO 2859-1 is met.
b) Test method: Check whether there is a supply sequence of at least 10 batches.
c) Reference: Clause 6.
d) Type: Basic.

A.2. Requirements for the control data set
A.2.1. Test case identifier: Greater accuracy
a) Test purpose: To verify that the control data set is at least three times more accurate than the controlled data set.
b) Test method: Check whether the documentation of the control data set confirms that this requirement is met.
c) Reference: Clause 9.
d) Type: Basic.

A.2.2. Test case identifier: Independence
a) Test purpose: To verify that the controlled data set and the control data set are mutually independent.
b) Test method: Check whether the documentation of the controlled data set and the control data set confirms that this requirement is met.
c) Reference: Clause 9.
d) Type: Basic.

A.2.3. Test case identifier: Cover
a) Test purpose: To verify that the control data set completely covers the scope indicated by the data quality unit of the controlled data.
b) Method: Check whether the control data set properly and entirely covers all aspects stated by the data quality unit of the controlled data set.
c) Reference: Clause 9.
d) Type: Basic.

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A.3. Sample for the control

A.3.1. Test case identifier: Randomly control sample generation

a) Test purpose: To verify that the control sample has been randomly generated.

b) Test method: Check whether an automated method has been used to derive the sample for the control.

c) Reference: Clause 8.

d) Type: Basic.

A.3.2. Test case identifier: Distribution of the control sample

a) Test purpose: To verify that the control sample provides a good distribution for each item established in the scope of the data quality unit.

b) Test method: Check whether the control sample has a proper distribution.

c) Reference: Clause 8.

d) Type: Basic.

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A.4. Metaquality

A.4.1. Test case identifier: Confidence

a) Test purpose: To verify that the stand alone quality report describes the confidence element of metaquality.

b) Test method: Check whether there is a qualitative and/or quantitative description of the confidence.

c) Reference: Clause 10.

d) Type: Basic.

A.4.2. Test case identifier: Homogeneity

a) Test purpose: To verify that the stand alone quality report describes the homogeneity element of metaquality.

b) Test method: Check whether there is a qualitative and/or quantitative description of the homogeneity.

c) Reference: Clause 10.

d) Type: Basic.

A.4.3. Test case identifier: Representativeness

a) Test purpose: To verify that the stand alone quality report describes the representativeness element of metaquality.

b) Test method: Check whether there is a qualitative and/or quantitative description of the representativeness.

c) Reference: Clause 10.

d) Type: Basic.

Annex B

Standalone quality report

- Not finished

Conclusions

Conclusions about the statistical method

- A new statistical method for positional control has been presented.
- The method is very simple, statistical sound and based on international standards.
- This method can be applied to any kind of error model (parametric or non parametric) and to any kind of geometry (e.g. points, line strings, etc.)
- The main strengths of the proposal are:
  -It is not linked to any specific statistical hypothesis on errors.
  -It allows controlling position and thematic attributes together.
  -It allows controlling of lot by lot and isolated supplies
- The idea can be extended to other counting based methods (e.g. Dodge-Roming or Philips procedures, zero defects, etc.)

Conclusions

Conclusions about the standard

- The statistics resides on ISO 2859.
- It is aligned with many ISO standards.
- It Introduces specific exigencies for positional controls (e.g. about the sample, reference data set, etc.)
- It clarifies meta quality.
- It establishes a test for conformity.

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Future works

We are working in three lines:

- Sequential “point by point” controls.
- Statistical tests for the base models.
- Implementation of WPS for positional accuracy.