# Formalization of cartographic edition rules to automate topographic maps quality control

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**Abstract:** This paper shows the way the National Geographic Institute of Spain is tackling one common problems of cartographic production using ETL tools: the generation of an automatic edition control of the MTN25 series by means of cartographic rules definition.

The main purpose of this software tool is formalizing the cartographic edition rules used in MTN creation and its further integration into the edition mistakes automatic workflow as a menu tool. To achieve this goal we built a systematic and comprehensive compilation of the fundamental rules of mapping Edition in a repository internally called "Edit rules", from which we could automate a procedure of Automatic Control of cartographic Edition (CAE in Spanish).

## 1. Introduction:

Nowadays, edition tasks are laborious but, at the same time, an essential job done by cartographic institutions when publishing its maps. The aim of these tasks is to detect and solve some of the cartographic edition mistakes such misunderstandings, difficult interpretations, incongruities or lack of cartographic elements.

In the National Geographic Institute of Spain (IGNE) this meticulous work is being carried out by specialized cartographic operators with a high knowledge in map edition tasks. Acquiring such knowledge requires a large process of learning, which is only achieved through many years of experience in this specific task. It is a fact that just a few experienced people are able to satisfactorily review maps; furthermore, this labour takes too much time for each map.

For this reason, IGNE has decided to start a project which will be applied to the MTN25 reviewing: formalizing edition rules with the help of expert operators, in order to be implemented in an automatic revision process.

The following describes how we are conducting this experiment, which has mainly the two main results: On one hand, the gathering and formalizing the operator's knowledge about map reviewing. Until now this knowledge has not been defined in any systematic way, and it used to be transferred in a spoken way from the expert operators to the apprentice ones. And on the other hand, automatic map revision leads to an objective and harmonized result, as well as it decreases the production times.

We are carrying out our challenge through the execution of the following stages: (1) Meetings and interviews: editing knowledge is collected from the cartographic operators in this first stage. (2) Defining rules: Rules are defined from the obtained knowledge by

means of criteria evaluating the cartographic elements. (3) Quantifying criteria parameters that measure the criteria fulfilment over a map (i.e. distances, overlapping areas, tolerances...) (4) Implementing the defined rules in a software environment (Feature Manipulation Engine, FME). (5) Feedback: Cartographic operators check the implementation, evaluating how the automatic revision works, and proposing changes in the rules and its settings. (6) Loop to stage three until the implementation satisfies the operators. Then it is an iterative process which "calibrates" the settings parameters characterizing the rules.

**2. Knowledge Collection and rules definition:**

In MTN25 (National Topographic Map of Spain 1:25.000) the reviewing stage was a very hand-crafting process, little regulated, and with a subjective component which obstruct completion deadlines. Furthermore, the knowledge was held by cartographic specialists, who in general, were near to retirement age.

Another fact to consider is the low number of companies dedicated to cartography at medium scales, which is made worse by the current economic crisis.

Therefore, it became necessary to formalize the mentioned cartographic knowledge and then, automate the tasks as much as possible. For this purpose a multidisciplinary team was created combining cartographic specialists with young engineers dealing with formalizing the specialists' knowledge.

To achieve this item, it was held meetings with operators and carried out an exhaustive study of existing documentation. The result of this work was the creation of nearly 150 Cartographic editing rules that defined comprehensively and systematically the conditions necessary to validate the printed maps.

Each rule consists of the following parts:

**Error Code**: The first four digits refer to the code of the element generating the mistake, and the last two ones refers to the rule code associated to such element /the kind of mistake.

**Error**: Literal description of the error.

**Error Type**: This classifies the error in the followings:

01: Distance: Error due to exceed the maximum and minimum threshold set in the distance between two elements (i.e. a river not going through a watercourse).

02. Overlaps: Error due to two elements-overlapping (i.e. Overlap between cartographic symbols).

03. Disposition: Error due to unsuitable collocation of an element respect to other. (i.e. bad situation of a text regarding to its corresponding element).

04. Completion: Due to the excess or lack of elements (i.e. high density of elevation points).

05. Shape: Error existing in shape elements (i.e. symbols not keeping the correct proportions).

06. Format: Error existing in the format of an element or a text (i.e. bad written texts).

07. Orientation: Error existing in the orientation of an element

08. Categorization: (i.e. text with an incorrect font according to its classification).

**Description**: It describes how the FME application searches for the error in the case that the rule is implemented.

**Criteria/parameters**: It contains the tolerance threshold, the parameter values are applied in the search of the mistake and the criteria that must be applied.

**Exceptions**: It describes real world cases or in which this rule must not be applied.

**Observations**: Remarks regarding the rule job and/or examples of MTN25 sheets where we have found mistakes and observations above them.

The following figure shows an example of the slope rule definition:

| Rule code | Error code | Error | Error type | Description | Criteria/ Parameters | Exceptions | Observations |
|---|---|---|---|---|---|---|---|
| 080008 | 01 | OVERLAPPING | Black text that overlaps with a black line | Black linear symbology | Overlap between characters allowed, and must be a distance of 5m (vpl) | In the case of tangencies and not hinder the reading, when it be the best solution | If they are too long they could be divided into two lines of text |

*Figure 1: Rule definition example*

### 3. Software developed:

The rules definition allows the development team to have access to this editing information in order to develop an application which makes easier the cartographic reviewing before printing (digital or conventional) the sheets.

It was used the FME workbench due to it's a very easy use piece of software and has the possibility to deal with different vector and raster formats. this implies an advantage because makes an easier migration to other workflow environments useful in the future or in other projects which could take advantage of this effort. Figure 2 shows an example of the software development.

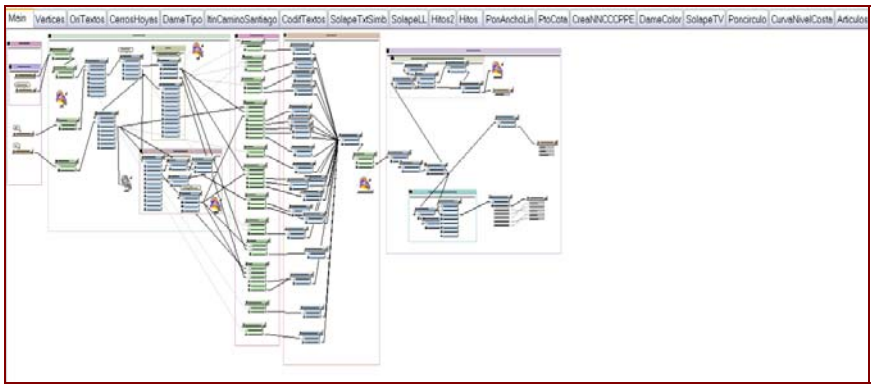


*Figure 2: graphic programming with FME of one rule*

It was carried out a pilot process materializing the rules defined trough FME to detect mistakes. Its development considered the parameters (distances, angles, areas, i.e.)

contained in the edition rules as well as the specific tolerances in such case. Then the rules were redefined and the tolerances were adjusted in order to eliminate spurious errors and exceptions as much as possible.

The following figures show different examples of how are working some of this rule: Figure 3 shows a river which is not going through a watercourse, figure 4 indicates that a linear text is too far from the correspondent line feature, and figure 5 shows two buildings overlapping.


*Figure 3: A river not going trough a watercourse (Error type 01)*

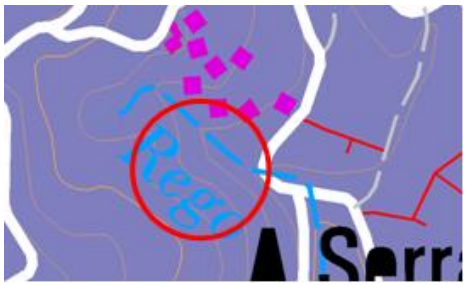

*Figure 4: Linear text too distant to the line feature (Error type 01)*

*Figure 5: Two buildings overlapping (Error type 02)*

## 4. Edition Automatic Control (CAE)

The designed workflow consists on running the automatic process over an edited MTN25 at the time finished. CAE execution schema is showed below (figure 6).

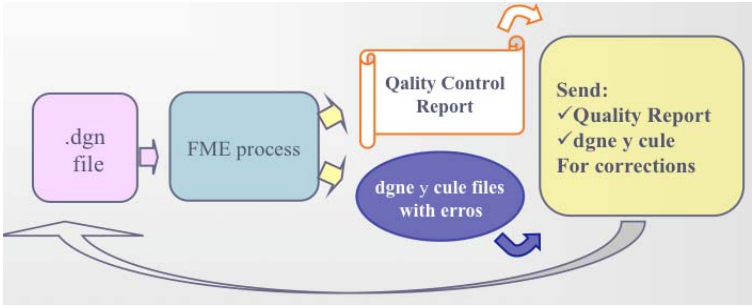


*Figure 6. CAE workflow schema*

The took analyses the edited files (Microstation files) and generates another Microstation file containing the detected mistakes marking where the error happens.

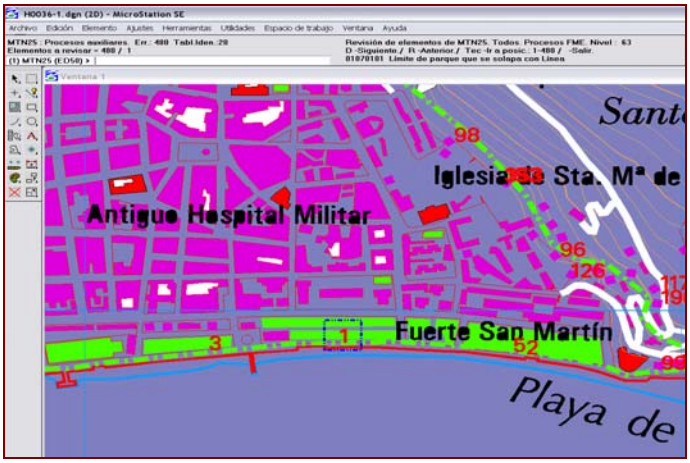


*Figure 7. Microstation file with the detected errors*

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Furthermore, two reports about quality results are obtained: One containing the error identification and the rule infringed and the other one showing statistic information about the infringed rules, providing the number of mistakes detected and its identification (figure 9).

| Errores1 | |
|---|---|
| IDerror | Codigo_regla |
| 1 | Límite no coincide con deslindes |
| 2 | Falta curva nivel o cota incorrecta |
| 3 | Curva auxiliar corta |
| 4 | Curva auxiliar corta |
| 5 | Curva nivel cota 0 |
| 6 | Curva nivel cota 0 |
| 7 | Curva nivel cota 0 |
| 8 | Curva nivel cota 0 |
| 9 | Curva de nivel dentro de embalse o laguna |
| 10 | Distancia inadecuada Pto Cota |

*Figure 8: Report of detected mistakes*

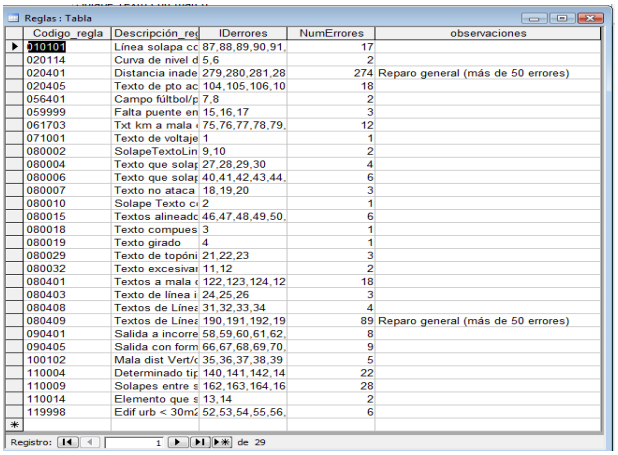


*Figure 9: Report of infringed rules*

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Lastly, CAE ends returning the mistakes to the cartographic agent (the person, company etc that makes the map) combined in the sheet file.

## 4. Error reviewing menu in Microstation

Once the data analysis is carried out in FME, the results are reviewed trough an interactive application developed in Microstation, which greatly facilitates error reviewing tasks and its tracing. It has the advantage of working over a very powerful development platform meanwhile the operators work in stable and mature well-known environment.

When CAE is executed, it creates marks reflecting the position of the error and its identifier in a dgne file, which allows error-handling from the Microstation environment. Examples of error marks and its identification are shown below: Figure 10 shows an error due to a rotated text, figure 11 due to overlapping between symbol and line and figure 12 overlapping between text and line. All this figures shows the infringed rule description in Microstation command line.

*Figure 10: Rotated text error review  Figure 17(Error type 07)*


*Figure 11:  Line-symbol overlapping error review  (Error type 02)*

*Figure 12: Text and line overlapping error review  (Error type 02)*

The application has two working modes: “REV” and “PRO”. REV mode allows error reviewing in a sequentially way or in a direct way introducing the error identification,

searching errors by element type, error type, or just visualizing 'Justified' type errors (figure 13). In order to facilitate the mistake correction, the tool shows information about the number, code and description of the visualized mistake.

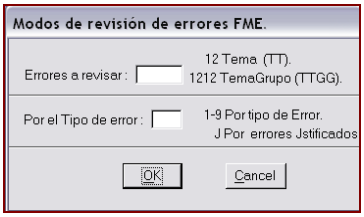


*Figure 13: error Justification*

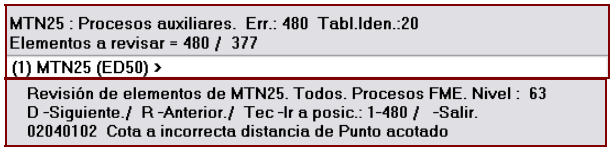


*Figure 14: Figure 14: Error reviewing*

The cartographic specialist corrects the error, although, if the specialist considers it's a false error, an explicative text can be written in order to justify it (figure 15).

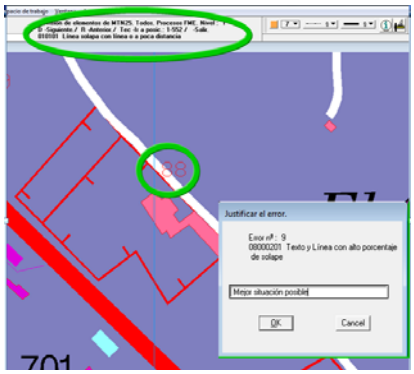


*Figure 15. Justification of error of Line-Line overlapping (Error type 02)*

The result of all the process is the file with the corrected sheet, the file containing the mistakes differentiating the corrected type errors from the justified ones and a text file containing a list with the errors and the operation performed over every one of them. In the case of "justified errors" it is added a description with the justification.

Once the errors have been reviewed, corrected and/or justified, in PRO mode the error visualization is updated: If the error persists, the mark itself change to red colour, if it has been corrected the marks turns green, and if it has been justified it turns yellow. The next figure shows a justified error.

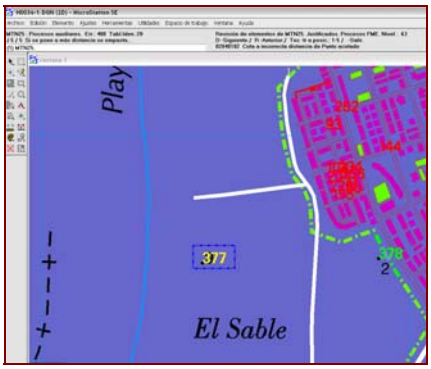


*Figure 16: Justified error due to distance between bounded-text and bounded-point*

## 5. Implementation into the production process:

Introducing CAE in the MTN25 reviewing process has generated a new workflow which means a more efficient use of the IGNE resources (figure 17).

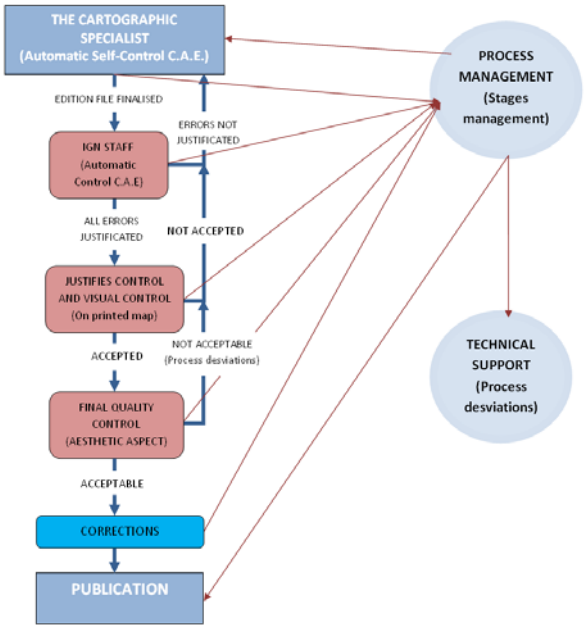


*Figure 17: New workflow in MTN25 reviewing*

The cartographic specialist who is responsible for carrying out the MTN25 sheet edition executes the CAE application before deliver the file and then corrects the detected errors and justifies those considered false errors. In this moment the edition tasks are considered finished.

IGNE receives the sheet and after running CAE, then, all the errors are reviewed in order to check if all the errors are corrected or justified as the first condition to keep on reviewing the file. Otherwise, the sheet is returned back to the agent. If the sheet fulfils the initial conditions, the justifications are revised and the general errors are marked visually. The non-conformities (the non accepted justifications) and the general errors are reflected in the file so that the agent repairs them.

Finally, the sheet is sent to the final quality control, in order to homogenize the product according to the definition of the MTN25 series. From this moment on, the IGN staff performs the possible corrections resulting from the process, and the sheet is therefore ready to send to print works.

**6. Conclusions:**

Nowadays, more than 130 rules have been defined to evaluate some aspects of a map, such as the legibility (i.e. element overlaps), aesthetic (i.e. dispositions and distances between elements), or the lack of excess or incoherencies in the information.

About 80 rules have been implemented up to the present moment, and they are included in the production process. The remaining rules have not been implemented by not being able to automate, either due to their complexity, or the number of false errors detected, but must also be taken into account when editing the map.

In view of the work developed up to now, we can mention four main conclusions:

(1) Besides some rules are very easy to define and implement, the ones related to aesthetic are more complicated due to the high number of parameters needed to evaluate the aesthetic aspect of a map.

(2) There are a high number of exceptions regarding each rule.

(3) We think that making an automatic revision will be difficult but possible in the near future, at less, over the more objective rules.

(4) This automatic revision contributes to saving time in maps production; however an expert specialist is always necessary.

It is important to note that the artistic component and the ease to understand and read the information contained in the printed map cannot be fully controlled by automatic processes. Therefore it will be always require the supervision of a cartographic editing.

The agent in charge of carrying out the Edition has like the IGNE the well defined rules and the application to detect errors. This aspect is fundamental for the first delivery of the sheet, since the number of errors is much smaller than with the old procedure.

Regarding the review of errors detected, the environment enables the communication between the agent and the IGNE, allowing the Agent justify errors that considers that they should not be arranged, and then allowing the IGNE to answer this justification, and in this way, the work can be tracked optimising the process.

Rules formalization has meant greater uniformity in the criteria of cartographic production, and furthermore its materialization in CAE has allowed responding to the producer Agent in a much reduced time. This fact is unimaginable before its implementation, despite suffering a reduction in human resources in the Department. This has drastically shortened the time of production of the MTN25.

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