New production environment for the National Topographic Database 1:25.000 (IGN-E). Intelligence for geographic databases.

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Abstract. This paper aims to show the technological change that happened in the cartographic production workflows of IGN-E during last years.

In the first decade of 2000 a geographic information product was defined, the National Topographic Database 1:25000 -BTN25-. This new product was created by means of a transitional technology consisting of a geographic database stored in Oracle Spatial, and it was implemented by a customizing CAD environment and also by some own applications related to management and data control.

Since May 2010, we are focusing our efforts on getting a safe production environment, specifically watching the consistency and quality in our products. In order to assure this consistency, semantic rules have been introduced, which establish a set of permissions and restrictions by means of topological relationships that “must or can” be accomplished by the geographic features.

Keywords: Geographical Data Bases/data production

1. Introduction

BTN25 is the basic infrastructure of geographic vector data information which describe the reality in a uniform way in Spain, one of its main uses is the production of the National Topographic Map 1:25,000 Spain.

BTN25 began its production in 2006 and it's the successor of the former Numerical Cartographic Base 1:25,000 -BCN25- which went out of production in the same year.

What are the differences between the BCN25 and BTN25? Basically the origin of its data source, this origin determines the nature of the product.

First, BCN25 begins in 1995 with the purpose of providing an infrastructure of basic digital geographic data with national coverage at 1:25,000 scale, designed and structured for allowing analysis operation by automatic processes in GIS [GAR09].

The production process of BCN25 begins with MTN25. From digital files of each sheets of the map, original geometry is extracted, eliminating symbols and everything that is in order to improve visual interpretation. Thereafter, carries out a topological and geometric treatment, while checks are made to ensure the quality and consistency of data.

Therefore, BCN25 has a cartographic character because of its origin, displacing geometry in case of conflict, and the end product is a set of files, and analytically and semantics correct, covering the entire territory, one per sheet of MTN25 with continuity ensured between sheets and two-dimensional. In Figure 1 you can see how BCN25 fits in real world.

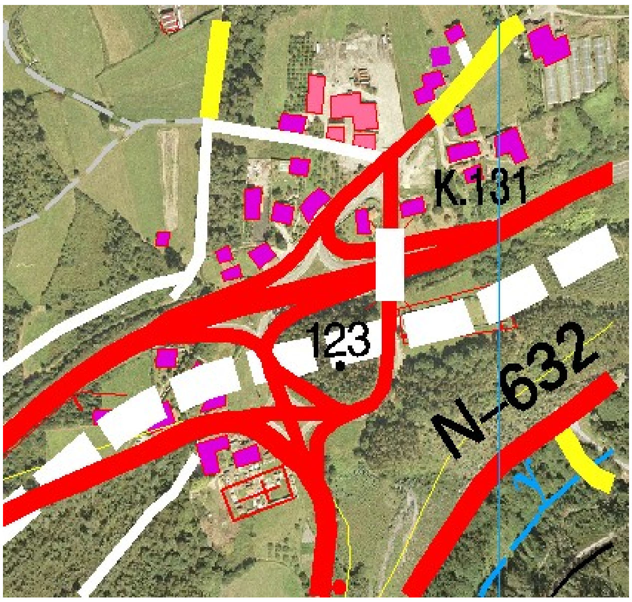

Figure 1. BCN25 superimposed on PNOA orthophoto

Without much thought, we can see that the product is not suitable for analysis, it is also very complex direct update on the orthophoto, due to its cartographic displacement.

As an immediate consequence, in 2006 a new product was defined, BTN25, consisting of a set of tree-dimensional topographic vector data representing reality directly without cartographic modification. The BTN25 principal objective is directly provide data that allow analysis and planning in Geographic Information Systems, GIS, and to serve as a reference source for other products and services such as the geographic map series, the National Geographic Information System of Spain, the Spatial Data Infrastructure of Spain -IDEE- etc. [BTN09]. Figure 2 shows the coincidence with the orthophotograph BTN25 PNOA

Figure 2. BTN25 superimposed on an orthophoto of PNOA

The transition between these two products suppose a change of paradigm, it is going to have the priority objective MTN25 and the by-product BCN25, to focus attention on BTN25 and get the other products and, moreover, it is a total modification of the production process, which affects even the work platform.

Then will proceed to show the strategy used in the modification of the production process. Strategy based on the development and technological innovation to achieve more efficient methodologies in order to ensure product integrity.

2. Transition from Bcn25 to Btn25. A Change in Two Phases

This process began in 2006 with the aim of obtaining the BTN25 with the conditions above have been cited with no delays in production.

There were two phases to undertake the process modifications. The following details each.

2.1. RES25 project

At this stage, the strategy was to continue producing with a consolidated working environment, MicroStation, customized to improve production and ensure product quality. Parallel own applications were developed in C # and Fortran in order to automate part of the workflow.

Thus, starting from the original information of BCN25 and latest photogrammetric restitution available, updated previously, BTN25 was obtain in DGN format. Subsequently, all the information is centralized in an Oracle spatial database according to the data model designed for this product that could be accessed from most of the GIS applications and it was possible to export to popular formats used in the sector. Figure 3 shows in detail the workflow in the project [GON06].

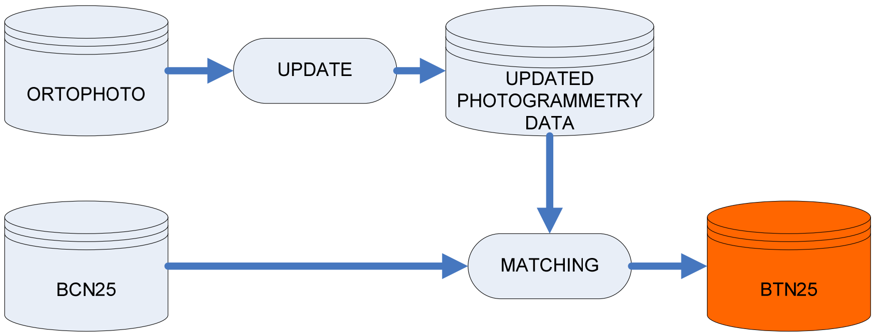

Figure 3. Project Flowchart RES25

The critical process in this development was to solve the correlation phase, which was achieved by linking BCN25 elements and their counterparts in the photogrammetric restitution, so the final result, the BTN25, benefited from the thematic information BCN25 and three-dimensional geometries of restitution.

Finally, BTN25, with three-dimensional geometries and DGN format, was imported into a centralized database Oracle Spatial.

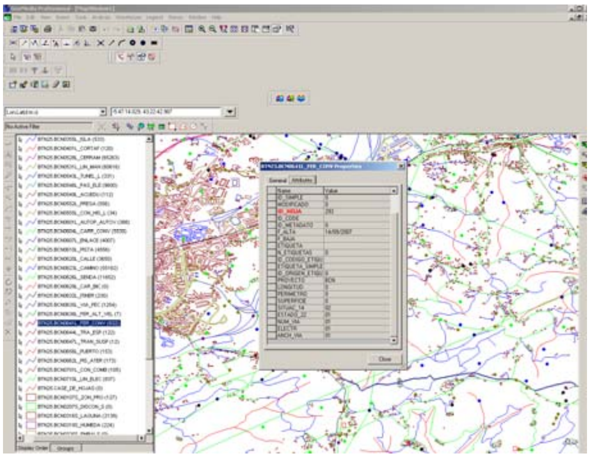

Figure 4. BTN25 from RES25 project

While the goal was achieved, ie BTN25 was obtained with the three-dimensional geometry captured in their true position, with production unit MTN25 sheet but continues in the Spanish territory, and with a geometric structure and in an environment that allowed GIS use, the fact of not having been fully produced in a GIS environment it not allowed get a lot of features that were essential to manage BTN25.

2.2. BTN25 GIS project

In 2009, after the RES25 project started in full swing, the task of change the production platform of BTN25 was addressed.

The environment was chosen Geomedia, lay ahead create a development group that would carry out the production project BTN25 GIS and support different teams.

The task became urgent as needed to keep record and feature identifiers along updating processes, managing new elements, deletions and modifications that were created in these processes and to have them identified in varying periods of time . In this way changes could be supplied to the user which uses BTN25 to update its own data while that could create temporary views thereof. This was impossible or at least very difficult to assure on a graphical CAD. On the other hand, a new set of possibilities that facilitated internal consistency control tasks and control data consistent with external data reference were opened.

Therefore, we designed a production and control environment for BTN25 in a GIS platform with the following characteristics:

- Easy capture environment with high productivity rate.

- Control environment that allows managing the reviews of the product with the agents that update it.

- Management of the three-dimensional information in an easy way.

- Possibility of temporary views of the data base.

- Maintenance of item and feature IDs during product updating process.

- Management of new element, deletions and modifications in the updating process

- Error detection at the time of capture or subsequently by implementing consistency rules

- Implementation of capturing profiles by which, on the one hand, simplifies the attributes value capture and, on the other hand, automatically controlling the validity of combinations of attribute values code list.

- Using a procedure for verifying the consistency of information regarding the external reference information identified in the BTN25 production manual.

Besides geometric and topological treatments used in all geographic information databases production processes.

Based on these requirements a production process according to the following scheme was established (Figure 5).

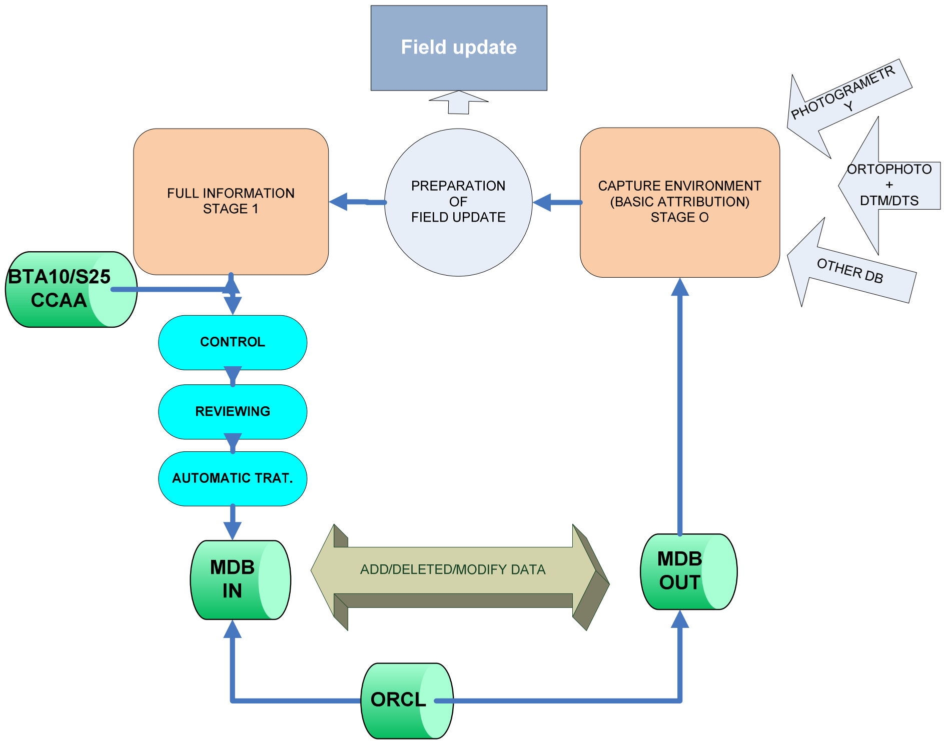

Figure 5. Workflow in BTN25 GIS project

Four phases were defined in the BTN25 GIS production process [GAR10]:

2.2.1. Stage 1: Exporting the information to be updated

This stage aims to prepare the information and set up the environment to update it. This will perform the following operations:

- Export a Geomedia MDB file from the central database ORACLE on which update will be performed.

- It automatically creates the environment settings with the metadata stored in the central database

- It makes a backup to analyze new elements /deletes / modifications once you have updated the Geomedia MDB file.

2.2.2. Stage 2: Updating.

It makes capturing information that will aim to update the BTN25. In this sense a customized work environment has been created that enables different update methodologies, while giving the opportunity to perform consistency checks at the capturing time or using off-line process, so the information is always keeping the integrity as defined in BTN25 [BTN11].

It has also provided the to the work environment applications to manage external data reference identified in BTN25 Production Manual.

2.2.3. Stage 3: Checks, review and automatic procedures.

Once captured and modified the information needed to update the BTN25, we proceed to review the resulting information. An control environment has been created with the following possibilities [Mar11]:

- Automatic applications to verify the consistency of the information. As has tools that facilitate visual inspection using the orthophoto

- Topological and geometric control tools

- Applications that make easy the task of reviewing information according to background information identified in the BTN25 Production Manual.

- Definition of a process that facilitates and manages the review of errors detected with automatic and visuals controls.

2.2.4. Stage 4: Import the updated information.

Finally, updated and tested once the information is appropriate to integrate it into the central database.

In this phase are two operations, first create the new/deletes/ modifies elements file comparing current information with the backup made in Phase 1 and then import takes place in the central database of information that has been modified.

At the time of the import is management additions, deletions and modifications in the central database, which allows among other possibilities ensure traceability of modified items and temporal views of the database.

3. Update and Control Work Environment of BTN25 GIS

The objective is to organize and facilitate work on GIS environment. By using general purpose software, their use requires a high degree of knowledge of it, which can be a limitation in production. To avoid this potential problem a custom environment has been created, using the possibility to develop applications in standard programming languages on GIS platforms.

All the workflow setting is performed with external tables. You can configure the tasks to do, the list of features and attributes that you capture and also control and error detection utilities. Thanks to the external tables configuration you can use the same program for different production projects just changing the configuration.

One important goal in BTN25 GIS production process is the development of semantic rules in order to preserve the logic consistency and quality in the cartographic products obtained.

Such rules establish a set of permissions and restrictions by means of topological relationships as: connectivity, adjacency, completely surrounded of, included, completely covered, proximity, partial overlapping and crossing, that "must or can" be accomplished between certain groups of features or individual feature, that ensure the logic consistency defined for a set of geographical data.

Logic consistency is defined in "ISO 19113 Geographic information – Quality standard" as the "degree of adherence to logical rules of data structure, attribution and relationships (data structure can be conceptual, logical or physical)".

Implementing semantic rules, in a practical sense, consists on materialize more than 150 queries that notice of noncompliance the data capture conditions, relationships between elements and own characteristics of each feature class defined in a formal document called "Data dictionary and capture standards of the National Topographic Database 1:25.000".

The first step in developing semantic rules was systematically formalizes the rules expressed literally in the document above in the format described in the figure 6.

Rule code	Def	Error	Query code	Query/ Tool	Feature type in	Feature type out	Relationship	Error examples
050101	**Entidad de población no debe solaparse a otra Entidad de población**	Entidad de población se solapa a otra Entidad de población	05010101	Intersección espacial	0501S_ENT_POB	0501S_ENT_POB	Se solapan	0001C4 0223C3 1068C2
			05010199	Consulta de atributo	05010101		ID1 <> ID11	

Figure 6. Semantic rule systematic notation

For implementing such rules, a systematic analysis of the conditions mentioned in the documents above has been done, defining for each one of them: a) feature class that the rule is concerned about, b) degree of association that can be classified in: “must” or “can”, depending on the compulsory of the relationship and c) Association name, that defines the topologic relationship among feature classes, that can be also classified as: 1) connectivity, 2) feature A1 included in feature A2 b) A1 feature proximity with A2 feature, 3) partial overlapping, 5) crossing, 6) overlapping and 6) disjoint

Analysis result is implemented in GIS environment by means of building as many set of queries as many rules are obtained, showing the database elements that violate the rules.

Semantic rules operation can be done by mean of two procedures: a) On-line: as the data is being captured, before storing, is detected if the element accomplishes the established rules or not and b) Off-line: is applied to a set of data that are captured in previous stages and one needs to verify if the preset conditions of the rules are accomplished or not.

In the next picture can be show an example of result of one semantic rule, it is not possible that one communication route crosses through the building.

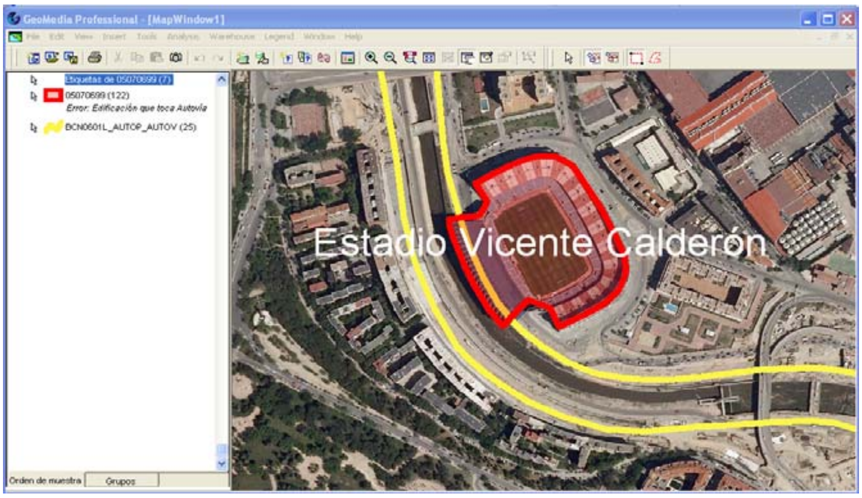

Figure 7. Communication route crosses through the building

On the other hand, the updating and control environment has two different views, each actor-oriented views is involved in the work process. One is for the agent who is responsible for the update and another is for the operator who is responsible for monitoring. In the next picture you can see the two environments

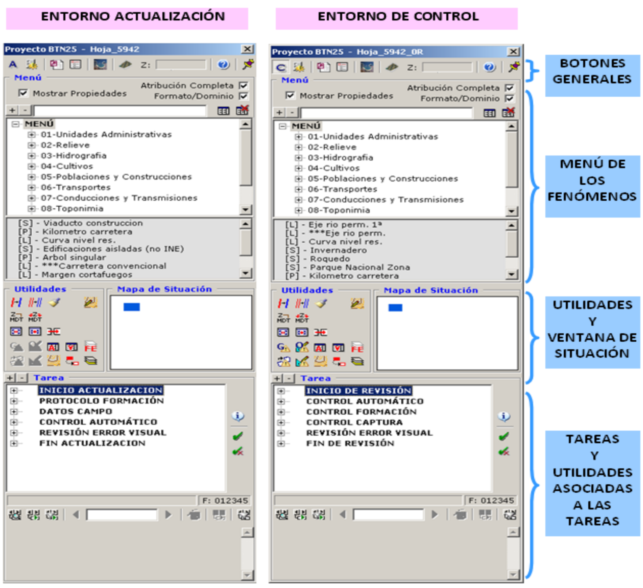

Figure 8. Overview of the environment

Basically it's the same, except for two minor differences:

-The updating view has no profits to mark visual errors

-Error management in the relationship agent / reviewer

This is because one of the objectives in the development has been to ensure that both, the agent in charge of the update and the operator responsible for its review have the same tools for error detection in order to self-assess the quality of the product it is delivered. This greatly simplifies the task of revision.

3.1. Tools for updating

Besides control utilities that will detail in the next section, specific tools have been designed that allow efficient and safe update of BTN25.

-Capture Profiles have been implemented, defined by one feature class and a combination of attribute values that allow quickly and safely record the instance.

- It allows capturing tridimensional geometries; this is done by relying on a DTM, previously loaded. Also it allows marking the items that altitude hasn't been assigned, for doing automatically in further off-line process when DTM has been loaded.

- Contour lines are able to be generated from DTM in order to updating altimetry data.

- Other tools for symbolize, reviewing data and layer management to make easy the manipulation of the information and the work environment have been facilitated, even the possibility to access to external geographic data viewers centered in the updating area.

3.2. Tools for controlling

Quality control is detecting non-compliance with BTN25 specifications [BTN09] [CEN07]. It is divided into two different kind of control: Automatic and visual. The first is to automatically detect the errors, while the second should be the reviewer which detect and mark with a specific encoding.

The following describes the controls performed in each of them.

3.2.1. Automatic Controls

Automatic controls detect errors at any time of the updating by a complete inspection of the file, so are able to run both on-line and off-line using specific menus, Figure 9

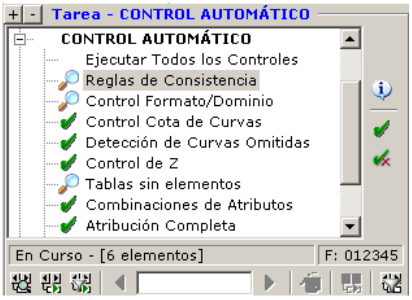

Figure 9. Automatic Control Tasks

Online detection prevents operator mistakes while capturing and its activation is optional. Offline method executes the post-process controls.

The control operator can run as many times as necessary, repair errors and deliver the file with the assurance that all errors are detected automatically, are fixed.

The controls that are being made at the present are:

- Allowed Combinations and Empty Attributes Control: some Capture Profiles are defined under feature definition. That is, one feature is defined with the entity and the possible combinations of values for its attributes. This control detects whether the combination of the values of attributes codelist type of an element belongs or not to set Capture Profiles that are included in the project specifications [BTN09].

It's not enable capture elements with invalid attribute combinations if it's working with the project environment.

- Control Z: Detects the lack of agreement between the Z coordinate of an element and the elevation model loaded with the tool, also the possible lack of registered contour lines is checked.

- Format and Domain Control: Detects the nonconforming to formatting and domain rules specified in the BTN25 Manual [BTN11], for attributes that are not codelist type.

- Consistency Control: Detects the nonconforming to semantic rules based on spatial relationships to be established between interdependent phenomena to be consistent with the real world and with the specifications in trapping standards [BTN11].

The latter two can be detected in time of capture or post-processing.

- Geometric and Continuity Control: it detects geometry and connectivity errors of the set of sheets (connectivity in and between sheets, loops, duplicate vertices, solve intersections, etc...). The tool provides solutions to errors that can be resolved automatically, semi-automatically or manually.

3.2.2. Visual Inspection

Visual errors are detected using external sources of reference, elevation models and orthophoto. In the control environment are defining tasks of reviewing information according to BTN25 Content Definition Protocol necessary for proper allocation of attributes of the update phase.

Errors detected are stored and displayed by "marks", figure 10, with a standard description understandable by agent and editor, which is composed according to the type of fault based on the classification of the ISO19113 Quality Subelements [ISO02]

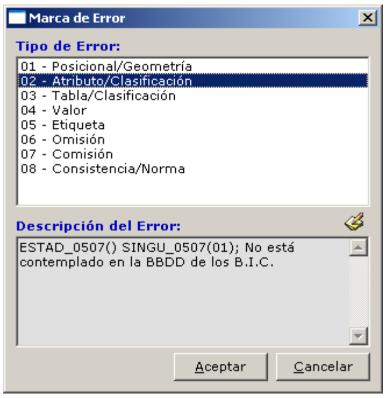

Figure 10. Window and selecting the type of error flag

In order to make the standard classification a specific application has been created that facilitates the management of them, figure 11

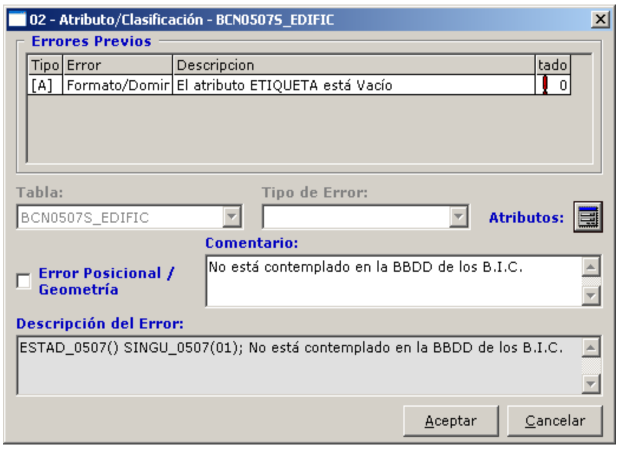

Figure 11. Coding window error flag

4. Errors Management

It is a management system to ensure automatic error detecting tracking during the reviewing process.

4.1. Error States

Errors are handled by states. Once an error is generated, it is automatically assigned a state that indicates the situation in which it is since first detected until it is fixed or classified as false.

Errors never disappear. Once detected only are able to change from one state to another. Figure 12 shows the classification of states and their meaning.

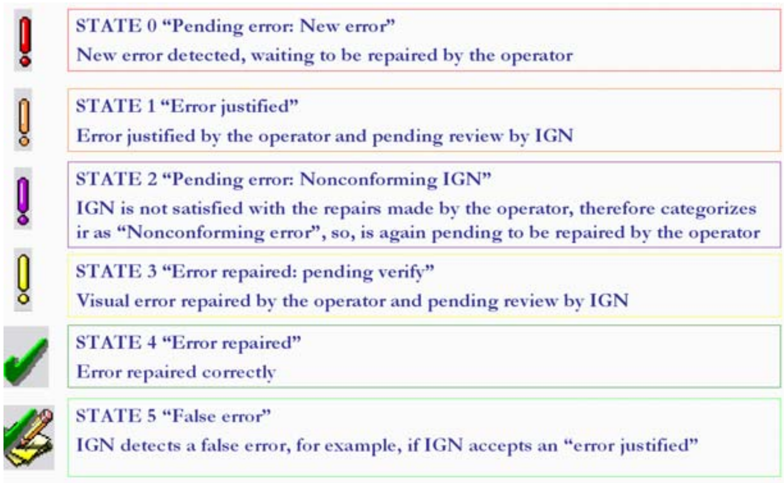

Figure12. Classification error states

Filters allow visualizing the error states that we are interested depending on the task that we are running. Figure 13 shows the window where choose the error state to visualize.

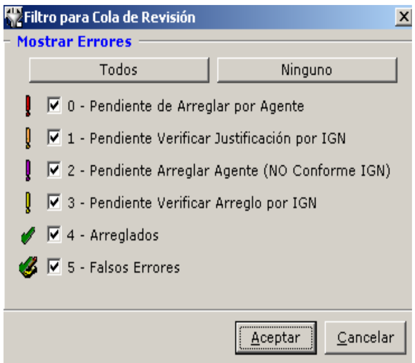

Figure 13. Filters error states

The agent must have active at least State-0 to see new errors, and State-2 for their own justified errors but not accepted by IGN.

Meanwhile, IGN, at least must have active errors in State-1 which are justifications made by the agent, and in State-3, visual errors arranged by the agent and that have not yet been verified by the IGN.

As State-4 stores errors properly fixed and State-5 are false mistakes, you don't need active them.

Following figures show s the state changes that may occur depending on the type of error and the work environment (14 and 15).

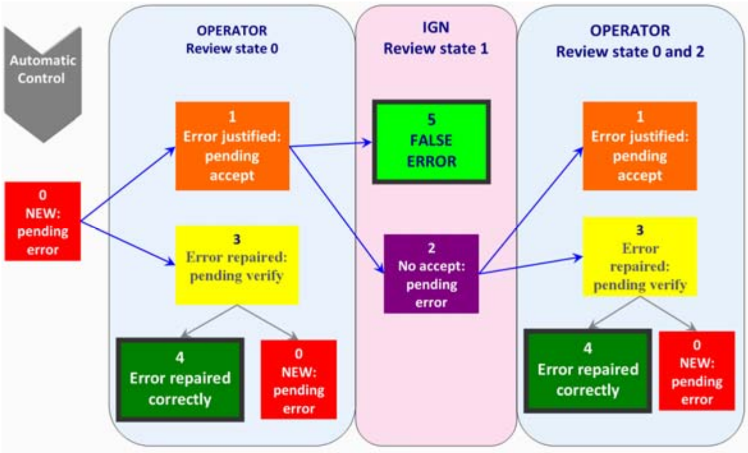

Figure 14. State changes in automatic error

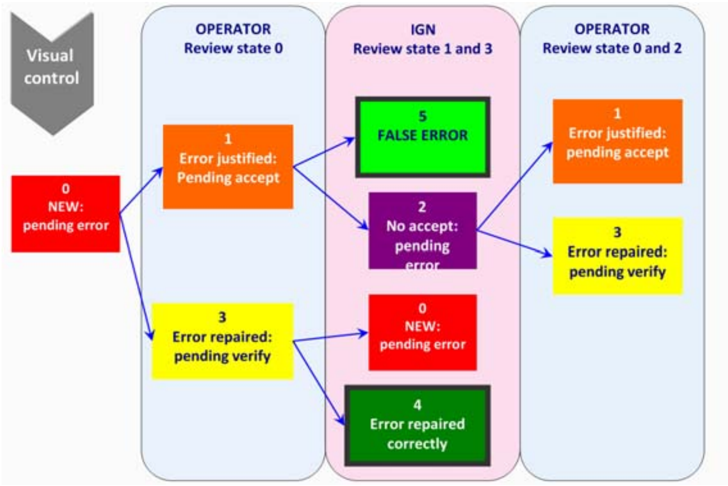

Figure 15. State changes in visual errors

4.2. Reviewing Errors

After running the automatic controls or marked visual errors shall be checked one by one in order to give it a solution.

The application has a reviewing window which allows fluid communication between agent and IGN for tracking the errors, and it has a variety of tools to facilitate the arrangements, in order to speed up the error handling process (Figure 14).

UPDATE ENVIRONMENT **CONTROL ENVIRONMENT**

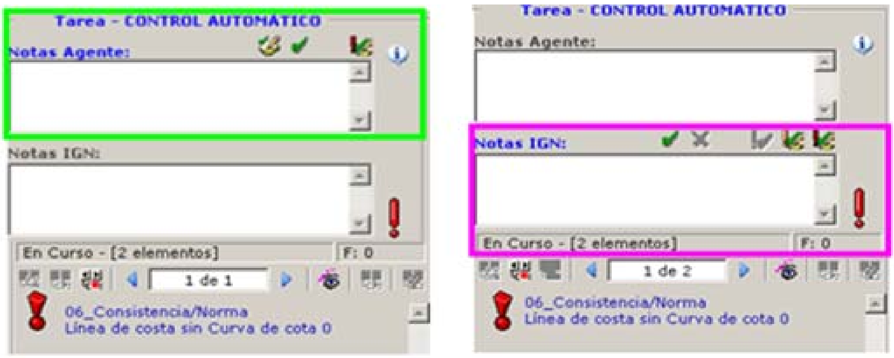

Figure 16. Review window of error in each of the environments

As shown in the figure, the state change buttons and typing area varies depending on the environment in which it is being reviewed.

The application allows to change from one state to another depending on the environment and the previous state in which the error is, justify, flag as solved, waiting for verifying, or mark as false errors.

In this way, the agent at the end of the update will not be left without fixing any errors or justify it. And meanwhile IGN should not let any error pending for verifying.

This systematic methodology of error handling facilitates communication between the agent and the IGN because review and correction processes of BTN25 have been standardized.

5. Conclusion

The General Subdirectorate of Geodesy and Cartography, specifically, the Department of Basic and Derived Mapping is responsible for the production of National Geographic Information Databases and National Mapping Series. The 1:25,000 scale production project is one of the most complex in the national level, both for its size and its diversity.

The Department of Basic and Derived Mapping is involved in a continuous process of reengineering of the production systems in order to improve efficiency. This unequivocal commitment to innovation is giving very good results in order to improve the efficiency.

The systematic definition of the project and the creation of BTN25 GIS production environment has established a clear and objective methodology, while ensuring the consistency of information according to the product definition, with knowledge at all times of information official reference to be used for updating each kind of feature.

Also, it enables establish frame of communication between the agent and IGN, both for management of visual and automatic errors as for tracking the workflow, even to notify automatically the change of state to the agents involved and being able to handle the file movement and pending tasks assigned to each operator.

All these features make it easy BTN25 production and thus improve outcomes.

The successes achieved so far encouraged to continue this technology commitment. Currently, the new development works in the area are directed to the production of printed maps. On the one hand, the development of automatic generalization based processes for creating quality printed maps based on topographic databases. On the other hand, development of data models and more efficient production environments for cartographic production in order to have better communication with reference databases and facilitate the implementation of mapping on demand.

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