

# **PROPOSAL OF A METHODOLOGY AND PROCEDURE MANUAL FOR REGULAR UPDATES AT 1:50,000 SCALE MAPPING USING SATELLITE IMAGERY.**

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## **Introduction**

Given the existing need of "updating of national cartography," it is necessary to have a methodology to perform the upgrade on a permanent and systematic way, making maximum use of alternatives offered by the market, incorporating the use of satellite imagery.

This study explores the implementation of an appropriate methodology for Cartographic Updating process through the use of satellite imagery, supported by a Procedure Manual for the process.

## **Objectives**

The objectives for this work are:

1. Studying the generation process mapping at 1:50,000 scale in the IGM, in order to know their procedures, production times and information stored in the GDB through the lifting of their processes and establish priorities for upgrading.
2. Studying the fundamentals of remote sensing and satellite imagery, in order to determine the type and spatial resolution images suitable to be used to systematize the process, according to the standards of the IGM.
3. Determining the methodology for updating mapping using satellite imagery, considering all steps necessary, in order to define the processes to follow during the upgrade.
4. Raising the procedures for updating mapping using satellite imagery, in order to generate a Procedure Manual, in line with the current ISO 9001-2000 certification from the IGM.

To fulfill the objectives outlined above, the survey was conducted in three stages in succession, which are explained below and let, finally, the development and delivery of a Procedure Manual in a logical and easy way for users.

**Initially**, we defined the upgrade needs to evaluate the information stored in the geospatial database, through a qualitative and quantitative analysis, allowing further study direction.

## Update Needs

To make the analysis of information from the database, a study was conducted in stages, in order to guide the pilot project effort of renovation, which seeks to identify the product and the resolution of the images to be used. The steps above are as follows: Sample Selection, Quantitative Analysis of the sample, qualitative analysis of the sample matrix, and finally integration of data.

## Sample selection

We chose a pilot sample of 15 topographic maps in digital and paper of a total universe of 1445 topographic charts 1:50.000 which provides national cover, covering the 1.038% of total coverage. The number of topographic charts in the sample was calculated using statistical methods with 95% confidence level or 5% of statistical significance, a study of the transport variables, services, population, industry, hydrography and boundaries.

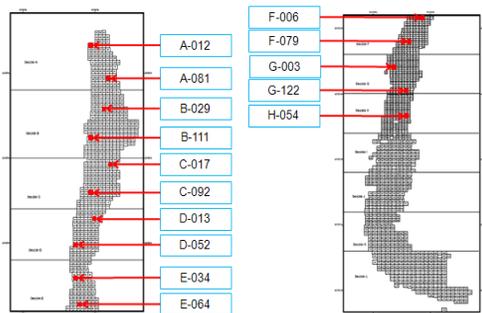


Figure 1: Sample used in the study of Geospatial Database. Prepared by the author.

## Quantitative Analysis

The information in the geospatial database has undergone a considerable number of conversions and management after its capture. The information to be captured Photogrammetrically and its further revision in Geomedia, within the list of codes, names and nomenclature. This classification is divided into 11 categories, which in turn are subdivided into 160 subcategories.

Subsequently, the formatting information is converted to be entered into the database and follows the Data Dictionary for VMAP2 (FACC). The product for the end user is shown in Figure 2.

|            | AREAS |    |     | URBES |    |     | PUEBLOS |    |     |   |
|------------|-------|----|-----|-------|----|-----|---------|----|-----|---|
|            | I     | II | III | I     | II | III | I       | II | III |   |
| CATEGORIA  |       |    |     |       |    |     |         |    |     |   |
| ELEVACION  |       |    |     | X     | 1  | 5   |         | X  | 2   | 5 |
| TOPOGRAFIA | X     | 2  | 2   | X     | 1  | 1   |         | X  |     |   |
| HIPOGRAFIA | X     | 4  | 8   | X     | 5  | 8   |         | X  | 5   |   |
| INDUSTRIA  | X     | 2  | 2   | X     | 1  | 1   |         | X  | 2   |   |
| LIMITES    |       |    |     | X     | 4  | 5   |         | X  | 1   |   |
| POBLACION  | X     | 6  | 7   |       |    |     |         | X  | 1   |   |
| VEGETACION |       |    |     | X     | 1  | 1   |         | X  | 1   |   |
| TRANSPORTE | X     | 1  | 2   | X     | 7  | 11  |         | X  | 2   |   |
| VEGETACION | X     | 7  | 8   |       |    |     |         |    |     |   |

| Subcategorias | Categorías | 9x3 | 27 |
|---------------|------------|-----|----|
| Ier NIVEL     |            |     | 58 |
| II do NIVEL   |            |     | 85 |
| III er NIVEL  |            |     | 0  |

Figure 2: "Levels of disaggregation of the product for the end users". Prepared by the author.

The aim of this paper does not consider the update of the altimetry. This is why reducing the elevation layer obtained as shown in Figure 3, which shows the data and allows the making of the following chart.

| CATEGORY              | Information Fields | Overall | %      |
|-----------------------|--------------------|---------|--------|
| TRANSPORTATION (DOTS) | 53                 | 33838   | 57,014 |
| TRANSPORT (LINES)     | 33783              |         |        |
| TRANSPORT (AREA)      | 2                  |         |        |
| SERVICES (DOTS)       | 8                  | 186     | 0,313  |
| SERVICES (LINE)       | 178                |         |        |
| POPULATION (DOTS)     | 13105              | 15074   | 25,398 |
| POPULATION (AREAS)    | 1969               |         |        |
| LIMITS (POINTS)       | 16                 | 3449    | 5,811  |
| LIMITS (LINE)         | 3433               |         |        |
| INDUSTRY (DOTS)       | 219                | 260     | 0,438  |
| INDUSTRY (LINE)       | 14                 |         |        |
| INDUSTRY (AREAS)      | 27                 |         |        |
| HYDROGRAPHY (DOTS)    | 478                | 5211    | 8,780  |
| HIDROGRAFÍA (LINE)    | 4427               |         |        |
| HIDROGRAFÍA (AREAS)   | 306                |         |        |
| PHYSIOGRAPHY (LINE)   | 445                | 661     | 1,114  |
| PHYSIOGRAPHY (AREAS)  | 216                |         |        |
| VEGETATION (AREAS)    | 671                | 671     | 1,131  |

Gráfico de capas de información de la muestra sin elevacion

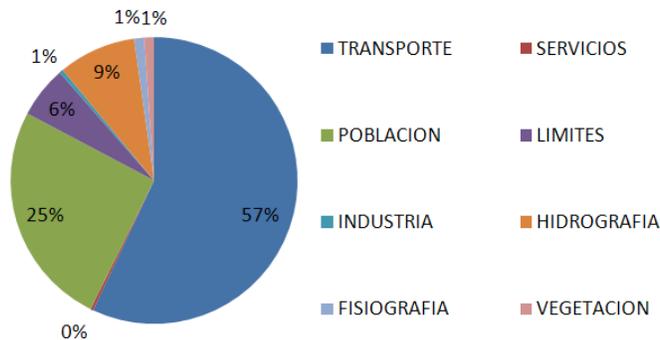


Figure 3: "Organization for Marketing Information. Prepared by the author.

We conclude that the layers of information representing the quantitative analysis are the layers of transport, population and hydrography.

### Qualitative analysis

To analyze the quality of information, a weight matrix was defined, in order to assign a reference parameter to each of the layers of the pilot sample used in the selling of cartography.

|   |                                    |  |
|---|------------------------------------|--|
| 1 | Primera Prioridad de actualización | Debido a los permanentes cambios en periodos cortos de tiempo (menor a 2 años)                               |
| 2 | Segunda prioridad de actualización | Debido a cambios que no son permanentes en el tiempo (entre 2 a 5 años)                                      |
| 3 | Tercera prioridad de actualización | Cambios poco visibles a la escala 1:50.000   |
| 4 | No se actualizará                  | No se considera actualizar por el método definido. Imágenes Satelitales planas no usando par estereoscópico. |

Figure 4: Weight matrix for assessing the information layers. Prepared by the author.

With the evaluation matrix presented in Figure 4 we evaluated all the layers of information, entered the results of the analysis in Figure 5.

|                      |   |                    |   |                      |   |
|----------------------|---|--------------------|---|----------------------|---|
| TRANSPORTE (PUNTO)   | 1 | POBLACIÓN (PUNTOS) | 1 | HIDROGRAFÍA (PUNTOS) | 1 |
| TRANSPORTE (PUNTO)   | 2 | POBLACIÓN (ÁREAS)  | 1 | HIDROGRAFÍA (PUNTOS) | 1 |
| TRANSPORTE (LÍNEAS)  | 2 | POBLACIÓN (ÁREAS)  | 3 | HIDROGRAFÍA (PUNTOS) | 3 |
| TRANSPORTE (LÍNEAS)  | 2 | POBLACIÓN (ÁREAS)  | 2 | HIDROGRAFÍA (PUNTOS) | 2 |
| TRANSPORTE (LÍNEAS)  | 1 | POBLACIÓN (ÁREAS)  | 2 | HIDROGRAFÍA (PUNTOS) | 1 |
| TRANSPORTE (LÍNEAS)  | 1 | POBLACIÓN (ÁREAS)  | 1 | HIDROGRAFÍA (LÍNEAS) | 2 |
| TRANSPORTE (LÍNEAS)  | 1 | POBLACIÓN (ÁREAS)  | 2 | HIDROGRAFÍA (LÍNEAS) | 1 |
| TRANSPORTE (LÍNEAS)  | 1 | LIMITES (PUNTOS)   | 2 | HIDROGRAFÍA (LÍNEAS) | 2 |
| TRANSPORTE (LÍNEAS)  | 2 | LIMITES (LÍNEAS)   | 2 | HIDROGRAFÍA (LÍNEAS) | 1 |
| TRANSPORTE (ÁREA)    | 2 | LIMITES (LÍNEAS)   | 2 | HIDROGRAFÍA (LÍNEAS) | 2 |
| SERVICIOS (PUNTOS)   | 3 | LIMITES (LÍNEAS)   | 3 | HIDROGRAFÍA (ÁREAS)  | 1 |
| SERVICIOS (LÍNEAS)   | 2 | LIMITES (LÍNEAS)   | 2 | HIDROGRAFÍA (ÁREAS)  | 2 |
| SERVICIOS (LÍNEAS)   | 2 | VEGETACIÓN (ÁREAS) | 3 | HIDROGRAFÍA (ÁREAS)  | 1 |
| SERVICIOS (LÍNEAS)   | 2 | VEGETACIÓN (ÁREAS) | 2 | HIDROGRAFÍA (ÁREAS)  | 1 |
| FISIOGRAFÍA (LÍNEAS) | 2 | VEGETACIÓN (ÁREAS) | 3 | INDUSTRIA (PUNTOS)   | 3 |
| FISIOGRAFÍA (ÁREAS)  | 2 | VEGETACIÓN (ÁREAS) | 3 | INDUSTRIA (PUNTOS)   | 2 |
| FISIOGRAFÍA (ÁREAS)  | 2 | VEGETACIÓN (ÁREAS) | 3 | INDUSTRIA (LÍNEAS)   | 2 |
| ELEVACIÓN (PUNTOS)   | 4 | VEGETACIÓN (ÁREAS) | 2 | INDUSTRIA (ÁREAS)    | 2 |
| ELEVACIÓN (PUNTOS)   | 4 | VEGETACIÓN (ÁREAS) | 3 | INDUSTRIA (ÁREAS)    | 2 |
| ELEVACIÓN (LÍNEAS)   | 4 |                    |   |                      |   |

|             |      |
|-------------|------|
| TRANSPORTE  | 1.50 |
| SERVICIOS   | 2.25 |
| POBLACIÓN   | 1.71 |
| LÍMITES     | 2.20 |
| INDUSTRIA   | 2.20 |
| HIDROGRAFÍA | 1.50 |
| ELEVACIÓN   | 4.00 |
| FISIOGRAFÍA | 2.00 |
| VEGETACIÓN  | 2.71 |

Figure 5: Qualitative analysis of the pilot sample information. Prepared by the author.

The tables presented show that the value of information layers, as the emphasis for an upgrade, it is concluded that higher priority layers of information correspond to the layers of Transportation, Population and Hydrography.

### **Data integration**

When analyzing the results of the qualitative and quantitative analysis of the pilot sample, we may similarly conclude in a similar way to other international updating projects; being a priority for the update, either by the characteristics or by the amount of information contained, the layers of information related to road infrastructure, which is apparent in the layer of information called transport, urban coverage located in the information layer called population and finally the hydrographic coverage.

The layers mentioned above are those that change much over time, either naturally or by human intervention, it is for this reason that the project update will assign greater importance to these layers of information.

In a **second stage**, it was determined the product (satellite image) and the optimal resolution for the update process, through the use of weighing matrixes and evaluation, under which were analyzed nine decision criteria.

There are many sensors for mapping purposes, but the availability of images depends on the representatives of Chile, which is why there has been a comparative study of the products available in the IGM.

The following products were considered for the study: Quickbird, Formosat 2, Landsat 7 ETM + sensor and finally the product SPOTMaps.

### **Product Rating**

An evaluation of the products will be carried out and a decision matrix will be used, considering the following criteria:

1. Width scene.
2. Spatial resolution.
3. Size of digital files.
4. Ease of visualization work at 1:50.000 for identification.
5. Ease of visualization work at 1:25.000 for identification.
6. Overlay vector files 1:50.000
7. Overlay vector files 1:25.000
8. Possible operator errors due to image resolution.
9. Ideal scale proposed by international agencies.

These criteria will be controlled with the four images or products above mentioned.

For the final evaluation of products, the first thing we will do is to assign each decision criteria a matrix specific weight percentage of each of them, considering the importance and relevance of the decision. A note will be assigned to each product alternatives

studied and weighed by each of the decision criteria in order to define the 2 images that have the best conditions for a further pilot study.

The decision criteria selected were taken considering the use to be given to the images, i.e. define a Procedures Manual for Cartographic updating 1:50.000 using satellite imagery.

### Decision matrix

In the table in Figure 6 shows the weigh decision criteria presented.

| No. | Decision criteria.    | Weighting |
|-----|-----------------------|-----------|
| 1   | Width Scene           | 10        |
| 2   | Spatial Resolution    | 20        |
| 3   | Size Digital Archives | 12        |
| 4   | Working at 1:50.000   | 12        |
| 5   | Working 1:25.000      | 8         |
| 6   | Overlay 1:50.000      | 10        |
| 7   | Overlay 1:25.000      | 6         |
| 8   | Operator Errors       | 8         |
| 9   | Ideal scale proposal  | 14        |

Figure 6: Weighting of decision criteria. Preparation of the Author.

In addition to evaluating and comparing different products with the respective decision criteria, the values of the table in Figure 7 will be applied:

|   |  |
|---|--|
| 0 | Does not meet minimum requirements for work. |
| 1 | Meets the minimum requirements for work.     |
| 2 | Meets the requirements accordingly.          |
| 3 | Meets the requirements remarkably.           |

Figure 7: "Evaluation Criteria". Preparation of the Author.

|     |                       |           | Allocation       |                 |                |                |
|-----|-----------------------|-----------|------------------|-----------------|----------------|----------------|
| No. | Decision Criteria     | Weighting | <i>Quickbird</i> | <i>Formosat</i> | <i>Landsat</i> | <i>SpotMap</i> |
| 1   | Width Scene           | 10        | 2                | 1               | 1              | 3              |
| 2   | Spatial Resolution    | 20        | 3                | 2               | 0              | 2              |
| 3   | Size Digital Archives | 12        | 1                | 3               | 1              | 2              |
| 4   | Working at            | 12        | 3                | 2               | 1              | 2              |

|   |                      |    |   |   |   |   |
|---|----------------------|----|---|---|---|---|
|   | 1:50.000             |    |   |   |   |   |
| 5 | Working 1:25.000     | 8  | 3 | 2 | 1 | 1 |
| 6 | Overlap 1:50.000     | 10 | 1 | 2 | 2 | 2 |
| 7 | Overlap 1:25.000     | 6  | 1 | 2 | 1 | 1 |
| 8 | Operator Errors      | 8  | 1 | 2 | 1 | 2 |
| 9 | Ideal scale proposal | 14 | 1 | 1 | 0 | 2 |

Figure 8: "Evaluation of each product." Preparation of the Author.

Finally, to make a decision and determine what are the 2 best alternative proposals, the procedure will be to weigh the evaluation obtained according to their respective weights, having as its goal the update mapping at 1:50,000 scale

|     |                       |           | <b>Weighting obtained.</b> |                 |                |                |
|-----|-----------------------|-----------|----------------------------|-----------------|----------------|----------------|
| No. | Decision Criteria     | Weighting | <i>Quickbird</i>           | <i>Formosat</i> | <i>Landsat</i> | <i>SpotMap</i> |
| 1   | Width Scene           | 10        | 20                         | 10              | 10             | 30             |
| 2   | Spatial Resolution    | 20        | 60                         | 40              | 0              | 40             |
| 3   | Size Digital Archives | 12        | 12                         | 36              | 12             | 24             |
| 4   | Working at 1:50.000   | 12        | 36                         | 24              | 12             | 24             |
| 5   | Working 1:25.000      | 8         | 24                         | 16              | 8              | 8              |
| 6   | Overlap 1:50.000      | 10        | 10                         | 20              | 20             | 20             |
| 7   | Overlap 1:25.000      | 6         | 6                          | 12              | 6              | 6              |
| 8   | Operator Errors       | 8         | 8                          | 16              | 8              | 16             |
| 9   | Ideal scale proposal  | 14        | 14                         | 14              | 0              | 28             |
|     |                       |           | 190                        | 188             | 76             | 196            |

Figure 9: "Final score obtained. Preparation of the Author.

With the results obtained in the preceding table, one can determine the alternatives best evaluated correspond to the products *SpotMap* and *QuickBird*.

### **Comparative study in a pilot area with Spotmap and Quickbird**

After analyzing the different images, a detailed study will be carried out with the 2 best alternatives evaluated, as follows:

#### **Input Data:**

- Image "*SpotMap*" resolution of 2.5 meters, with the combination of the bands blue, green and red (natural color).

- Image "*Quickbird*" resolution of 0.60 meters with the combination of the bands blue, green and red (natural color).
- 1:50.000 digital topographic chart of the sector covering the previous images, called E-34 "Papudo".
- 1:50,000 Paper Topographic Chart E-34 "Papudo".
- Software: *ArcGIS* 9.2, with its modules *ArcMap* and *ArcInfo*.

Using *ArcGIS* 9.2, it was made an identification of the elements in digital mapping (vector data) and its correlation with each satellite image (raster data) to display the precision of the data stored in digital form in the BDG IGM and the amount of changes that have occurred, given the long period of time between the two main sources of information and, if this product is used and meets the needs presented to the process of updating the information vector.



Figure 10: "Images with Road Network *SpotMap* Hydrographic to :10,000 scale display "

Capture the author.

#### Final comments on the best rated products

|                      | Product <i>SpotMap</i>   | Product <i>Quickbird</i> .   |
|----------------------|--|--|
| Resolution           | Suitable for updating the mapping at 1:50.000 scale.                                   | Suitable for updating the mapping at 1:50,000 scale.                                   |
| Viewing the elements | Proper visualization for positioning and hydrographic roadways.                        | Proper visualization for positioning and hydrographic roadways.                        |
| Field Support        | It can not detect all the details, thus requiring the most support from ground.        | Minor because of its higher resolution. (0.6 m)  |
| Geometric Accuracy   | Better geometric precision than digital mapping, making it very difficult to conduct a | Better geometric precision than digital mapping, making it very difficult to conduct a |

|                       |  |  |
|-----------------------|--|--|
|                       | metrical analysis between both products.               | metrical analysis between both products.                                       |
| Displacement vectors. | In making the overlay there is a shift of information. | In making the overlay there is a marked and detailed displacement information. |

Figure 11: Final SpotMap products and Quickbird. Preparation of the Author.

The table in Figure 11 delivers some considerations obtained in the study with the best products at the pre-weighted stage.

With respect to the spatial resolution of an image sensor is recommended in a resolution between 1 to 2.5 meters in order to require less ground support. There are agencies that recommend 5 meters, but as the product at 1:50,000 scale digital map has lower geometric accuracy with respect to the image, will generate a problem of proper interpretation of the geographic elements as a result of the displacement.

The ideal radiometric resolution of the image is 11 bits so you can distinguish more shades of gray and therefore observe with better clarity and contrast the elements in the shadows.

Another important factor is that the orthorectified images are good to decrease the working time because otherwise we would add a stage with consequent time and manpower used in the process.

The product with a higher weighting was *SPOTMap*, which has a spatial resolution of 2.5 m.

In a **third and final stage**, we proceeded to analyze the Multinational Geospatial Co-production Program, providing appropriate guidance to assist in defining the methodology for updating and propose a flowchart for the update process.

### Positional quality study

To get the positional quality of raster and vector data will be useful to compare the data and consider upgrading directly, because as it was seen in the initial phase of the pilot project we could see a shift between the two types of data, for wich an analysis of specific detail of this variable is required. Here we present the positional quality study that seeks to find the circular error of both, which will decide whether to perform an upgrade or a new data capture.



Figure 12: Integration of positional validation. Prepared by the author.

Figure 12 shows the huge gap between the information contained in the geospatial database and the information contained in satellite images, giving some ideas of the difficulty of updating the information with this great difference between these two sources of information; on the other hand there is great difficulty analyzed by users for a quick and accurate upgrade. This is why it is necessary to explore different ways of updating various producers of geospatial information.

### Updating versus Generation

The concept of updating the existing vector information in the geospatial database is complicated because the first thing to define is whether we need to modify the existing information or whether we need to capture it into its new location or new features.

By doing a simple exercise with an image and its corresponding vector information is easy to realize how complex it is moving or updating information, adding to the perspective of the Geomatics Department personnel, and the Research and Development of the Military Geographical Institute who report that it is easier and faster to draw something new than changing what exists. As a proof, you are going to see a set of figures showing the complexity of modifying existing information.

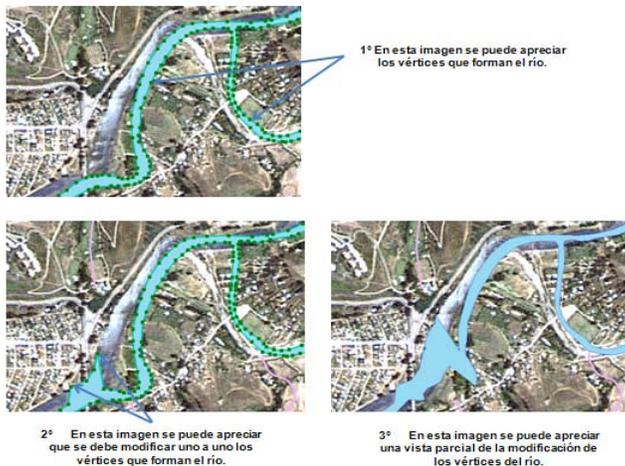


Figure 13: Set of images showing the change of information. Prepared by the author

The images seen get worse by adding the other layers of information found in the database, being very difficult to modify vertex to vertex different areas, which should fit with the adjacent area, so there are no overlaps, or generation of unexisting new areas or missing information areas.



Figure 14: Set of images from the modification of different areas". Prepared by the author

The other option is to capture new information with the tools of the *ArcGIS*, specifically with the *PLTS* module, which is being used by major producers of global mapping, in particular by the Multinational Geospatial Co-production Program.



Figure 15: "Set a new capture images of a river". Prepared by the author  
**Multinational Geospatial Co-Production Program**

To analyze the Multinational Geospatial Co-production Program will enable us to evaluate its methods and procedures in order to make an adaptation to give the best answer to our needs.

The MGCP is a coalition of nations engaged in the production of high resolution geospatial data vector delivery worldwide for storage, exchange and use of geospatial information. It is sought to populate the IGW, International Geospatial Warehouse. The IGW is created and maintained by the United States, specifically the National Geospatial Intelligence Agency NGA.

In this program, the source of data, the process of extracting information, features, resolution, or other intervening factors, allow the collection of data using different parameters within the different parts of a work cell; the metadata for each area share parameters and are organized in subregions. The metadata for a subregion describe the data using a common set of criteria for the extraction, from a common source.

The importance of this program is that it presents a logical methodology for extracting information, allowing a modification of its processes in the map update process.

The IGM is currently acting as a cooperating agency of the program doing some work and using that methodology in its processes.

**Finally,** by integrating the results we can generate an organized Procedure Manual based on five papers that provide operators with guidelines, rules and examples for the update is performed in a standardized form. The incorporation of the HOP are the following: Semantic Information Model Guide Update, Set of Elements, Rules Guide topological and Metadata Specifications.

## **Conclusions**

The IGM has the personnel, infrastructure and organization necessary to realize a change of technology in its production processes.

Tests with different images and studies of existing information on Geospatial Database, allow us to know the differences between the various sources of information, making it necessary to study in detail the displacement taking place.

When defining a methodology, we chose a system that has been very successful internationally: the "Multinational Geospatial Co-Production Program (MGCP).

As for specific findings concerning the Manual of Procedures for the update, we have considered the following:

1. The model of "semantic information" to define and prepare the conditions for work, considering the verification measures, guidelines and standards of verification.
2. The Upgrade Guide is a guide for the operator which lets you guide the update process, providing a logical method that provides consistency to the captured data.
3. The "Manual of Topological Rules" generates spatial relationships between same and different characteristics, supporting the operator's work and giving directions for making the capture correction of errors.
4. Finally the "Set of Element" and "Metadata Specifications" deliver the necessary features that captured information should have.

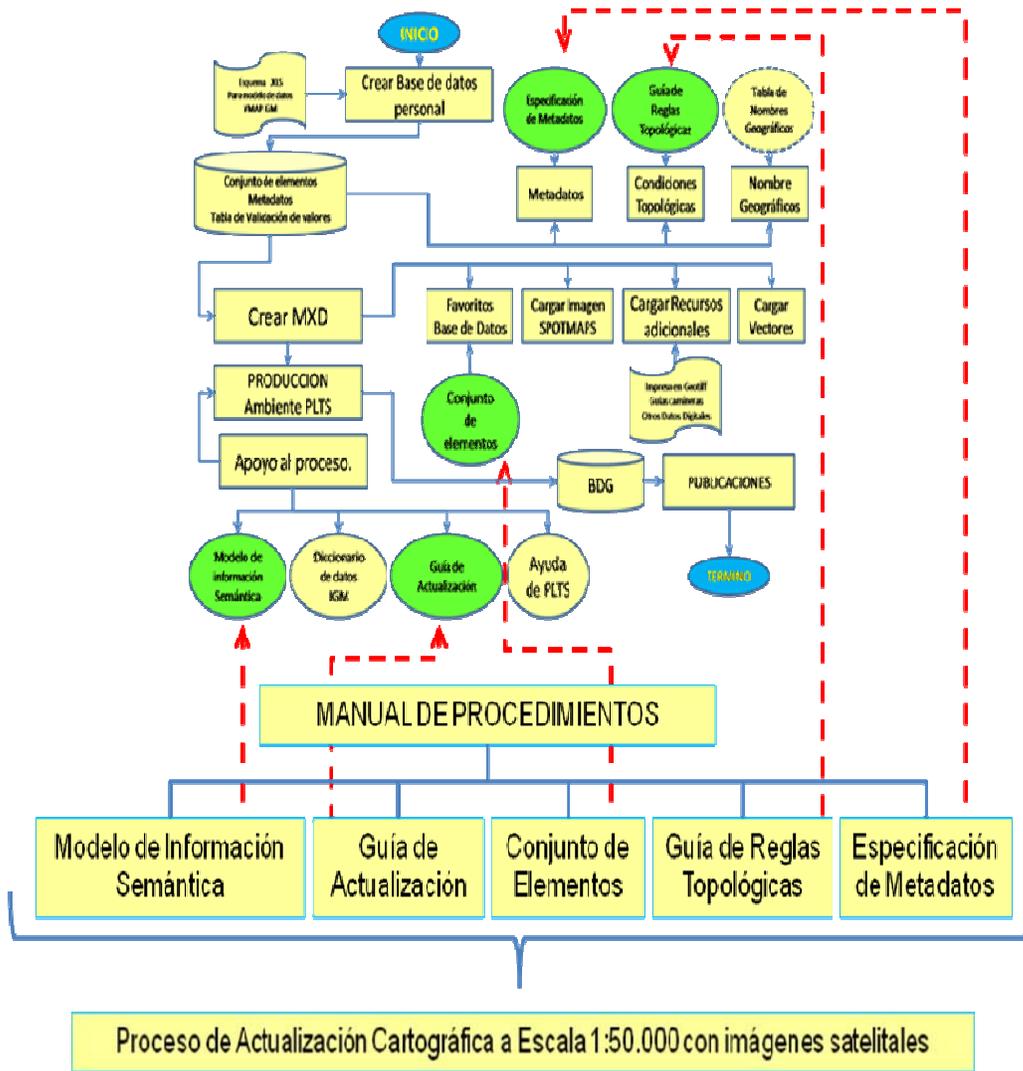


Figure 15 "Proposed Flowsheet for Cartographic Updating process supported by the Manual of Procedures". Preparation of the Author.

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