

The Systematic Land Verification (SyLVer) Protocol

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SUMMARY

Currently in the Philippines, cadastral database is on a transition from paper-based to computer-based. Encoding and plotting were done using the original cadastral lots. However, cadastral data are regularly updated because of various processes and events. The most common events and processes that affect the change in spatial characteristics include a parcel's subdivision or splitting, consolidation or merging, consolidation-subdivision and boundary adjustment.

Monitoring and updating are done by two land agencies, the Department of Environment and Natural Resources and the Land Registration Authority. These updates affect the spatial and attribute characteristics of the cadastral parcels.

Ideally, the topological relationship and integrity of the affected cadastral parcels must be maintained as the changes happen. The objectives of the research are to determine and evaluate the factors affecting changes in the cadastral database, provide a protocol that updates the main cadastral database and place the previous and historical data to a history layer and maintain the topology between the cadastral parcels and between the history and current layer. These will greatly help the key land agencies once the computerized cadastral database has been completed. The protocol is coined as the Systematic Land Verification (SyLVer) Protocol. A third party software ArcGIS from ESRI can be used in the implementation of the protocol.

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1. INTRODUCTION

Cadastral database is a parcel based and up-to-date land information database which includes the geometric descriptions of the land parcels such as location, dimension and size. It is linked to other records that describe the nature of interests such as informations related to the rights, restrictions and responsibilities associated to the land parcel.

In the Philippines, the primary source of information of cadastral database are from outputs of cadastral surveys and isolated surveys. Cadastral surveys are surveys done to determine the metes and bounds of all land parcels within an entire municipality or city and the proponent is the government executed by licensed geodetic engineer (DENR 2007). Isolated land surveys are surveys of individual or small groups of parcels done to determine the metes and bounds, correct erroneous boundaries and for other purposes and the proponent is either the government or private entities executed by licensed geodetic engineer. Isolated surveys can be done on a parcel of land prior or after a cadastral survey project in the area containing the subject parcel. This provides the problem on keeping cadastral database up-to-date.

The Department of Environment and Natural Resources (DENR) through the Land Management Bureau and field offices is the government agency mandated to do cadastral surveys and isolated surveys for the purpose of managing and disposing of alienable and disposable lands. Thus majority of information related to a cadastral database such as cadastral maps, projection maps, control/ reference points and isolated survey plans are contained within the premises of the DENR.

In the past years recent years, programs and projects were undertaken by DENR to improve land administration in the country. First, The establishment of the Philippine Reference System of 1992 aimed to provide a standard reference system for land surveys and mapping in the country using GNSS technology. Second, the Land Administration and Management Project (LAMP), which started around 2001, aimed to increase land tenure security and improve the efficiency and effectiveness of land titling and administration system. Recently, efforts were done by regional offices of DENR to digitize cadastral data by encoding and plotting the coordinates of individual parcels or by scanning and digitizing cadastral maps thereby producing a computerized cadastral database. However, isolated survey maps and information are not yet included in the computerization. In addition, the concepts related to the core cadastral domain model (CCDM) and its updated version the land administration domain model (LADM) are slowly taking roots.

2. RESEARCH MOTIVATION

Although there are numerous initiatives done to improve land information system, minimal or no effort was done to answer the problem of maintaining and updating a cadastral database. Development of modern geographic information systems (GIS) may help solve the problem

of incremental updating of cadastral database. One of the tools that can be used is the Parcel Editor module within third party GIS software ArcGIS 10 of ESRI.

The study tries to propose a Systematic Land Verification (SyLVer) Protocol that may help agencies such as DENR to do computerized incremental updating while maintaining the topological integrity of a cadastral database. It is therefore the objectives of the study to determine and evaluate the factors affecting cadastral database's changing information, provide a way to create and update a cadastral database and provide a way to maintain the historical information.

3. CADASTRAL DATABASE

Table 1 shows the different attributes present in the cadastral records and other survey data in the Philippines. These are information obtained from different land related documents and maps such as approved cadastral and isolated survey plans, land titles. Other than DENR, there are other government agencies that serve as sources of cadastral attributes. These are the Land Registration Authority (LRA) and affiliated Registry of Deeds (RD). Similar to DENR, LRA evaluates, approves and stores isolated survey plans but are limited to titled properties and subdivision (splitting of lot) to not more than nine (9) lots. RD on the other hand records and issues certificate of land titles.

The Unique Parcel Identifier (UPI) which serves as a primary key refers to the identification exclusively assigned to a land parcel based on its spatial position on a land information map. It contains the lot number and the survey plan number. Table 2 shows some of the different survey plan number used.

An approved survey plan includes location information such as barangays, municipality, province and island; name of claimant/ owner; name of the geodetic engineer that conducted the survey; technical description and land area; and dates surveyed, submitted and approved.

Certificate of title contains information similar to an approved plan since required document for application for certificate of title includes approved survey plan. Additional information from a title includes the original certificate of title number and subsequent transfer certificate of title number.

Other historical attributed that maybe found in land related documents include mother lot number, mother lot survey number, original survey number, original survey date, original survey date approval.

Table 1: Attributes of the Cadastral Database

FIELD NAME	DESCRIPTION	REMARKS
UPI	Unique Parcel Identifier, primary key	
Lotno	Lot number	
SurveyNo	Survey number	
Claimant	Claimant or owner	
CMQuadSec	Cadastral map quadrangle where the parcel is located/plotted	applies to cadastral data from Cadastral Maps
Brgy	Barangay	
Muncplity	Municipality	
Province	Province	
Island	Island	
GeEngr	Geodetic Engineer	
d8Surveyed	Date Surveyed	
SurvSymNo	Surv. Sym. & No.	applies to titled lots only
LRCNo	LRC Record No.	applies to titled lots only
Area	Area of the lot declared on the survey plan	
D8Submitted	Date Submitted to DENR for verification and approval	
D8Approved	Date the survey plan was approved by DENR	can be used to trace the successive history of a parcel
Mothr_lotN	Mother lot number	applies to isolated surveys only
Mothr_surN	Mother lot survey number	applies to isolated surveys only
Mothr_UPI	Mother lot unique parcel identifier	applies to isolated surveys only; can be used as link between the mother lot and resultant parcel
OrigSurNo	Original Survey number	applies to isolated surveys only
OrigSurD8	Original Survey date	applies to isolated surveys only
OrigD8Aprv	Original survey date of approval	applies to isolated surveys only
OCTNo	Original Certificate of Title Number	applies to titled lots only
TCTNo	Transfer certificate of Title Number	applies to isolated surveys on titled lots only
CompArea	Computed Area	

Table 2: Typical survey symbols based on the type of survey conducted.

Types of Survey Based on Survey Symbols	
Survey Type	Survey Symbol
Cadastral Survey	Cad
Original Survey	Psu, RS, Fli, Msi
Subdivision Survey	Psd, Csd
Consolidation Survey	Pcn, Ccn
Consolidation-Subdivision Survey	Pcs, Ccs
Verification Survey	Vs

4. CADASTRAL DATABASE INCREMENTAL UPDATING

Cadastral data is dynamic due to different land transactions and processes involved. Thus, a regular monitoring and updating process is needed to keep an up-to-date, accurate and relevant cadastral database.

There are two (2) types of change in a parcel. Firstly, change in the spatial characteristics of the parcel wherein the geometry of parcel is affected and secondly, change in the attributes wherein only the attribute characteristics changes (Chen, Zhou and Li 2007). The changes in the spatial characteristics of a cadastral entity include segmentation or split, mergence or union, complex change, boundary adjustment and addition of new parcel. Examples of attribute change include ownership and land classification change. Attribute change is not reflected in DENR records unless the parcel has been subjected to survey transactions, submitted to the said agency for approval. The study focused on change in spatial characteristics.

Subdivision survey refers to survey private or public which splits one mother lot into two or more resultant parcels. Consolidation surveys are surveys that merge or combine two or more mother lots into one parcel. Consolidation-subdivision survey merges two or more mother lots then split the merged parcel into two or more parcels with the technical descriptions of the resultant parcels different from the technical description of any of the mother lot thereby providing a more complex change. Verification survey adjusts the boundary or changes the technical description of the mother lot. Original survey and Cadastral survey add new parcel to the cadastral database.

The change in the characteristic of a lot can be identified by the topological relationship between the parcels before and after the change; topological integrity constraints and attribute property (Chen, Zhou and Li 2007).

The topological relationship between the parcels before and after the change applies to the mother lot and its resultant parcels or the parent-child parcel. Three possible relationships

between the parent and child parcel are “contain”, “overlap”, and “equal”. The “contain” relationship is achieved when a subdivision survey is done; “overlap” for a consolidation-subdivision survey and possibly for verification survey; and “equal” for a consolidation survey.

The topological integrity constraints apply to the boundary and neighboring parcels or entity. Before and after the change, there should be no free-standing points and boundaries, no dangling boundaries, no cross and extending boundaries and no overlapping and missing parcels. All these conditions must apply to all the layers in the Cadastral database. Topology rules must be applied during the creation and updating of the cadastral database to maintain the topological integrity of the parcels.

A History Layer is introduced to allow outdated parcels to be removed from the current layer but preserve its spatial information. Overlaps shall be allowed between entities of the current layer and the history layer as a result of subsequent updating.

5. ARCGIS PARCEL EDITOR

ArcGIS provides a module called parcel editor that can be used in the implementation of incremental updating. The discussions below provide the idea on what specific concepts and tools in ArcGIS that can be used in such a task.

5.1 Parcel Fabric

A parcel fabric is a dataset for storage, maintenance and editing of parcels (ESRI 2012). It stores a continuous surface of connected parcels called a parcel network. A parcel is defined by polygon, line and point features. The accuracy of a parcel fabric can be classified based on the accuracy of the survey done.

5.2 Base-map Creation

Base-map creation is important as it would be the main layer where all updated parcels would be overlaid. ArcGIS requires users to create a point, line and polygon entities to be able to build the topology. The Geoprocessing toolbox of ArcGIS can be used to extract the needed entities. The new New Topology Wizard can be used to build a topology. Topology rules must be set.

The following topology rules can be set:

- a. Line features must be covered by boundary of polygon features;
- b. Line features must not self overlap;
- c. Line features must not self intersect;
- d. Line features must be a single part;
- e. Line features must not intersect or touch interior with
- f. Polygon features' boundary must be covered by line features.

5.3 Update Layer

Updating of layer can be done using the Parcel Editor. Updated parcel layers could be joined to the parcel fabric. New parcel layers can be added by copying updated line features as construction lines to the Parcel Fabric. Parcel Fabric fits these new layers by means of the least squares adjustment. Attributes of each parcel can be viewed and edited in the Parcel Details Window.

5.4 History Layer

A parcel history management is provided by ArcGIS. The command “Job Book” in the Parcel Editor contains the date and time of all parcel operations done. Edited parcel in the Parcel Fabric could be built as historic and are shown as historic lines. Mother lots or parent parcels may be viewed from the parcel explorer window.

6. PROPOSED SYSTEMATIC LAND VERIFICATION (SyLVer) PROTOCOL

The proposed SyLVer Protocol consists of different procedures that can be used in the base-map creation to incremental updating. This includes procedures in the cadastral database map build-up and cadastral database map updating.

6.1 Cadastral Database Map Build-Up

The conceptual framework in the development of a computerized base map is based on the general procedure of creating a new feature dataset using ArcGIS, a third party GIS software by ESRI. Figure 1 shows the general flowchart for the base map creation.

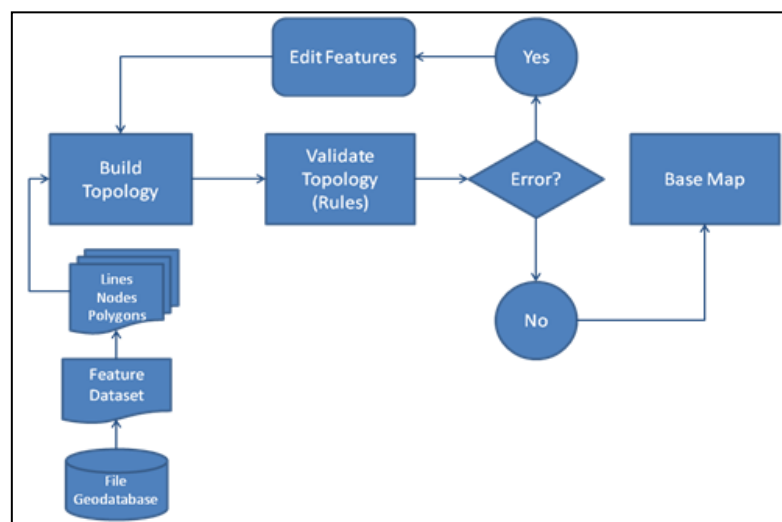


Figure 1: Base Map Creation Flowchart

A file geo-database shall be created. This geo-database shall include new feature dataset that

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can contain lines, nodes and polygons. These features can be extracted from the shapefile created during data collection. Topology shall be built and validated using the minimum topology rules. Parcels passing the topology rules shall be included in the base map otherwise rechecking and editing shall be done.

6.2 Cadastral Database Map Updating

Figure 2 shows the flowchart for updating the cadastral database map.

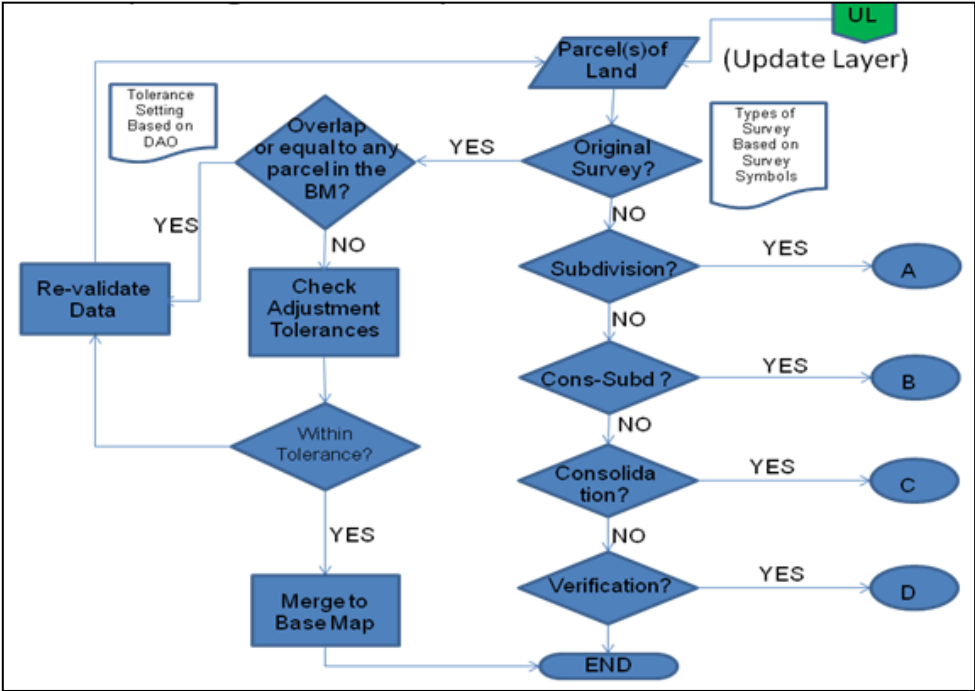


Figure 2: Procedure for Updating Cadastral Database Map

Parcels that resulted from verified and approved subdivision, consolidation, consolidation-subdivision, verification or original surveys by DENR shall be made and will be contained within the “Update Layer”. Based on the flowchart, the first task is to check what survey event the subject parcel(s) underwent using the parcel’s survey plan number.

A parcel that underwent an original survey shall be checked for topological relationship within the other parcels in the Base Map. It should not “overlap”, “contain” or be “equal” to any of the parcels in the Base Map. If the parcel did not pass the check, it will not proceed to the next check; it has to be revalidated for the correct technical description or type. Any parcel that do not pass any check in any survey event workflow shall be revalidated for the correct technical description or type and it will go back to the first step.

Second task is to check for the tolerance. Tolerance is considered since the aggregate boundary of the parcels in the Update Layer does not exactly conform to the technical description of the mother lot(s) in the Base Map. Translation and/ or rotation of parcels in the

Update layer may happen with respect to the mother lots in the Base Map. Translation happens because of the rounding-off of distances and direction of the parcel lines. It can increase as the parcel's distance is increased from its reference points. Translation can also happen affecting the polygon entities in the same directions or it can affect only some points of the parcel. Rotation on the other hand has minimal chance of happening since technical descriptions of the aggregate boundary of the parcels in the Update Layer is the same technical description of the mother lots. The tolerance setting can be set to 10 centimeters as this is the maximum allowable displacement of a point based on Section 443 of DAO 98-12.

After the subject parcel passed the check for tolerance, the parcel will be removed in the Update Layer and moved to the Base Map Layer.

Parcels that will not fall under original survey shall be checked for other type of survey events and proceed to their respective workflow. Figure 3, 4, 5 and 6 shows the protocols for subdivision survey, consolidation-subdivision survey, consolidation survey and verification survey respectively.

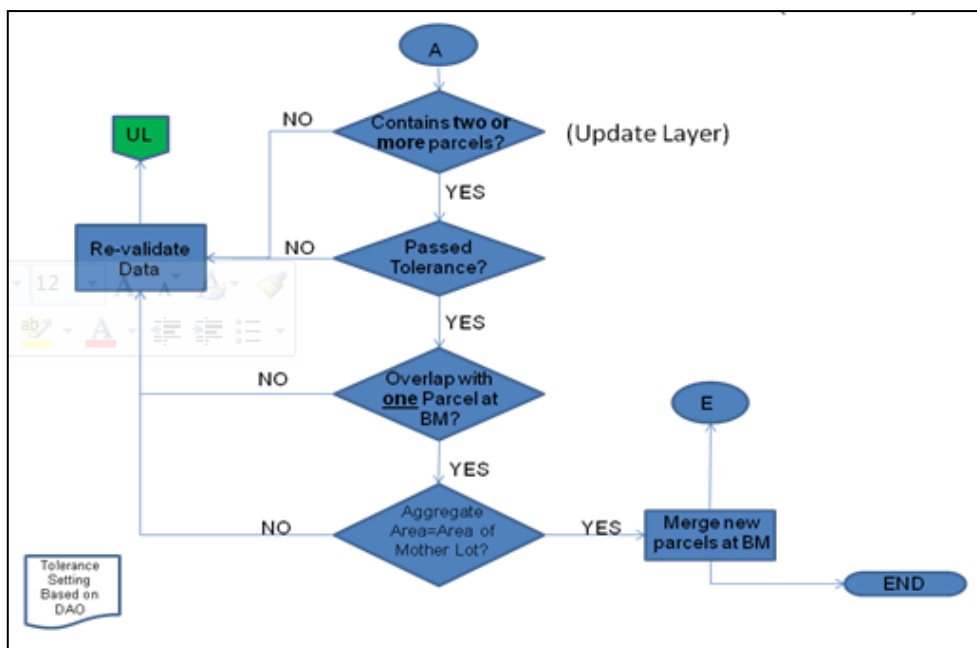


Figure 3: Subdivision Survey Protocol

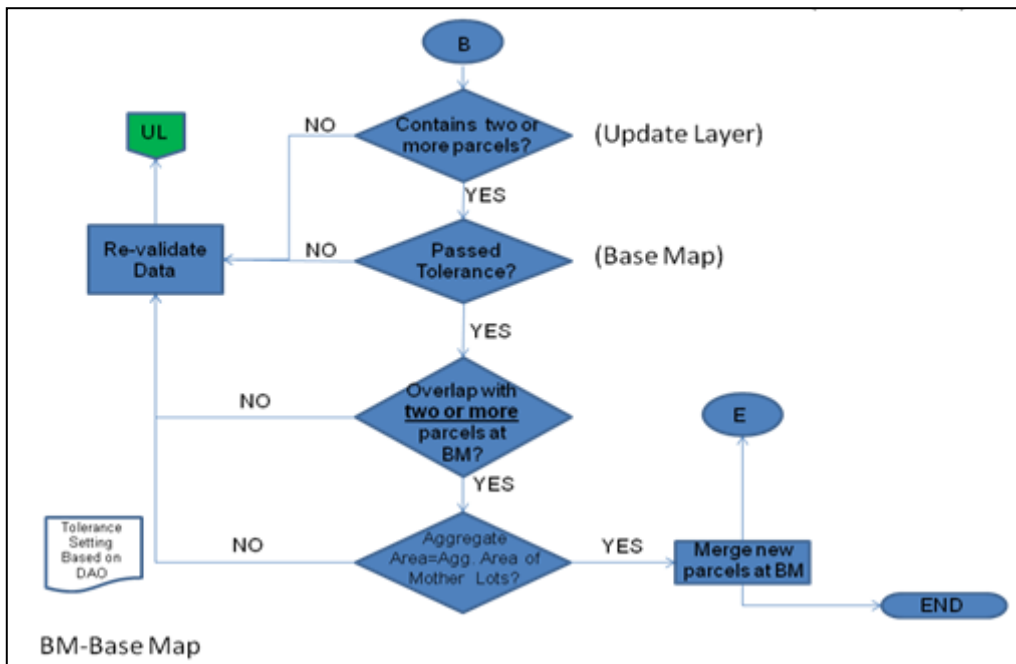


Figure 4: Consolidation-Subdivision Survey Protocol

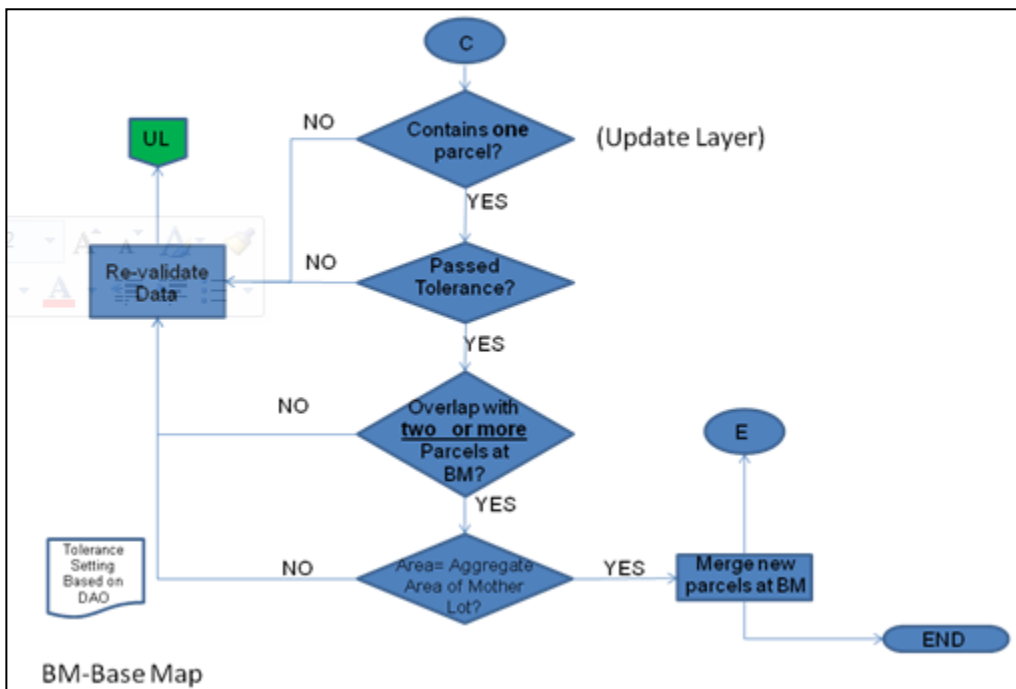


Figure 5: Consolidation Survey Protocol

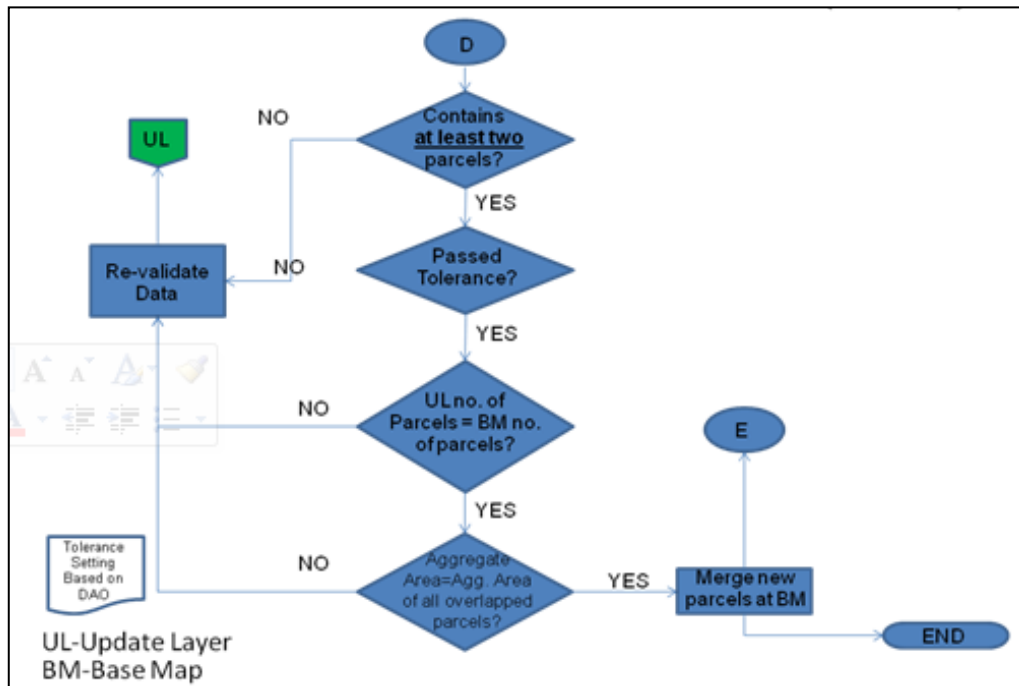


Figure 6: Verification Survey Protocol

Protocol checks for subdivision, consolidation-subdivision, consolidation and verification surveys include the following:

- a. Checking of the number of lots in the Update Layer;
- b. Tolerance checking;
- c. Checking of the number of mother lots in the base-map; and
- d. Checking of the computed land area of the parcels in the Update Layer and the Base Map Layer

The criteria in the Base Map built-up shall be adopted in the tolerance checks in the cadastral database updating. Table 3 shows the summary of required parcels in the Update Layer and Base Map for each survey event. This can be used for the first and third protocol checks.

The final check, is the comparison between the computed land area of the parcels in the Update Layer and Base Map Layer. The total area of the resultant parcels must be equal to the total area of the mother lots.

If the parcel passed the four (4) protocol checks, it will be removed from the Update Layer and placed to the Base Map Layer. Parcels that will not pass any check in any survey event workflow shall be revalidated for correct technical description or type and will go back to the first step.

Table 2: Required number of parcels for Update Layer and Base Map

Event	No of parcel in the Update Layer	No. of mother lot in the Base Map
Subdivision	at least two	one
Consolidation	one	at least two
Subd.-Cons.	at least two	at least two
Verification	at least two; same no. as the mother lot	at least two ; same no. as the corresponding lot in the Update layer

6.3 History Layer Build-up

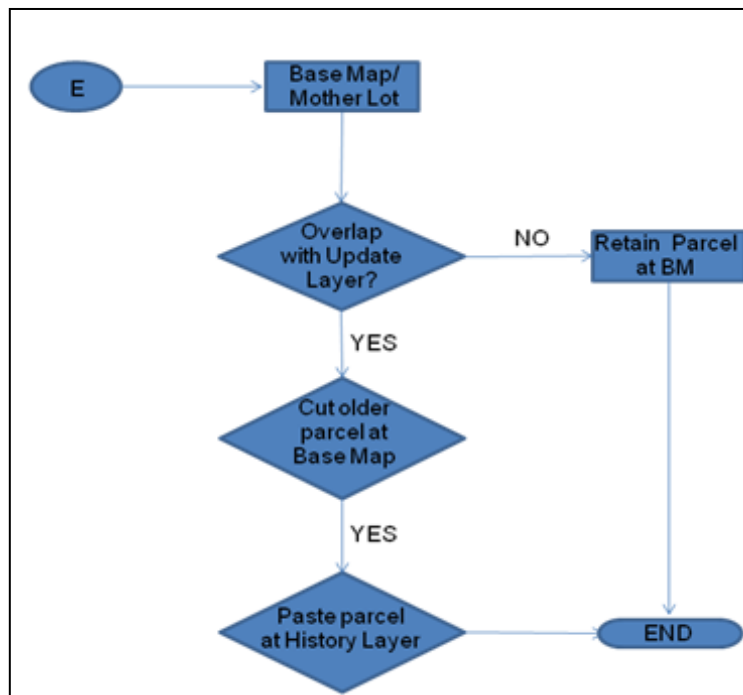


Figure 7: History Layer Workflow

Figure 7 shows the workflow in the creation of a History Layer. Parcels for the History Layer will come from the Base Map. Every time a parcel in the Base Map is updated due to any survey events, the parcel will be considered as a mother lot, be removed from the Base Map and moved to the History Layer.

The first step in the History Layer build-up will be to check if there are parcels which conform to the topology relationship in the Base Map. Parcels in the Base Map must not “overlap”, “contain” or be “equal” to any of the parcels within the Base Map. This check is different from the previous checks where the parcel in the Update Layer should either

“overlap”, “contain” or “equal” to the parcel in the Base Map to qualify to the parent-child parcel relationship. In the History Layer workflow, only parcels within the Base Map are checked. In the Base Map, overlaps are not allowed therefore forcing one of the overlapping parcels, the older parcel, to be removed and placed in the History layer. If no overlaps were found, the parcel shall remain in the Base map.

The History Layer will allow overlaps since a parcel entity occupying a space in the cadastral database can be updated several times since all mother lots will go to the History Layer.

Chronological order of overlapping parcels in the History Layer can be checked using the attributes date approved or the survey number attributes. Parcels with an earlier date of approval can be considered as the older mother lot. On the other hand, the lowest survey plan number can also be considered as the oldest parcel.

7. CONCLUSIONS AND RECOMMENDATIONS

The study provided an understanding of the current Philippine situation related to cadastral database management. A good parcel updating system is important as it provides user with up-to-date information. Historical data are still relevant as it provides chronological history of parcels that may be needed in several purposes such as investigation. The proposed SyLVer protocol may provide a means to do the implementation and updating of cadastral database in a computer environment.

GIS software can provide an efficient and capable tool in the implementation of cadastral database build-up and incremental updating. ArcGIS provided modules such as the Parcel Editor that can readily be used. However, the cost of buying such third party software must be considered.

Implementation using actual data is the next level of the study and use of the SyLVer Protocol. This will be done in coordination with DENR.

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BIOGRAPHICAL NOTES

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Louie and Rosalia Balicanta are happily married and proud parents of two.

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