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LAND ADMINISTRATION DATA INTEGRATION – MODERN CONCEPT

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Abstract

Successful implementation of a national land administration system depends on various factors, and one of the most critical of them is populating the system with relevant and complete data, through data digitization, migration, and integration. The data migration/conversion plan of large-scale land administration projects traditionally separates the major components of:

- Data digitization/conversion of different paper-based document and map sources into intermediary datasets formats/structures;
- Data migration of legacy digital databases if any;
- Integrated system implementation, followed by the migration of an existing dataset into the final system.

Integrated land administration content comes with a complicated data structure and requirements to ensure the quality, completeness, sequence, and integrity of the data. Separately digitized datasets (silos) requires additional stages of labor-intensive data cleansing and transformation and, even more importantly, proper linkage, before all data can be integrated.

Herein is presented a modern approach of data integration based on the IT-Leap concept. From the start, the "top-down" approach forces the definition of the *Land Administration Domain Model* (LADM)-compliant data models of different sources to ensure effective data consolidation, harmonization, and integration. The approach enforces quality criteria and validation rules for identifying and fixing mismatches, and correcting errors at the stage of data production, which is a part of the enterprise-wide system processes.

Key Words: IT-Leap approach, data conversion, data integration, LADM-compliant model, land administration

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INTRODUCTION – INTEGRATION GENERAL CONCEPT

"*Good programmers worry about data structures and their relationships*." Torvalds, Linus (2006-06-27)[1].

The concept of integration has been freely applied to businesses, systems, processes, and data. This paper focuses on data integration; considering its information technology aspects and methodologies.

The ultimate goal of the data integration is to provide users with a unified and consistent logical view of data that originate from several physically distributed data sources.

> *"The discipline of data integration comprises the practices, architectural techniques and tools for achieving the consistent access and delivery of data across the spectrum of data subject areas and data structure types in the enterprise to meet the data consumption requirements of all applications and business processes*[2] *".*

The main integration challenge is the detection and resolution of schema and data conflicts regarding structure and semantics. Collecting and structuring data in a useful way right from the beginning makes working with it easier and maximizes its potential.

It is important to differentiate between specific types of integration pre-processing steps. Specifically, those are:

Data Harmonization – the process of bringing together data of varying file formats, naming conventions, and columns, and transforming it into one cohesive data set. Ultimately, harmonization aims to turn the disparate data into the "apple to apples" format suitable for analysis.

Data Cleansing – the act of correcting or moving inaccurate, broken, or erroneous data from the dataset.

Data cleansing is required because the most common issues associated with the violation of the data structures are as follows:

- The correctness of formats and data representations;
- The uniqueness of primary keys in the database tables;
- Completeness and integrity of data;
- Completeness of relationships between data entities;
- Compliance with some analytical and domain-specific constraints.

[1] https://en.wikiquote.org/wiki/Linus_Torvalds
[2] Gartner IT Glossary. https://www.gartner.com/it-glossary/data-integration-tools/

For each level of the data structure – an individual cell, a record, a whole table, an individual database, or a set of databases – there are different failure factors that reduce the quality of the data. The most typical errors according to the structural components of the database are presented in the table below.

Table 1. *Typical errors corresponding to the structural units of the database*

Cell	Record	Table	Separate DB	Set of DB
• Spelling errors • Gaps in the data • Dummy values • Logical inconsistencies • Encoded values • Composite values	• Contradictions between cells	• Duplicate records • Inconsistent entries	• Data integrity contradictions	• Data structure mismatches • Same name for various attributes • Different representations of similar data • Different timeline

In the process of data converging and integration, the following operations are performed most often:

- Data structure conversion;
- Data aggregation and disaggregation;
- Translation of values;
- Creation of new data;
- Data cleansing.

DATA INTEGRATION IN LAND ADMINISTRATION

Building a national-scale land administration system inevitably depends upon existing data digitization, conversion, and integration of the digitized data. The design of many large-scale land administration projects follows a traditional approach of structuring the activities into manageable parts and considers separate components, such as:

- Data digitization/conversion of different sources aiming to start early production of the digital data in some temporary formats and structures;
- Followed by system implementation with migration and integration of those early produced digitized data, including legacy data from existing electronic systems.

Separating data digitization from system implementation allows for an early start of the lengthy data production processes using different readily available tools, mainly serving specific needs such as scanning, indexing and maps digitization. The primary focus on early data capture and data conversion is considered the fastest way to prepare digital data for enterprise automation. As a result, datasets are accumulated with a default assumption to be further agglomerated and integrated at a late stage together

with the implementation of the enterprise-wide system. Every enterprise-wide project included tasks of data migration and the need to perform matching and converging of different data structures, as illustrated on ***Figure 1***.

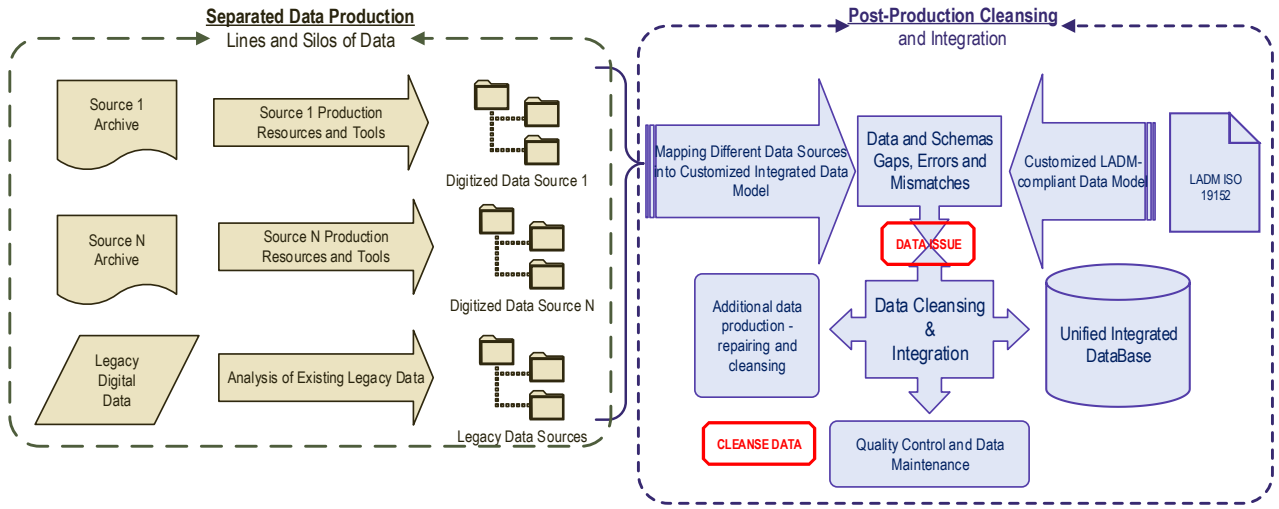

Figure 1. *Traditional separated conversions and integration processes*

Experience has shown that it is an underestimated and challenging integration task to analyze all types of the existing legacy and digitized converted data and to consistently map those into the integrated data model with unified semantics. This overall transformation from silos to integrated data has been viewed as the only practically justified evolutionary path from simpler isolated data conversion activities of preparing data for the future integrated enterprise system. As has been proven by many actual projects, those isolated data silos produced early without consideration of the future target database required much more effort to cleanse, harmonize and unify than were expected (see Quote Box). The integrated content of the land administration records requires a more complicated data structure and, accordingly, more elaborate technologies to ensure the quality of the produced data, including such characteristics as completeness, sequencing, and consistency. Ensuring the quality control and cross-checks while producing data is much more efficient than trying to fix the errors and inconsistencies at later stages.

Box. Quote of Nkurunziza, Emmanuel from "2. Implementing and sustaining land Tenure regularization in Rwanda." (Hilhorst, 2015)

"The decision to use a mix of open-source and commercial software on the LTRSS was based on breaking down data-processing activities into small component tasks and choosing the most appropriate software or combinations thereof to complete each task. However, this approach also had a downside as the lack of an overall data infrastructure created space for inconsistencies*. Later on it was sometimes difficult to link the various pieces effectively, ensure interoperability, and use the LAIS data for policy analysis. It took much longer than planned to have a fully operational LAIS."

**Underscored by the paper authors*

An example of this evolutionary approach to data integration at the international scale is the IMOLA[3] project initiated by the *Europe Land Registry Association* (ELRA) that is aimed at developing a model for standardized national land registry outputs. It was recognized that each of the project countries' national registry was developed using a different technique and encoded in different formats and, in most cases, accessed only through proprietary protocols. The project's first phase, IMOLA I, resulted in the creation of the intermediary standard, *European Land Registry Document* (ELRD), that defines a structure or template of common fields via the XSD/XML schema, allowing for the semi-automatic processing of exposed information through shared rules and metadata. As stated, it should give homogeneity to the registration information of those different national registries. It's a separate set of complex tasks to extract the required information from a specific registry and transform it into this standard interface allowing the unified access[4] (see the reference concerning property registries in France: "*The 354 French property registers are independent of each other, and there is no interaction between them. Moreover, in France there is no Internet portal that allows people to consult these registers*"[5]).

This reference illustrates the complexity of land administration data harmonization and integration, especially when the only way to address the interoperability challenges is through the *bottom-up* approach based on already existing various data. With a variety of national systems in place, this approach requires building a detailed semantic knowledgebase about each national land administration domain, and mapping and matching those to enable cross-national interoperability (this scope is covered by IMOLA II follow-up project).

The authors promote the IT-centric *top-down* mode of implementing land administration projects (*IT-Leap* approach, see *Popiv, 2017*; *Popiv, 2018*) which establishes the enterprise land administration IT system as the core driver and technology platform for the modernization projects. Data capture/conversion/cleansing processes along with the data migration and maintenance should be viewed as an integral part of the overall enterprise-wide business processes supporting ongoing formalized tenure operations. Based on the experience gained in several national-scale projects, the authors propose to introduce a holistic "top-down" IT-driven approach into the very early stage of data digitization and acquisition.

The key concept of the approach is in the early analysis of the different data sources from a perspective of the integrated services and enterprise system functions, in defining migration schemas of the digitized

[3] Interoperability Model for Land Registries – see https://www.elra.eu/imola-ii/
[4] Supposed to be available at e-Justice portal https://e-justice.europa.eu/content_land_registers-107-en.do but so far refers only to different structure and formats of the national registries.
[5] See *https://e-justice.europa.eu/content_land_registers_in_member_states-109-fr-en.do?member=1*

data directly in the unified database, and in customizing conversion processes accordingly as an integral part of the enterprise system (see ***Figure 2***).

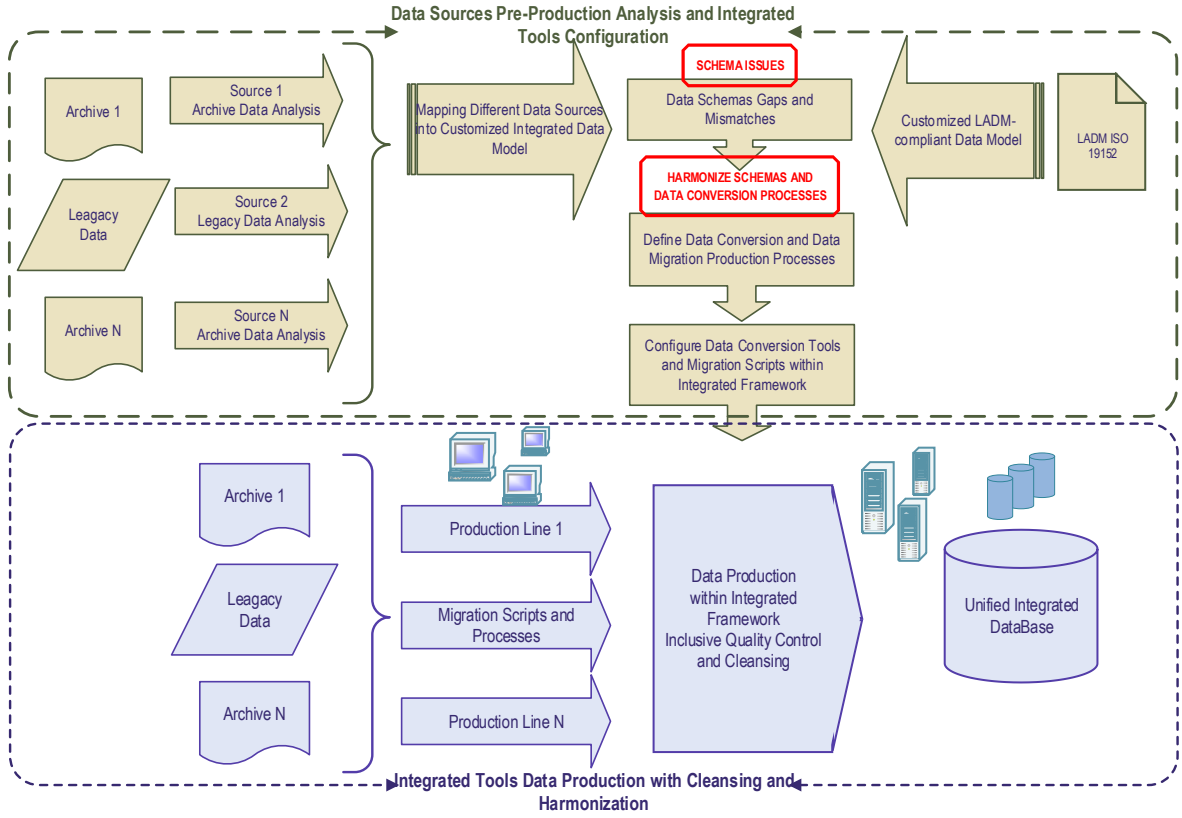

Figure 2. *Modernized top-down conversion and integration processes*

The top-down schema-driven approach forces the definition of the data models of different sources to ensure the data consolidation, harmonization, and direct integration into the unified database. The very critical efficiency factor and major differentiator from the traditional approach is that, for each data production stage, it would be possible to identify specific data quality criteria and validation rules for all integrated data in order to identify and fix possible inconsistencies at the time of data production. Such a holistic "forward-looking" approach is further ensured by two critical elements:

- Integrated logical data structure customized and extended as a national land administration data model profile adhering to *ISO 19152:2012 - Land Administration Domain Model* (LADM);
- Configurable and flexible land administration system built on top of that LADM-compliant national data model, providing all necessary functions for data digitization, migration, and integration based on the rule-based configurable workflows.

An integrated IT enterprise system based on the unified LADM compliant data model serves to capture digitized data, and allows for the execution of a set of data quality control checks at the very early stage

that ensure that the migrated and acquired data are consistent, harmonized, and linked. The most valuable result of this early data integration into the enterprise-wide system is that those data are at once shared for validation and utilization by all other departments in their daily operations and data maintenance. Having data consolidated and available through a workflow-driven system allows for defining specific data maintenance "cleansing" procedures that bring the data into a standardized form and populate any missing fields or correct relationship mismatches. Standardized data, in turn, are easy to share and exchange with third parties via secured Web services or via APIs. Land administration systems are most often required to exchange data with external services such as persons and legal entities registries or financial systems that validate identities and service fees paid.

The key aspect of the modern IT solution is the end-to-end coverage of the enterprise with integrated business processes. A flexible land administration system implemented on top of the database, compliant with the national LADM profile, serves as the integrated software framework to enable required data digitization production tools through easily configured workflows and rules and to allow data to be "on-the-fly" validated and consolidated. Such a system allows subsequent transactions to be linked to the back-file integrated data within the same integrated environment.

The following types of land administration data integration can be defined:

- Historic data integration – the result of data conversion/acquisition from different paper sources (such as archives, maps, plans, registration books);
- Legacy data integration – the result of data migration from existing legacy systems and their data (silos);
- Real-time/online integration of actual data from external online services (person's ID, addresses, confirmation/extracts from financial systems, additional digital map layers from external GIS servers).

The following sections present specific experiences of data conversion and integration that Innola Solutions, in cooperation with *IGN France International* (IGN FI) and *GEOFIT* (France), has gained in Uganda and Tanzania while implementing the national land administration projects financed by the World Bank.

TANZANIA CASE – ILMIS

The project for the implementation of the *Integrated Land Information Management System* (ILMIS) in Tanzania started in 2016. The implementation of the software of the ILMIS system was primarily configured around the Innola® software framework (see *Lizenko, 2018*), where the Innola Solutions and GEOFIT development teams performed the customization of related businesses areas. For the first phase

of the project, Dar es Salaam zonal office was selected as a pilot site with two district offices – in Kinondoni and Ubungo.

For the data conversion component of the project, the goals from the technical perspective were quite standard for this type of project:

- Migrate, clean, and integrate data from the existing databases into a single system;
- Convert various paper documents into digital records – both as images and indexes – and integrate them into the ILMIS system to ensure secured storage and access;
- Automate and harmonize businesses processes in the various departments of the Ministry of Lands, Housing and Human Settlements Development of Tanzania to increase data quality and avoid redundancies and duplication;
- Replace various existing non-integrated systems and in-house built databases with one enterprise solution.

Three key departments were selected for the system implementation and automation in the pilot – *Survey and Mapping Division* (SMD), *Registrar of Titles Unit* (RTU), and *Land Administration Department* (LAD). Two other departments – *Property Valuation Unit* and *Physical Planning Division* – were only partially integrated into the system at this stage. As the main *paper* data sources for the future integrated computerized system, the following were identified:

Table 2. *Source data for ILMIS pilot*

Data Origin	**ILMIS Objects**	**Records Converted**[6]	**Department**
Paper Survey Plans	Land Parcels	87 313	SMD
Paper Title Folders	Active Title	Titles: 45 433 Spatial Units: 47 373	RTU
Paper Plans	Survey Plans	13 655	SMD
Paper Plans/Drawing	TP Drawings	2 949	TPU
Paper Folder	SD Files	245	SMD
Paper Folder	LD Files	127 798	LAD
Paper Folder	Comps Files	12 633	SMD

At the same time, the Ministry was running MOLIS (*Ministry of Lands Information System*) and SRS *(Survey Registration System)* – two locally developed systems that partially automated selected processes in corresponding departments, which were considered for data migration. However, after information

[6] As of June 2018

review analysis it was decided that existing data was too incomplete, outdated or corrupted, so only data missing in other sources were extracted from MOLIS and loaded into ILMIS – namely, land rent payment information and history.

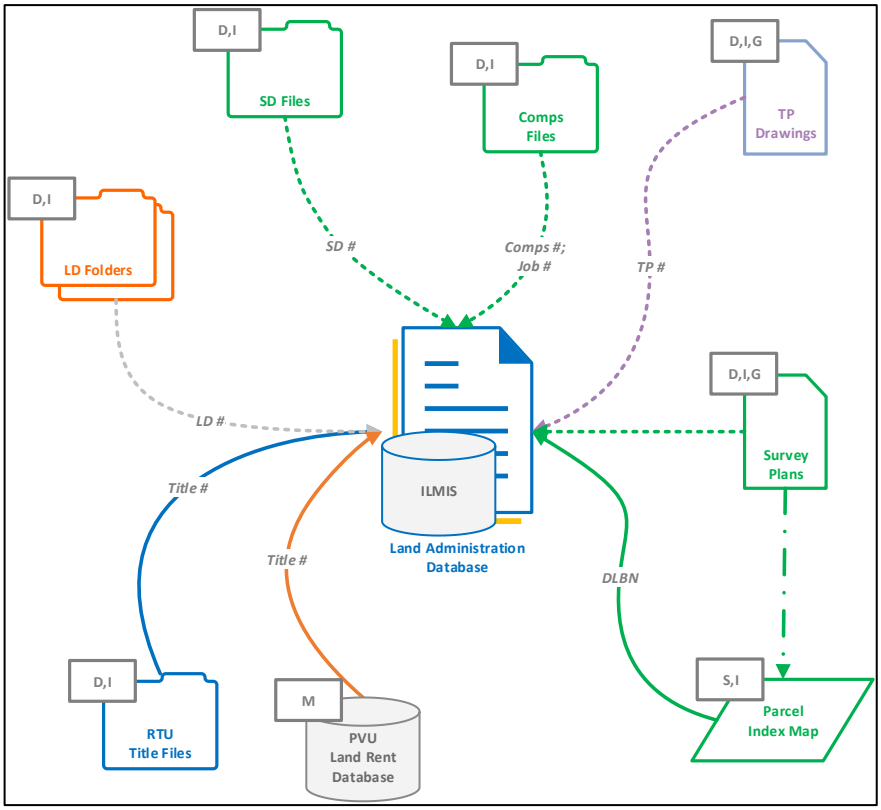

Figure 3. *Primary source data for Tanzania ILMIS*

Considering the aggressive project schedule and targets, the conversion of paper-based information was done in three stages:

- Scanning and basic indexing of all paper sources except Title folder was accomplished using GEOFIT conversion tools since the indexing of scanned documents was quite simple and did not require a complex data model for storing indexed data;
- Vectorization and basic indexing of land parcels was also performed using QGIS and special GEOFIT extensions;
- Upon completion of the vectorization of the land parcels, the most complicated part of data conversion – scanning and indexing of Title Folders/Certificates – was performed using the initial ILMIS release where the Innola software framework was specifically configured to provide specific data conversion workflows, reports, and interfaces for double/blind data entry.

With such approach, the converted certificates of titles/occupancy with the structured property, person and encumbrance data were stored immediately in a LADM compliant database, laying the foundation for the principal source and origin of data for the future system. Other data sources were linked and loaded into the ILMIS pre-production database before the system went live.

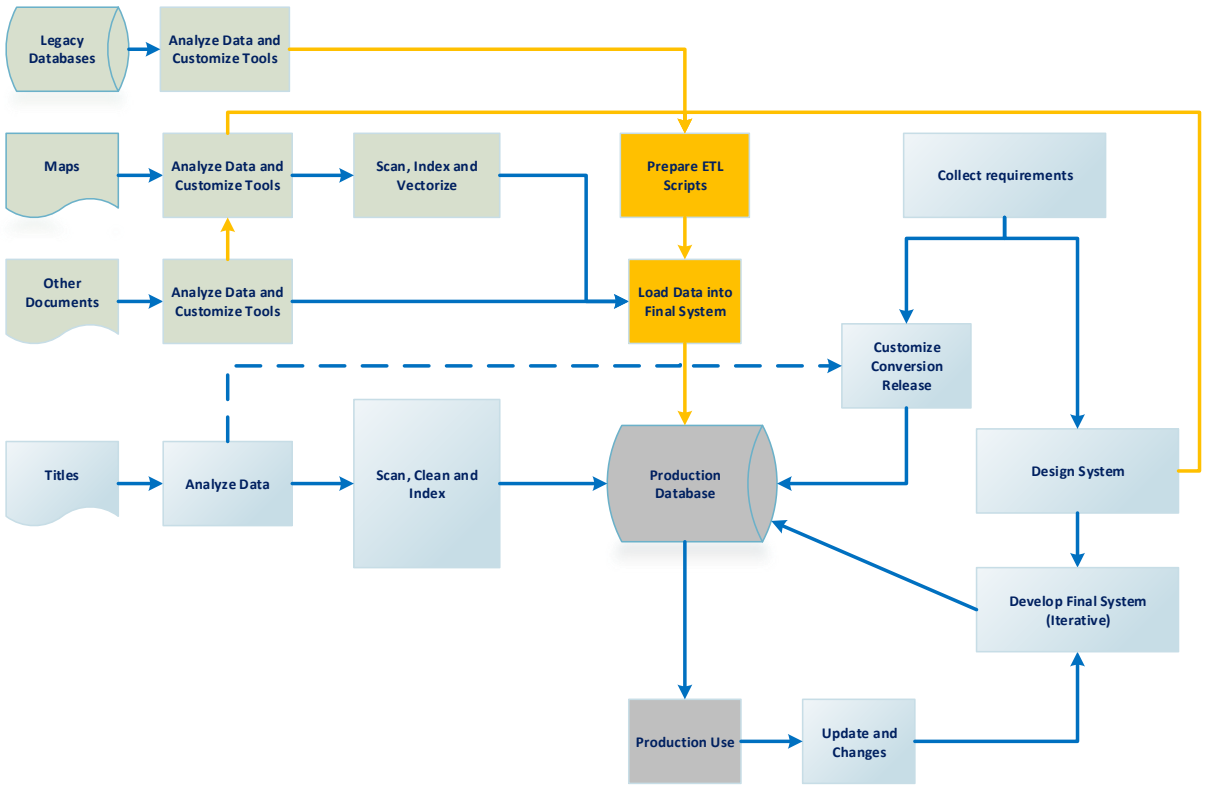

Figure 4. *ILMIS data conversion and migration overview*

At the same time, the design and customization of the full-scale production ILMIS release was done in parallel with the data conversion, where the data conversion instance of ILMIS was constantly updated with production release candidates. This approach provided additional benefits as compared to common practices when all data is converted using the specific conversion tools and then it is transformed and loaded into the final system after the system is ready:

- All Title information was indexed into the data structures that were designed for final production and built as an extension to the ISO LADM standard. All value dictionaries were cleaned and kept from unauthorized alteration. Old dictionary values are marked as historic and not used for day-forward data entry but stored to support searches on legacy data.
- All object information, when available, was entered into proper fields and validated against the same business rules as in the future production system. The exception was done only for missing

data, since old documents do not have details like gender, citizenship or, obviously, phone numbers.

- Document scanning was fully integrated into the title indexing workflow, and special user interfaces were configured for a blind double entry method – two persons were entering the same title index data independently, and at the end of the workflow the designated RTU staff performed the final data quality control by comparing the results of the two operators against the scanned copy of the linked title, or, if needed, against the paper copy of the title documents.

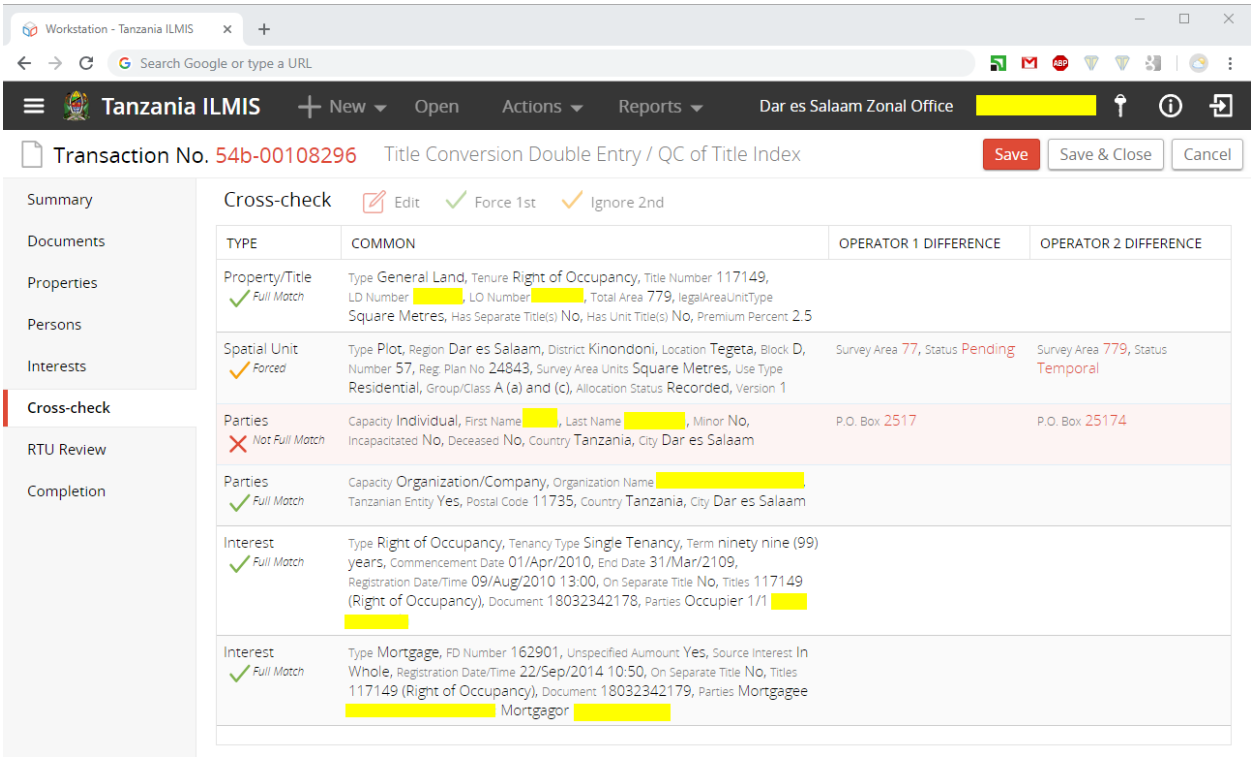

Figure 5. *ILMIS interface for double entry verification of Title data*

Several days before production roll-out, the title conversion database was moved to the production server, and all additional data were merged into the electronic title registry, mainly adding geometries for land parcels and other scanned documents like Land Administration Department archives, scanned survey plans, and auxiliary survey documents. The copying of land rent information from the legacy MOLIS system was done later since the source data required fairly extensive cleaning.

The Tanzania ILMIS configuration was a first but surprisingly positive experience, when, rather than having many independent tools for data conversions, *the fit-for-purpose* version of the future land information software was quickly configured for the data conversions of the principal dataset.

However, as is the case with any first attempts, the experience gained included both positive and negative sides:

- The “edition” of ILMIS/Innola tailored specifically for data conversion provided a solid and user-friendly tool for converting the paper title registry into the digital form and saved valuable time on preparing ETL for traditional data migration from a data conversion tool into a full-scale land administration system. Most of the functionality (>80%) implemented for data conversion workflows was reused for a standard ILMIS registration workflow.
- Although the GEOFIT data conversion tools were used in parallel to perform scanning of LAD and Survey files, at the end of conversion it became clear that it would be easier to do all scanning with Innola software – this would save time on index data transformation and, more importantly, on copying the hundreds of gigabytes of data between different file storages.
- There is no doubt that the use of double entry for data indexing provided obvious benefits and dramatically reduced the amount of lost or incorrect data, but it took a couple of weeks to tune up all business rules and the workflow to get all benefits from this approach and to ensure that the extra time spent on the second indexing was not in vain.
- The decision to perform title conversion into LADM structures added an additional essential requirement to involve only skilled RTU staff into the final quality control since there were numerous issues related to the data interpretation of the document. The most complicated part was related to two areas:
    - Interpretation and correction of shares for tenancy in common;
    - Interpretation of encumbrance status and encumbrance details.
- As with any other tedious job requiring focus and analytical skills, even the most productive staff began to make obvious mistakes after several hours of work. Thereby, for very aggressive schedules, it is recommended to do two or even three shifts, but of shorter duration.
- Thanks to the ability to customize Innola software nearly in real time and without the need to redeploy the software for most customizations, it was possible to keep the pace when yet another registration tradition was discovered that required a business rule change or data entry form adjustment.
- And finally, since all title conversion workflows and functions are in fact a part of the ILMIS production release, it is possible to continue title data conversion for other districts directly in the production instance of the ILMIS.

UGANDA CASE – NLIS

Uganda has been under a serious land administration modernization program since 2010 with the 1st phase of the Pilot Initiative *Design, Supply, Installation, Implementation of the Land Information System and Securing of Land Records* (DeSILISoR) finalized in 2014.

Development and implementation of the *Uganda National Land Information System* (NLIS) is in Phase 2 (2015-2020) of the *Design, Supply, Installation and Implementation of National LIS Infrastructure* (DeSINLISI) project, awarded to IGN FI consortium and funded by the World Bank. As a subcontractor to IGN FI, Innola Solutions and GEOFIT configured, customized and integrated the Innola® software framework to meet the registry, cadastral, land valuation, physical planning and public data access data needs of the *Ministry of Lands, Housing and Urban Development* (MLHUD). The project envisions establishment and operationalization of a comprehensive, decentralized, self-contained one-stop *Ministry Zonal Offices* (MZO) in 21 locations across Uganda with data replication to the *National Land Information Center* (NLIC) for publishing on the National Public Portal. To date (February 2019), 10 fully operational sites use the modernized system (and 4 other offices still operate the 1st phase system that will be gradually retired and replaced with the new LIS software product). In 2019, 7 more new offices are planned to open and 4 offices using the old system will be upgraded and data migrated.

An essential part of the system implementation is data conversion with the objective to complete rehabilitation, conversion to digital format, securing and uploading of all land records, documents, maps, drawings, and data needed for the land administration process to the LIS database. This includes the following types of legal documents:

- *Job Record Jacket* – survey documents from survey process submitted by certified surveyors;
- *Land Administrative File* – the set of the documents for first registration;
- *Blue Page* – historical titles for un-surveyed properties;
- *Root Title* – historical titles;
- *Mailo, Freehold, Leasehold Title* – all tenure types of titles;
- *Instrument Jacket* – instrument documents together with supplemental documents;
- *Valuation Form 6* – valuation of Market Value or Premium/Ground Rent;
- *Physical Plan Report* – urban and detailed development plans;
- *Physical Plan Minutes* – supplementary documents for PP reports.

In addition to the documents mentioned above, data conversion covered the processing and/or integration of the following:

- *Paper Maps* – for digitizing land parcels and scanning and geo-referencing maps;
- *Ortho-Photos* – migrated from the Phase 1 (years 2011-2012) system and created in Phase 2 (years 2016-2017);
- *Vector Layers* – from various authorities for base and administrative map, such as cadastral-index map, administrative division, roads, rivers, national parks, water bodies.

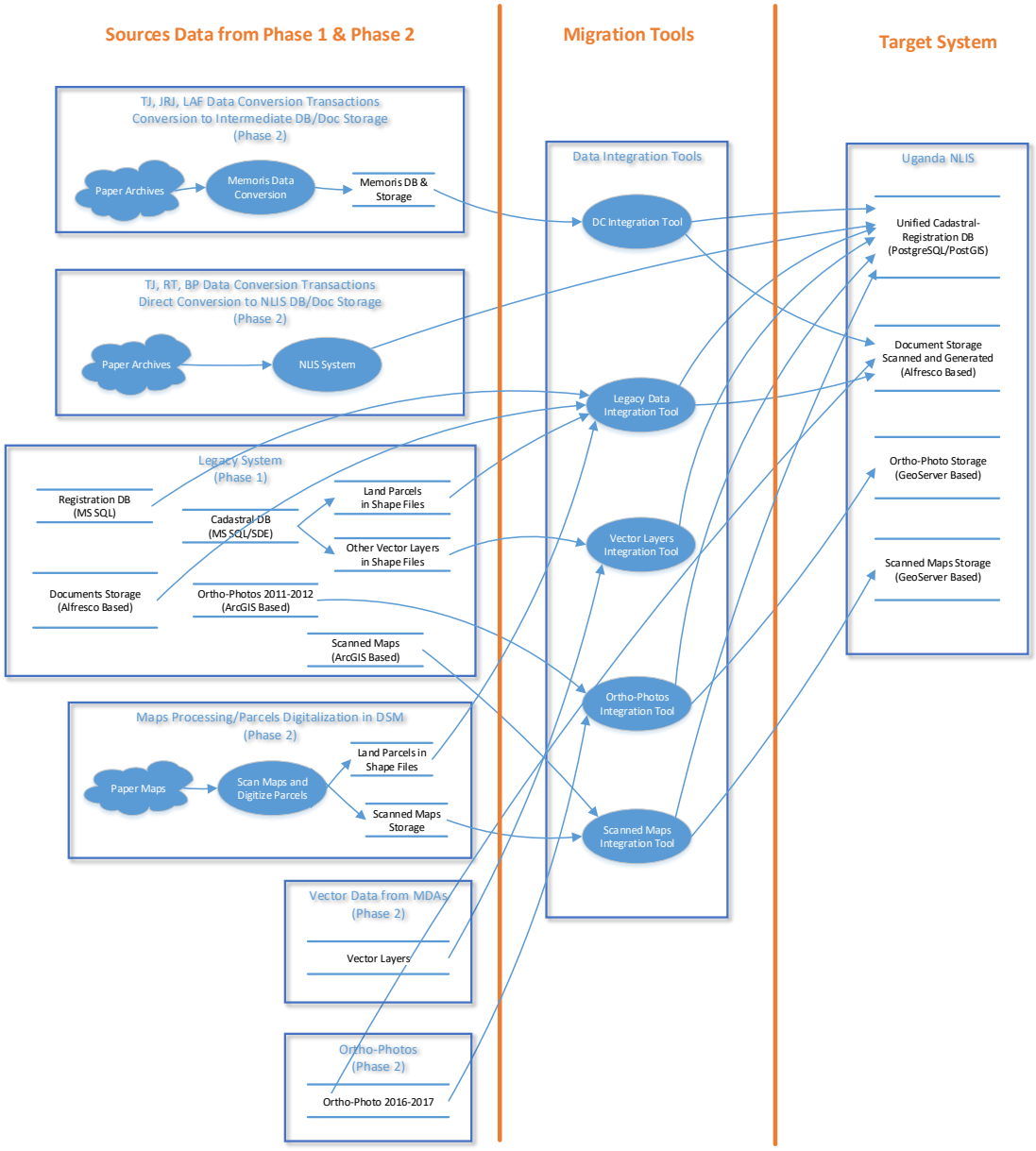

Figure 6. *Uganda NLIS – data conversion and integration context*

The specifics of data integration in Uganda is a heterogeneous production environment because data was converted in various systems with the use of different tools. Data conversion sites are either at the respective MZO in the production system or in the Survey and Mapping Department where the data conversion (DC) production line is implemented with the subsequent migration of DC data into the production system. In addition, data integration activities include the migration of cadastral-registration data from the legacy system (from Phase 1) with on-the-fly data transformation from the old to the new LADM compliant data model.

The following transactions are configured in the NLIS system for data conversion of legal documents such as titles, instruments, survey documents:

- Blue Pages Data Conversion;
- Blue Pages Data Conversion by Double-Entry;
- Instrument Jacket Data Conversion;
- Job Record Jacket Data Conversion;
- Land Administration File;
- Root Title Data Conversion;
- Root Title Data Conversion by Double-Entry;
- Title Data Conversion by Double-Entry;
- Title Jacket Data Conversion;
- Title Jacket Data Conversion by Double-Entry.

When indexing the information from the historical titles with hand-written memorandums, the probability of human indexing errors is quite high and requires configuration of the conversion process with indexing in four-hands or by double-entry followed by verification by a Quality Control operator (see ***Figure 7***). Commitment to the Registry of the indexed title is only by Registrar of Title, as required by the client.

The result of title data conversion is information on the property (parcel, parties, rights and restrictions) in the Registry and the scanned paper documents in the document storage.

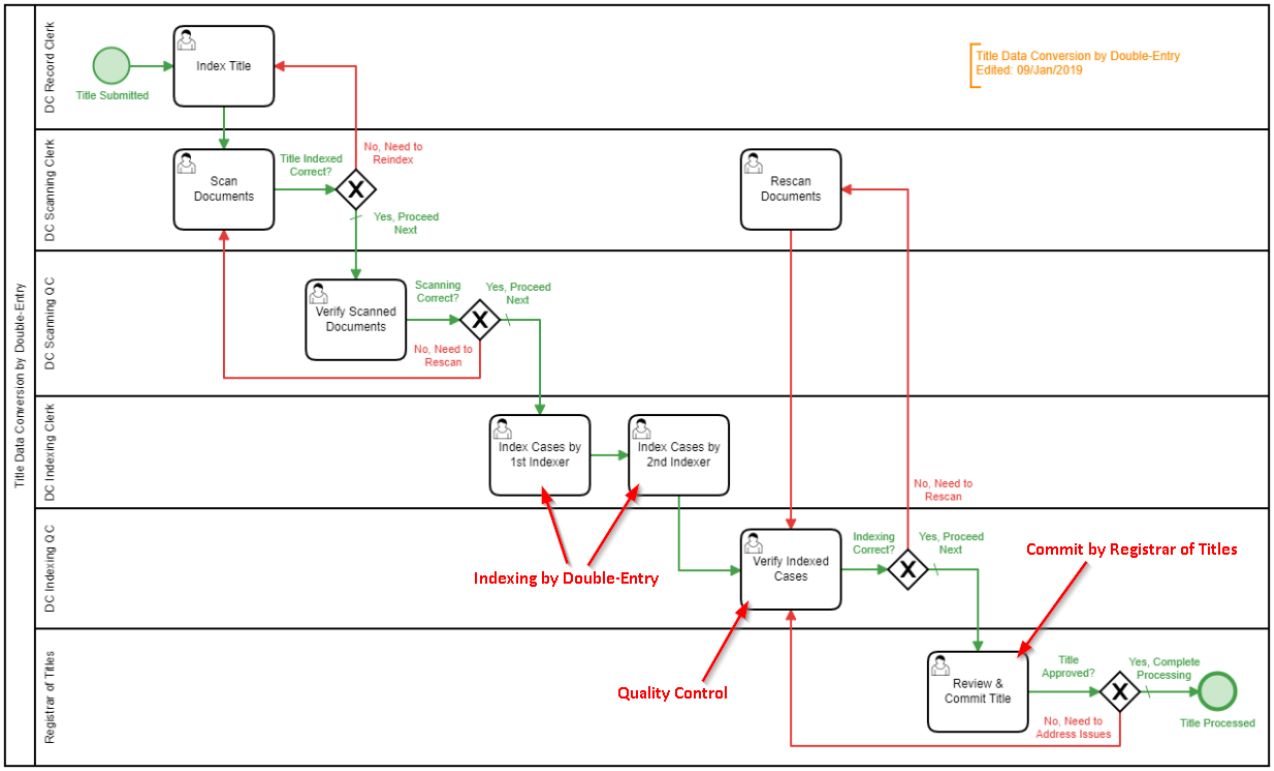

Figure 7. *Title Data Conversion by Double-Entry*

The operational NLIS with migrated data working at MZOs also integrates with other national systems such as:

- The *Uganda Revenue Authority* (URA) system to validate payment receipts provided by applicants for registration and cadastral services;
- The *Uganda Registration Service Bureau* (URSB) system to verify legal entities (Certificates of Incorporation);
- The *National Identification and Registration* Authority (NIRA) system to verify physical persons (National IF Cards).

For more details, see *Oput, 2019* paper presented for this conference.

CONCLUSIONS

Immediate key "take-aways" and "quick-wins" for the holistic *top-down* modern concept of data conversion and integration are as follows:

- **Data compliance and harmonization.** Use an integrated data model for specifying individual data sub-models for data acquired/converted from different sources to increase quality and reduce the effort for post-integration cleansing.

- **Process consistency**. Consider data conversion tools as specific work processes of the integrated operational system, in fact aligning the data migration production processes with the day-forward operational transactions. The staff involved in data conversion becomes familiar with the future production system and provides early feedback on the UI usability and business rules/workflows configuration; thus building internal capacity.

- **Data life-cycle quality assurance.** Integrated model harmonization cuts compliance costs and simplifies the process of meeting quality and completeness requirements. It also reduces complexity for those tasked with testing the production quality and defining quality criteria at each stage from the very beginning of data conversion to integration.

- **Crowd-cleansing and third-party services.** Loading digitized and converted data into a searchable Web portal makes the data available online for all interested stakeholders and/or public in a shorter time. The concept of data availability, coined as open data, proved to be fertile in many cases. It helps not only to involve stakeholders and public into "crowd-cleansing" of the possible errors in the records but also allows third parties to develop specialized value-adding services and integrate available open data into third-party services.

- **Access and interoperability policies definition.** Having standardized data readily available for exposure and sharing pushes stakeholders to define legal and regulative aspects of the data availability and accessibility policies that would govern which data are open, which data are private, and which data access services should be provided to various stakeholders (banks, financial agencies, tax authorities, etc.).

As a technology platform for IT-Leap, the Innola framework helps to address the following objectives related specifically to the data component:

- Establish baseline procedures and rules for data integration and harmonization;
- Reduce the number of data entry errors and typos made by operators;
- Identify gaps, overlaps, and duplications in existing digital data;
- Control the relevance of paper documents collected from various sources by checking for duplicate or redundant data;
- Control requirements for migrating the paper archives into digital format;
- Help to define standards and formats for data migration and conversion;
- Provide IT tools adapted for digitizing documents and converting and integrating data;

- Provide automated tracking of quality and integrity of the converted and migrated data as well as the support of the data correction and harmonization processes;
- Provide tools that report on staff productivity.

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