Tackling Undocumented Land Rights Worldwide with Improved Cadastral Survey Productivity: Case Studies

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SUMMARY

This presentation will highlight the effort required to register unregistered land parcels worldwide, describe the time-consuming challenges involved with current cadastral surveying processes, identify process improvements to overcome these challenges, present case studies that prove out the productivity savings, and identify a path to leverage these productivity savings to accelerate land registration globally.

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1. SUMMERY

This presentation will highlight the effort required to register unregistered land parcels worldwide, describe the time-consuming challenges involved with current cadastral surveying processes, identify process improvements to overcome these challenges, present case studies that prove out the productivity savings, and identify a path to leverage these productivity savings to accelerate land registration globally.

The volume of undocumented land parcels worldwide is estimated in the billions. In Uganda alone there are currently an estimated 15 million unregistered land parcels that current cadastral government authorities estimate will take Ugandan surveyors 1,000 years[1] to legally register.

Cadastral surveying has evolved significantly over the past 25 years, with the introduction of faster, lighter, and more accurate hardware technology to serve more traditional operations. Global navigation satellite system (GNSS) measurement, in general, has increased productivity dramatically. It has transformed from a post-processing solution to a real-time solution. The real-time solution has transformed from a heavy base/rover solution setup to a software-based GNSS receiver solution, like Trimble Catalyst, using satellite correction data. Moreover, field controllers have experienced significant increases in functionality and calculation power as well.

Field and office software has also evolved to handle large volumes of data in smaller packages and in formats readily accessible worldwide. However, with all of these advancements, there still remain challenges in the transition phases of cadastral projects. The processes associated with data processing and modeling that are required to produce cadastral survey deliverables are time-consuming and labor-intensive, thereby creating significant cost for public cadastral surveyors.

[1] https://cadasta.org/resources/infographics/surveying-the-landscape-to-reduce-poverty/

2. CHALLENGES IN ESTABLISHING LAND RIGHTS

The workflows and processes that can introduce delays and challenges in the establishment of land rights include:

- **Getting the right data/equipment to the right people at the right time.** Organization of field crews, their equipment, their schedule, and their data is still a largely manual process in most projects, and often requires significant prep time and strong communication to be executed efficiently.

    - **Inefficient file management:** Cadastral data files are often uploaded and downloaded via USB sticks and have to be manually converted multiple times across file formats. Surveyors may not arrive in the field with the right files on the right devices in the right formats. This increases opportunities for errors and lost time.

    - **Inadequate enterprise resource management:** In addition to the file management challenges cited above, disorganized equipment check-out processes can lead to surveyors not having the right equipment for the job when arriving on site. Sub-optimized crew dispatching and transportation management often plague this process as well. In the government survey context, disorganized task and crew management processes can multiply inefficiencies with scale, leading to increased cost and reduced service levels.

- **Mixed fleet of hardware and software equipment.** Most cadastral projects require more than one piece of equipment, software, and/or format in order to get the job done. This introduces data management challenges as well as equipment compatibility hurdles between manufacturers. This is in addition to the training required for each crew member to operate at full capacity.

- **Time-consuming process to update changes in the field.** In traditional, form-based data collection software it is not possible to maintain the full GIS-based data model. This creates difficulties in collecting and updating cadastral data. First, the data collection workflows are point orientated and not streamlined to collect point, line and area features. This limitation does not allow for easy and fast data collection. Second, geometry edit functions are missing in traditional field survey software all together. As data cannot be updated directly in the field, edited data must be captured as new data and manually updated in the office. Third, as the field software does not understand the rules of the data model, the field user must maintain them on his/her own in the field. All rules must be known and processed without any software support. If errors are made in data collection, it can be difficult to identify in the field. Lastly, as the full data model is not supported, style guidelines cannot be processed. The visualization of the data set in the field is different from and not as detailed as the visualization in the office which often leads to misinterpretations and errors.

- **Multiple iterations required between field and office.** Most cadastral survey crews will work an entire day in the field before receiving any feedback from the office, and communicating changes is often manual or fraught with errors. In some cases, multiple trips are required in order to finish a job correctly and to specification. One simple example occurs when required data which can be collected only in the field, such as landowner data or a landowner's signature, is not collected. Another example is the ineffective dispatching of field crews. If crews are dispatched with the wrong equipment or with crew members with the wrong skill sets, several iterations between field and office are required.

- **Manual deliverable production and processing.** Once all the data has been captured and verified, production or drafting of deliverables often involves the use of many software's and various export/import formats and media to prepare data for final approval. Often, these are smaller workflow tasks like exporting data as a CSV file, importing to Excel, formatting, and labeling and printing it for documentation. If these tasks are performed day after day by several field crews, the cumulative cost can be significant. These inefficiencies become more dramatic as the complexity of the deliverable increases.

3. KEY TECHNOLOGY INTEGRATION COMPONENTS

Given these cadastral workflow challenges, we have identified several key technology integration components to streamline these processes:

- **Map-based and data model-driven data collection tools.** Combining cadastral field surveying techniques and high-accuracy GIS data collection in one intuitive, easy-to-use, map-based interface is essential for increased productivity, limiting manual entry errors, and providing real-time feedback in the field. The field software assists field users in dealing with the complexity of a GIS data model and the related rule sets. A good example is the maintenance of the GIS data set topology. If the user splits a line into two pieces, the software will automatically ensure that the underlying line features are also split into two pieces.

- **Data validation and verification in the field.** Designing a data validation wizard that is compatible with the project and database model allows for better attribution, verification, and completeness of data while crews are active in the field, and limits the iterations between field and office. Historically, surveyors are concerned about the point accuracy they reach. Traditional field software takes care of the point survey workflows and the desired level of accuracy. To ensure the field job is performed completely and correctly, the whole dataset needs to be validated. Attribute tests, geometry tests, and topology tests need to be performed to ensure that the data captured in the field follow the needed requirements of the backend system in the office. As the field user can perform validation tests in the field against the backend system rule sets, he/she can directly check for and resolve errors in the field where

they occur. This direct recheck of the work performed provides the surveyor with confidence that the field data can be updated to the backend system.

- **Streamlined deliverable process.** By automating common drafting and post processing activities, and standardizing on a common data model, manual work and prep for production is significantly reduced. A good example of this is the backend update process. As the backend office software and field software work on the same data model and remain aligned throughout the field data collection process, the data update process can be fully automated. Another example is the automatic generation of reports like a measurement accuracy report. This report will be designed once and automatically generated with each subsequent project. As each report has the same format, no manual work is needed and documentation is consistent.

4. ORDNANCE SURVEY NORTHERN IRELAND: A CASE STUDY

A good example of this type of workflow system integration is a project Trimble performed for Ordnance Survey of Northern Ireland (OSNI), a directorate within Land & Property Services (LPS). LPS is a division within the Department of Finance and Personnel (DFP) and is responsible for delivering a broad range of land and property services and products. LPS plays an important role in supporting economic development in Northern Ireland. They collect well over £1.1billion in rates revenue which helps fund vital public services and delivers a significant stream of income to the 11 new councils. The services LPS provides underpin the ownership of land throughout NI – an important foundation for a progressive economy.

Primary LPS deliverables:

- **Rates:** Collect rates on over 850,000 properties to fund important public services.
- **Valuation:** Maintain Valuation Lists which support collection of Rates.
- **Registration:** Provide a registration service to record legal interests in land and provide land information for conveyancing purposes.
- **Mapping Service:** Provide mapping services for public and private sectors, informing policy development and enhancing service delivery.
- **Property Data:** Deliver property valuations, estate management and property data services.
- **Rate Reliefs:** Administer various rate reliefs to help those in need to pay their rates.

OSNI is the official producer of high quality, accurate, and current geographic mapping data for Northern Ireland. Public and private sector customers rely on OSNI's products and services to support their business needs and those of their end users.

In early 2017, the project team began working in Northern Ireland to develop and implement a customized solution with map-based data collection software, adding enhanced editing, query, validation, and deliverable workflows to the existing platform to increase productivity in the field across 35 crews.

Trimble worked collaboratively with LPS's existing team to understand the processes and workflows currently implemented. The legacy solution was based on GIS office software. While the solution allowed for the editing of GIS data, it was not designed for field workers. Many tiny buttons and complicated workflows designed for office users kept field workers from working efficiently in the field. The lack of options to control field work forced field workers to know all of the GIS data model rulesets for updating existing map data. The only option for validating updated map data was to import the data into the backend system in the office.

Trimble and LPS developed technology recommendations based on the objectives outlined within the project. By developing a customized deliverable format designed to work specifically with LPS' new data model, integrating data model rules into the field software, and implementing a validation wizard for both survey and GIS data, LPS was able to reduce its time spent in the field.

In order to leverage the vast amount of field data already collected by LPS, the team developed a unique layer-view functionality that allowed for datasets to be manipulated and displayed according to the individual task at hand. Additionally, GIS query and validation engines were designed to search this data in an efficient and concise way to gather the appropriate information on field devices in real time. This system integration reduced the average number of trips required for job completion from 3 to 1.

Overall, by addressing the identified workflow challenges from an entire system perspective and modeling the initial results from implementation, we modeled a 24% overall productivity improvement.

5. GERMAN STATE OF BRANDENBURG: A CASE STUDY

Another example of workflow system integration is a project Trimble performed for the German State of Brandenburg to help the state meet its obligations under the European Union's Common Agricultural Policy.

As part of this policy, EU Member States are required to operate a system for the management and control of payments to farmers, more commonly known as the Integrated Administration and Control System (IACS). The purpose of IACS is to ensure payments are made correctly to farmers, and in turn farmers need to make correct declarations regarding the spatial information representing their land. Belgium, Germany, and the United Kingdom have a land parcel identification system (LPIS) for each region. All other EU Member States have one each covering the whole country. There are currently 44 LPISs in total, containing over 135 million reference parcels.

Brandenburg State, like other jurisdictions, faced a number of challenges in meeting the IACS requirements:

Reducing time spent in the field:

Customer challenges

- Difficulty in combining different formats of information. Information is gathered in various formats (paper maps, aerial imagery on laptop, shape file, owner information on paper or in excel), and often on several platforms.
- Large amount of data to review. Especially when working with agricultural areas, parcels and digitized aerial imagery can result in hundreds of gigabytes of aerial data, overwhelming mobile platforms.
- Time-consuming workflows to verify the parcels that have been digitized by farmers. Digitized parcels are controlled by complete remeasuring in the field.

Solution description

- Custom WMS streaming service for large imagery and background files as well as custom data exchange formats like GML.
- Application data held in the background of projects, to be leveraged in the adjustment of existing data or in the collection of new data (point, line, areas, geometry and attributes).
- Unique data collection and editing workflows for IACS field work:
    - Reuse of existing digitized geometry after accuracy control (copy/paste)
    - Replace function (side of area, line, etc.)
    - Collect in parallel (offset measurement from lines)

Delivered quality to meet control standards required by law

Customer challenges

- Difficulty in checking data in the field with standard GIS collection tools

Solution description

- Certified GNSS technology in combination with IACS-specific field data collection software is collecting and controlling the accuracy, position dilution of precision (PDOP) values, and other needed measurement information. Specialized reports can be created automatically.
- IACS-specific area calculation where depending areas are subtracted or added depending on the rules for submission (i.e. if there is a pond or non-farmed area, this is subtracted from total parcel area)
- All area calculations are using the IACS-specific tolerances

Automated and reduced manual office processes

Customer challenges

- Time-consuming reporting methods. Significant time is needed to export data to the correct system and backend database that the EU member state needs for reporting.

- Multiple workflows used for different reports. Field workers often need to combine geospatial information, calculations, tolerances, and GIS attributes into a single report.

Solution description

- Compatibility with customer backend system by using standard file formats like shape or customized file formats like GML
- Custom reports for farmers and controllers in preparation for financial calculation
- Exported PDFs with agricultural parcel report and sketch

By implementing streamlined map-based data collection and editing workflows, which are based on the IACS data model, the final result could be created directly in the field. The transfer of the measurement data into a middleware to create the final result was no longer needed. IACS-specific area and tolerance calculations were implemented into the field application. This allows the field controller to present the result directly in the field to the farmer. Discrepancies between the control result and the farmer's aid application can be clarified directly in the field.

The team automated and reduced manual office processes by integrating with the backend software system and by creating special reports. As a result of working directly with the IACS data model and the elimination of needed middleware, the field data could be transformed automatically from the field database into needed reports and sketches for documentation purposes.

The combination of Trimble off-the-shelf products and professional services to streamline workflows and implement customized IACS-specific functionalities enabled the project team to reduce the time spent on a control job by up to 30%.

6. APPLYING PROVEN PRODUCTIVITY IMPROVEMENTS TO INCREASE LAND REGISTRATION

Though the LPS and Brandenburg case studies are based in developed countries where access to connectivity, technology infrastructure, and qualified personnel are prevalent; the workflow components identified 1) organization of field crews/equipment, 2) mixed fleet of hardware and software, 3) time-consuming process to update in the field, 4) multiple iterations between field and office, and 5) manual deliverable processing and production; are all relevant challenges experienced in developing countries as well.

By applying the productivity improvements demonstrated in these case studies within a developing world context, the current number of field crews could potentially conduct more parcel surveys in the same amount of time. Also, as office workers are not consumed with reworking tasks and conflict management, they will save significant time and can focus on creating deliverables. When considering the scale of undocumented land parcels worldwide, these improvements have the potential to be material to the organizations undergoing land reform efforts.

In societies where land rights are largely undocumented, formal property rights establishment is often being conducted for the first time. Existing data is sparse, the collection process is inherently more difficult, and both legal and survey expertise is required on the ground. With missing or low-quality base data, no connectivity, and poor transportation infrastructure, the challenges faced from inaccurate and inefficient field operations are known to be significant. Resultant impacts are either slow to materialize or are not "positive", and can further complicate the tenure environment. Therefore, for the rights holders, "immediate" validation in the field is absolutely critical to ensure community acceptance, verification, and finalization of rights (boundary and attribute). For the field crews, they benefit from intuitive, self-correcting software that helps prevent technical errors and provides immediate feedback on the collected data.

Leveraging the power of data is essential to making informed decisions in the field and, though challenging, the results of doing so yield significant productivity gains. Additionally, the business process analysis and requirements gathering is not just about implementing new technology and software workflows, but about understanding what the true intent and purpose of a project is. By assessing the system and workflows holistically, and constantly iterating with feedback from both field and office components, cadastral workflows can truly be transformed to a new level of productivity to tackle undocumented land rights worldwide.

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BIOGRAPHICAL NOTES

Markus Koper

Markus Koper is a sales application engineer at Trimble. He is working on Trimble Land Administration software products and software integration projects. Markus started in surveying with a 3-year education in land surveying in 1998. Afterwards he started studying in Bochum. After finishing his engineering degree in survey at Bochum University of Applied Sciences in Germany, Markus started as a sales engineer at Trimble. He takes over the regional sales management of the GEOgraf A³ cadaster software and field software portfolio. The GEOgraf A³ product family was designed and developed for the German private surveyors. It supports the whole cadaster update process (office and field).

Today, Markus is working as a sales application engineer for Trimble Land Administration. He is focusing on sales and consulting for enterprise customers based on the Trimble product

portfolio. Combining off the shelf products with additional customization´s and system integration allows him to deliver customer-satisfying solutions.

His background within the cadaster and field software area is his key for successful system integrations in international Trimble Land Administration projects.

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