Could We Cadaster Faster in an Integrated IT System by using UAVs with GIS Services in a Cloud Infrastructure?

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The Motivation

Build a better connection between citizens and their properties, based on their legal ownership, using technology and expertise.
Problem Statement & Approach

Mass registration process is probably the most efficient way to obtain a complete cadastral map and property rights (restrictions, responsibilities) registry for certain geography, in a time frame that is considered acceptable in the current world landscape.

The Complexity:

- various types of in terms of culture, communication habits, institutional relations, knowledge and understanding of laws and procedures;
- massive data management of various type, quality, availability;
- extremely important results for the further development of the socio-economic environment.
study each phase of systematic registration process
identify activities that can be supported by an IT improvement
validate their effectiveness through the analysis of the results of the projects that used such (or similar) solutions or simulated scenarios.
Mass (Systematic) Registration Phases

- **Assignment Preparation**: Focuses on public awareness campaign, procedural and communication framework setup and legacy (baseline) data repository consolidation.
- **Data Collection & Processing**: Targets spatial data and property documents collection via aerial photography and field visits, data processing and correlation.
- **Data Validation**: Identifies spatial and juridical data inconsistencies based on manual and automated business rules validation and check against legacy data.
- **Public Display**: Displays validated data sets in various formats in order to be checked and contested by any interested party.
- **Issuing of Land Book**: Focuses on the conversion of the final accepted version of property data (boundaries, rights) into official cadastral map and land registry records and the issuing of the registration certificate.
1. Assignment preparation
Challenges

- **Stakeholders**: Many stakeholders (citizen, companies and institutions) with diverse experience, expectations and commitment.

- **Procedures**: Legal framework ambiguities, complex procedures, difficult to understand and follow.

- **Communication**: Various communication habits determined by culture, education and experience. Poor access to information.

- **Timeline**: Time constraints, process milestones not known.

- **Data**: Scatter, incomplete, various format legacy data from multiple sources.
1. Assignment preparation
Improvements – Communication platform (Portal)

- **Repository for simplified procedures**
  Simplified stakeholder-oriented procedural framework can be made available to public

- **Timeline display and milestone reminders**
  Major project milestone calendar defined and displayed. Appropriate reminders may be sent via SMS, email, mobile app to subscribed users

- **Key indicators dashboard and red-zone alerts**
  Stakeholders may receive summarized data about project progress and alerts for major deviations

- **Collaborative tools to speed problem solving**
  Multi-channel issue registration, allocation and solving can be managed by BPM tool
1. Assignment preparation

Improvements – Legacy Data Platform

Legacy data analysis
- Identify property data available at various public institutions and assess its e-accessibility

Import and remote access data
- Import data from various formats or connect to their managing systems

Data Correlation, Cleansing and Indexing
- Index, correlate and cleanse property data around key business identifiers

Data Exploration and Dissemination
- Explore consolidated datasets using advanced search capabilities

Collection effort decrease 30%
1. Assignment Preparation
Digitalization of paper documents - Case study

Volume 80,000 paper land books
An average of 9 pages per document

Speed: 2.8k pager / hour
Highly dependant on the paper quality, equipment performance and work organization

Time
2 month for an experienced team to finish the job

Consolidate
Integrate output in (Legacy) Data Platform
2. Data collection and processing

Challenges

- **Volume versus time**: High volumes of data should be captured and processed within a rather short period of time.

- **Field visits**: Field interview can be difficult to schedule and run and may generate higher costs if improperly managed.

- **Data capturing**: Selection of the most suitable tools and methods is essential. Involvement of owners, tenants and local authorities is "a must" in order to succeed.

- **Data transfer**: Data processing may start as soon as collection ends. Delays should be limited where possible. Paper document use should be reduced.

- **Data correlation**: Legacy versus captured data correlation is a complex activity. Data owners should be involved and their conflict resolution should be easily obtained and integrated to speed up the entire process.
2. Data collection and processing
Cadastral mapping using UAV

Site preparation
- Check point materialization
- Flying plan definition

Image collection
- Flying plan adjustment to local weather conditions
- Flight management

Image Processing
- Automatic alignment of images
- Scene reconstruction
- Measured markers
- Scene optimization
- Full 3D Model reconstruction
- Digital Surface Model based on 3D model
- Images ortorectification
- Mosaicking of rectified images

Export of products
- Orthophoto map
- Digital Surface Model
2. Data collection and processing
Cadastral Mapping using UAVs – Site preparation & Flying plan

<table>
<thead>
<tr>
<th>Check point identification</th>
<th>Check point survey</th>
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Overflight | 2.600 ha
Landmarks  | 30 points
Flying bands coverage | 60% (min)
Check points survey | GPS Trimble Geo 7x, real time kinematic mode
2. Data collection and processing
Cadastral Mapping using UAVs – Orthophoto & Digital Surface Model (DSM)

Orthophotomap (GDS = 5cm)

Digital Surface Model (GDS = 20 cm)
2. Data collection and processing
Cadastral Mapping using UAVs – Cadastral Map

Cadastral parcels delineation on 2 cm resolution Orthophoto

- 1000 processed images
- Vectorization effort: 0.5 – 1 h / parcel (including field work)
2. Data collection and processing

Improvements - Field visit management

Team Allocation & Routes
Field team allocation to time slots and visiting areas
- Best routes calculation based on specialized algorithms

Interview Assistant Mobile App
Property location, attributes and (legacy) owner identification data download for field use
- Assistance for interview forms completion
- Biometric signature (voice, fingerprint)

Property Data Capturing
Photo copying of property documents by using mobile device camera feature
- Spatial vector data transfer and storage (NFC, Bluetooth transfer)

Data Transfer
Collected data transfer to backoffice system when a proper internet connection is available
2. Data collection and processing

Improvements calculated

Team allocation
The effort related to team allocation activity decreased by 50-60%.

Data transfer
Collected data transfer per cadastral zoning (cadastral sector) decreased by 33-50% from 3 days to less than 2 days, considering the paper-based information cannot be excluded from this activity.

Interview preparation
The preparation of the interview (per land parcel) reduced by 30-50% from 30 to 15 minutes.

Interview form
Filling of interview form and property documentation photocopying duration (per land parcel) decreased by 50-75% from 20 minutes to 5-10 minutes.
2. Data collection and processing

Improvements - Processing of collected data

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**Data Import and Integration Capabilities**
- Import of various spatial data file formats
- Standard format spatial data service integration

**Assisted Data Entry & Correlation**
- Alphanumeric property description and right-related data
- Advanced spatial or text querying

**Spatial and Legal Business Rule Validations**
- Rule Engine
- Manually and automatically triggered
- Validation Reports

**Data processing effort decrease 30%**

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**Extensive Data Export Features**
- Export in various formats (custom transport XML, international standard GML)
3. Data validation

Challenges

- **Volume versus time**: Significant volumes of data should be validated within a rather short period of time.

- **Data quality**: Earning population trust in such project results is highly dependent on the quality of the displayed data.

- **Data exchange**: Exchange of deliverable data should be realized using a methodology that’s acceptable for both parties.

- **Human tasks**: Intensive manual operations are required to check data accuracy, especially right registration.

- **Feedback**: Feedback from validation process is required to correct data inconsistencies, monitor the overall progress.

- **Fair treatment**: Data provider needs same or similar access to data and tools used within validation process by data beneficiary (cadaster and land registry authorities).
3. Data validation
Improvements

Data Exchange

Multiple channels:
- Transport File (custom XML, GML)
- Integrated APIs

Data Sampling & Allocation
Sampling algorithms for automatic selection of data sets that are subject to manual validation
- Programmed-assisted allocation of evaluators

Validation Tools
- Business Rule Validation Engine
- Data comparison tools (against legacy)
- Validation Reports

Transparent validation process results
Real-time validation decisions dissemination that may trigger rapid action
4. Public Display Challenges

- **Data format**
  Presentation format should be easy to understand and follow by the audience.

- **Data access**
  Displayed data should be disseminated through multiple channels to better serve the main scope.

- **Dispute capturing**
  Public dispute capturing should follow a simple, but efficient procedure, easy accessible by all entitled parties.

- **Dispute solving**
  Dispute solving should be transparent to all parties to raise the level of trust.
4. Public Display Improvements

Documentation rendering
- Cadastral Map
- Property Index
- Owner Index

Presentation Web Sites
Digital version of the displayed data (map, right registrations) presented through dedicated web site, accessible by registered users

Online registration of disputes
Dispute registration form
Digital documents upload

Dispute resolution communication
Solving progress communicated via email, SMS etc
Final report available and downloadable

30% Complaint management effort decrease
5. Issuing of Registration Certificates

Challenges

- Data continuity
  Resulted data set is a “snapshot” of ownership and other property-related rights image that deprecates over time if not managed within a cadaster and land registry information system.

- Communication
  Efficient communication methods should be used to rapidly disseminate the land registration certificates so that the official owners may benefit from them.
5. Issuing of Registration Certificates Improvements

- Mass Registration – Cadastre & Land Registry Integration
  System integration
  Data migration

- Mass Printing
  Registration Certificate (land book; card etc)
  generation capabilities
  Queue-based mass printing capabilities

- On-line distribution
  e-Registration Certification (digitally signed copy)
  distributed via e-mail

- “My immovable properties”
  Individual access to own property registered data (cadastral map, registration certificate, property documents, transaction etc) within a Citizen Portal

Electronic excerpt issued and distributed in 60 seconds
The implementation of real-time access to data validation decisions and citizen complaints can reduce the number of validation iterations with 25-50%.

The adoption of such a system is a complex, iterative process itself that may require piloting phases.

Communication and collaboration tools are essential components in the current social environment.

A smoother and more transparent access to information related to the property registration process will trigger an increase of population trust, involvement and general satisfaction.
Cadastral SurveyER Suite is a Web Integrated Land Management Applications Suite which provides complete services for cadastral and land management.

It is designed on flexible business architecture, starting with a core system and specific add-on components, providing a 360 view of society from the land administration perspective.
Cadaster and Land Management Ecosystem

Property Data Collection & Production
- Registration
- UAV Extension
- Surveyor Portal
- Mass Registration

Cadaster & Tenure Management
- Cadaster Registry
- Web GIS
- Land Book Registry
- Business Process Modeller
- Data Quality Engine

Communication
- BI & Reporting
- Citizen Portal
- Integration APIs
- Notification Engine
- eShop & ePay

Deeds Management
- Document Management
- Digital Archiving
- Digital Signature

Cadastral SurveyER Suite
Strong Points

Cloud-ready
The product architecture is based on micro-services and the components can be deployed using containers in any cloud platform.

Process centric using BPM
The business flows are coordinated using business process management engine. Business rules are applied in data processing flows...

Standards
The product adopts multiple domain-specific standards: LADM, INSPIRE, OGC standards.

Highly scalable
In order to manage a scalable licensing, many business features can be independently deployed and managed.

UAV Integration
Our solution encompasses the software product and the usage of our own produced UAV system (Hirrus) or any other ground or aerial device for collecting data.

GIS and vectorization competence
For any project we involve our strong GIS competence and vectorization services.
Components

The product brings openness, interoperability, standardization, automation and flexibility. All is done by using loosely coupled components. Each component uses multiple micro-services and can be deployed independently.
Components

Citizen Portal
An effective interface between citizens, private companies, governmental institutions, other types of organizations with different roles related to property management.

Cadaster Registry
Provides direct access to view and update cadastral data, both by information produces and by the approvers (Cadastral Department employees).

Mass Registration
Following the systematic registration flow, it provides real time, up-to-date information from the persistence stores to surveyors or other professionals assigned to the task.

UAV Integration
UAV products developed in our own Robotics Production Unit. End-To-End support for data collection, mapping, photogrammetry and geoprocessing. Integration with land and cadaster components.

Land Book Registry
Brings together a set of technological tools for efficient registration of rights, restrictions and responsibilities regarding immovable which concern individuals, companies and other organizations.

Registration
Registration is a central repository for storing all official incoming and outgoing customer requests an all correspondence received from or sent to the external entities in relation to an application.
Components

**Business Process Modeler**
Decoupled component to manage business processes. Workforce allocation, business rules, KPI management.

**Web GIS**
Spatial data management using ESRI and Oracle Spatial technologies.

**Integration**
Scalable integration engine, Integration API's based on technology standards, Decoupled registries, Spatial data integration

**BI and Reporting**
Configurable on-demand or scheduled document reports based on complex templating engines.

**Administration**
Dedicated administration component that manages whole platform. From business nomenclatures to application configuration parameters and business rules.

**Document Management**
Document management integrations using CMIS standard.
Components

Electronic payment
Dedicated component that manages product integration with payment processors such as PAYU, Mobil Pay.

Notification
Dedicated notification component for distributing event-based notifications and newsletters. Available channels: E-mail, SMS, WEB (using push-notifications).

Audit & Monitoring
Full-platform monitoring. From bare metal to business events. Collects logs, events, metrics and monitors business changes.

Security

Contextual Help
Dedicated component to manage interface contextual help features. Walk-through, Contextual search, Support assistant.

Batch engine
Dedicated component for managing scheduled and batch jobs. Designed to manage high data volumes.
UAV Integration
Hirrus System

- Ground Data Terminal
- Aerial Vehicle
- Ground Control Station
- Launcher
- Launcher Vehicle
Hirrus Technical Specifications

- Maximum take off weight: 9 kg
- Maximum speed: 110 km/h
- Cruise speed: 80 km
- Service ceiling: 3000 m
- Autonomy: 180 min
- Launching system: Automatic launcher
- Recovery system: Parachute
- Max payload weight: 0.9 kg
- Real time video streaming range: 15 km
- Propulsion: Electric
- Wingspan: 3.3 m
Hirrus Photogrammetry Parameters

- Photogrammetry sensor: stabilized on an axis
- Surface covered / flight hour: 800 – 1500 ha
- Number of flight hours / day: max. 6 h
Hirrus Produced Data and Vectorization

- Ground resolution: **2-10 cm**
- Digital surface model (DSM): **10-50 cm**
- Detailed images of interest areas
- 3D perspective (**XYZRGB**)
- Data in vector format
- Precision: **10 cm/px GSD**
Impact on other major systems
Cadastral SurveyER Suite

**In Emergency management**
- Quicker intervention due to addresses’ accuracy;
- Relevant information emergency agencies and first responders offering up to date buildings’ plans: access points, surface details etc.;
- Overview of affected properties for public utilities agents.

**For Agriculture management systems**
- Cadaster provides technical, economic and up-to-date data of agricultural land, systematically updated with all the changes taking place in the permanent agricultural land structure.
- These elements of cadastral agricultural fund are valued in the process of priorities of action for restructuring, modernizing and developing agricultural infrastructure.

**For Tax systems**
- The Cadaster system provides the necessary data system of taxes and fees for the correct tax liabilities of taxpayers requested by authorized institutions.

**In Environment control**
- Water cadaster: water management (intakes, evacuations), bridges’ management, which provide quick damage assessment in case of floods;
- Support for environmental protection regulations;
- Delimitation of areas: protected areas, protected waters, habitats etc.
Teamnet
Emergency & Crisis Management Suite

- **Mitigation**
  - EWS: Early warning systems
  - FACE RECOGNITION
  - HIRRU: Enterprise UAV system
- **Preparedness**
  - EMERSIM: Disaster simulation system
  - EVR Simulator: Emergency Virtual Reality simulator
- **Response**
  - EMERGIS: Multi-agency GIS based operational system
  - C2MOBILE: Command & control vehicles
  - eCall: Mobile app for first responders
- **Recovery**
  - EMERCONF: Communication and incident management system
  - Emergency Analytics
  - Damage assessment
  - Monitoring recovery progress
  - Update risk maps
Takeaways: Cadastral SurveyER Suite

- **Centralized system**: data produced at the source goes in one centralized system, where it can be accessed in real time by all interested parties;
- **Unified interface**;
- **Productivity**: mass data collection by drones, automation of data quality checks (validations);
- **Standardization** (LADM, INSPIRE, OGC, BPM, SOAP/WSDL)
- **Customization**: the system can be used in integrity, or only certain modules can used; modules can be customized and new modules can be added to fit client needs; core team available for customizations;
- **External entities portal**: for citizens, companies and state agencies;
- **Installation on premise or in cloud**;
- Can be connected to national registries or decoupled
- **Process management**: business processes can be optimized and / or adjusted to accomodate legal or internal procedures changes
- **Online electronic payment** available

Follow us on Friday, 9:00am, in room MC C1-100 for a Master Class where we will be presenting in detail our product, Cadastral SurveyER Suite.
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