Implementing a Smart Census to Optimize Statistical Data Management

Digital Technology Transforms, Streamlines, and Democratizes the Entire Census Workflow

12 July 2019

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Abstract

For many countries across the globe, data collection for the census has been a manual process. In most cases, fieldworkers receive paper maps to orientate themselves to their enumeration areas. Then they go out into the field with paper forms to collect the census information. This is a very tedious and complicated way of collecting data and requires fieldworkers to have additional knowledge of map interpretation.

With the improvement and democratization of technology, countries around the world can now benefit from the HxGN Smart Census solution. It provides modules that power the end-to-end workflow, from planning to digital enumeration and dissemination.

See how national statistical offices can build imagery base maps in a web-based smart GIS application with predefined workflows that control and limit each user (including fieldworkers) to their allocated geographical areas and tasks. A mobile application, intelligent caching, and data storage and backups make it possible for users, after only a limited amount of training, to have all the functionality required to capture data in the field without internet access.

Democratizing Data and Processes

Introduction

Technology is supposed to be a great equalizer, taking the power out of the hands of the few and making it accessible to the many. It has made data available to millions, but in many cases the ability to collect, process, analyze, interpret, and present this data has remained with the few who have the domain and technology knowledge to understand it.

Remote Sensing and GIS are two fields that have been locked away. While the ability to use satellite imagery to analyze landcover and land use half a world away is fairly standardized and well-documented, access to the data has been restricted to only those few who can afford it. And processing the data is a technological barrier to entry: understanding the complex nature of satellite/aerial imagery capture and processing, GIS analysis, and geospatial analytics restricts the pool of potential users even further, including only those who have sufficient training and education. Added to this are the complexities of interpreting the data and understanding what is being communicated. Mapping and cartography are complex studies, and clear communication of the information is difficult.

Vast improvements have been made in these fields. The democratization of data through generous programs like Sentinel and Copernicus makes satellite imagery and radar data freely available to everyone. The Internet of Things and explosion of sensors (drones, webcams, video feeds, connected traffic sensors, etc.) have ensured that we have access to more data than ever before.

While the data itself is freely available, knowledge of the technology to convert the data to usable information is not. While we can get free radar coverage of every point on the earth every two weeks, processing that data is still complicated. We can unwrap radar data to find minute changes in the earth's surface (down to a millimeter), but the knowledge of those change detection algorithms and how to use them remain a black box – and there is no foreseeable end to that.

Even with the technology to perform change detection on satellite imagery, it still requires a human being to interact with the imagery and make a map. Frequently, this process can take weeks to months to complete, and by the time the imagery is processed, and a map is created, the information is out of date. Because making traditional maps takes so long and is so expensive, we try to make them do too much.

Every map has to perform multiple purposes: land cover, land use, roadway mapping, and topography, to name a few. This compromises at least the intent of the map, if not the map's accuracy.

Information that can be derived from the data collected by all these sensors has great potential. What is needed is a way for domain experts to build sophisticated, reusable algorithms that can ingest streams of sensor data. We need a platform that allows data to be plugged in to the platform as soon as it is collected, and then have the system pull the data through processing steps so that analyses run automatically and generate updated maps. These maps would not only allow end users to see the current state of the land, but to see the entire time series so they can understand the patterns behind the change and begin to formulate predictions. Users need to see not only what was and what is, but also what can be.

This technology exists today. It is not a map; it is a Hexagon Smart M.App — a dynamic information service. By moving from the static map model — which collects data, analyzes it, and then produces a static printed, digital, or web-based map — to a dynamic information service, we can not only automate the process, but we can build job-specific and use-case-specific maps. Instead of multiple departments sharing a single multi-purpose map, each department can access its own view of the map containing information produced from the data specifically for them. Because these Smart M.Apps are lightweight and quickly produced, they are easy to prototype. Domain experts can build the map, incorporate feedback from users, and then make the map accessible to land use departments. As new data comes in, it is fed into the system, and the map is updated, including all of the relevant analytics.

It is time to stop using maps to communicate and to start using dynamic information systems that overcome the technological hurdles that keep people from using these powerful tools to analyze spatial data.

HxGN Smart Census in Practice

Census Definition

A population census is the most important and costly statistical data collection exercise conducted by a national statistical office (NSO). It involves the total process of planning, collecting, compiling, evaluating, analyzing, and disseminating demographic, economic, and social data. This data is usually limited to a specified time and delimited area, whether that be an entire country or just a well-delimited part of a country. It is usually conducted every ten years, and the results provide a detailed, small-geographic-area snapshot of the demographic, socio-demographic, and housing status of a country. It also provides the basis for a wide range of sample surveys.

HxGN Smart Census

HxGN Smart Census was developed on Hexagon's Geospatial division's M.App Enterprise platform. It combines traditional GIS functionality with a powerful workflow and workforce management tool to provide a total solution that covers all the phases of a census: pre-enumeration mapping, digital enumeration (including logistics, workforce training and management, integration with existing computer-assisted personal interviewing (CAPI) platforms, and dynamic progress reporting), as well as the dissemination of census results through dynamic Smart M.Apps.

The traditional census has four distinct phases: Pre-Enumeration Planning, Enumeration, Post-Enumeration Processing, and Dissemination.

Pre-Enumeration Planning

In preparation for a population and housing census, the entire country is divided into small areas of land, each one small enough to be handled by one interviewer during the time of the census. This is referred to as pre-enumeration census mapping, or demarcation, and the resultant demarcated areas are called Enumeration Areas (EAs). In some countries, such as Sweden and Austria, door-to-door canvassing to collect census data has been replaced by a registration-based census. However, in some parts of the world, such as Africa, civil registration and housing registers are not complete or current. Therefore, a conventional census is an important source of information and will remain relevant, if not critical, for many years to come.

To conduct a door-to-door census, the census cartographer needs to provide the census enumeration team with a set of unique maps covering the entire country that accurately defines the boundaries within which each interviewer (enumerator) has to work during the enumeration phase of the census. Furthermore, today's user community demands statistics to be provided within a spatial context. To facilitate this, desktop and server-based GIS solutions have become an important part of census data products and dissemination.

Cost Reduction

Censuses are by far the costliest statistical data collection project in a country. There is constant pressure on NSOs to improve efficiency while cutting the costs associated with a census. Traditional desktop GIS software, in combination with mobile GIS software, is the current standard in pre-enumeration census mapping. Since the costs associated with desktop and mobile GIS are determined by the numbers of users/licenses, it is usually significant – especially in countries where large numbers of temporary GIS operators and fieldworkers are deployed to do the work.

One license of HxGN Smart Census allows for unlimited users, resulting in significant cost savings. Although it does not have all the functionality of a high-end desktop and mobile GIS, HxGN Smart Census has all the GIS functionality required to do pre-enumeration census mapping and more. Raster and vector data are processed on the client side, rather than the server, which enables sophisticated GIS functionality, including vector data capturing, attributing, redlining, measuring, and querying, directly on the client. HxGN Smart Census therefore eliminates the need for numerous sophisticated and costly desktop and mobile GIS licenses.

GIS Infrastructure Integration

HxGN Smart Census implies fewer desktop GIS licenses, but it does not imply replacement of the entire current GIS infrastructure that may exist at an NSO. Since it accesses any established spatial database server, such as Oracle Spatial or SQL Server, HxGN Smart Census can be used together with any desktop software, such as GeoMedia or ArcGIS. This is a huge advantage to NSOs where there is already an established GIS infrastructure and expertise on a particular platform. The status quo can either be retained with the addition of HxGN Smart Census to provide the increased software capacity required for the large temporary census workforce, or desktop GIS licenses that are no longer required can be replaced by HxGN Smart Census.

Effective Implementation of Census Workflows into the GIS Environment

Although desktop and mobile GIS software have all the functionality required for census mapping, they have limitations when it comes to handling and managing project-specific workflows. This is a huge challenge which often requires use of a range of (usually unrelated) tools to establish and manage workflows. This leads to problems such as variances in interpretation of the methodology by different users and data integration issues that emerge as a direct result of using a set of disparate tools. Ultimately, it introduces unnecessary complexity that has a negative impact on data quality while increasing the overall risks associated with the project.
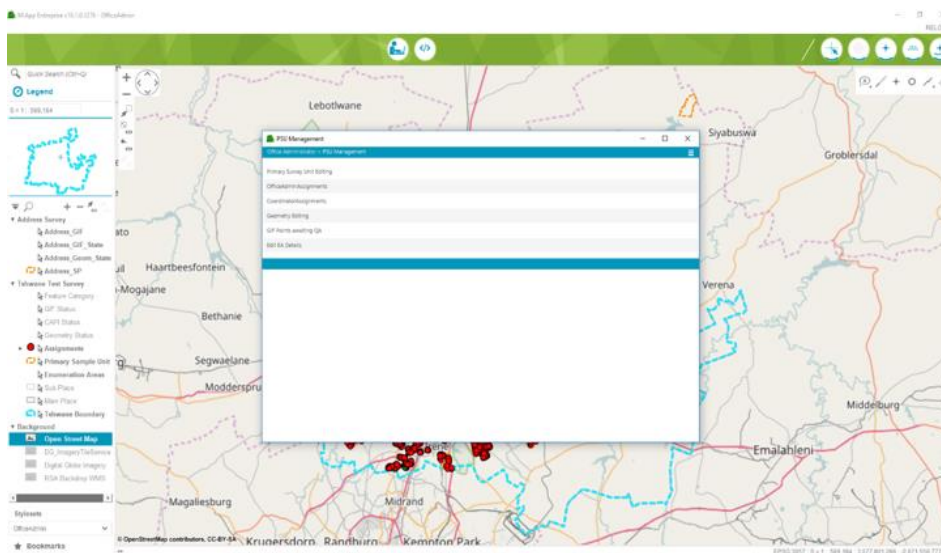
1:Pre-defined workflows use configurable rules to eliminate duplication of efforts.

At its core, HxGN Smart Census has highly configurable rules and a powerful workflow engine. This is a key attribute of the software. This enables Subject Matter Experts (SMEs) to implement census mapping workflows and feature-level access control that is managed by a single, fully-integrated system where all the parties, each with associated posts and roles, access the same database(s) through a single web server. Each post is associated with one or more roles, and each role has a specific set of tasks. Furthermore, access to the system is through standard internet/intranet security protocols involving a username and password.

The access control system allows a supervisor to allocate a specific unit of work, referred to as a production unit (PU), to a specific user associated with a specific post. The assigned user can only work on the assigned PU and can only execute the tasks relevant to his/her role in that part of the overall workflow. This eliminates duplication of efforts, since it is impossible for two teams to work on the same PU at the same time. It is also impossible for a user to do anything other than the tasks related to his/her role with regards to the allocated PU at that step in the overall workflow.

2: Powerful tools for workforce assignment and management mean that NSOs can rapidly respond to the needs in the field

Once the tasks for a PU are completed, the PU is submitted, and the supervisor receives a notification. This then triggers a set of quality control/quality assurance (QC/QA) steps, after which the work is either accepted or rejected and sent back for correction.

Streamlined Project Management

A census-mapping project is usually a huge undertaking, with a large workforce ranging from about 50 to more than 1000 persons, depending on the size of the country, the methodology, and the project timeframe. Project management is therefore a huge challenge. HxGN Smart Census enables the GIS manager to manage the entire census mapping project using a single tool. Since work allocation and task execution are performed on the same system, the GIS manager knows exactly who is doing what at any particular moment and, also, the overall status and progress of each phase of the project. And since HxGN Smart Census has a strong spatial component, work scheduling and progress tracking can be done using a combination of maps, tables, and lists.

This effectively manages, if not eliminates, most of the inefficiencies common to census mapping projects. These inefficiencies include: suboptimal scheduling of fieldwork that requires field teams to drive unnecessary distances between PUs, duplication of effort where the same PU is allocated to two teams or operators and obtaining of status reports from the field and office and compiling of progress reports. HxGN Smart Census provides the ability to detect a problem swiftly – long before it turns into a major crisis.

Improved Data Quality

Because numerous teams often work simultaneously on a census-mapping project, it is a huge training and management challenge to ensure consistency in the interpretation and execution of the methodology. HxGN Smart Census vastly improves the consistency of work, and this ultimately improves the overall quality of the data collected and processed by the respective parties in the workflow.
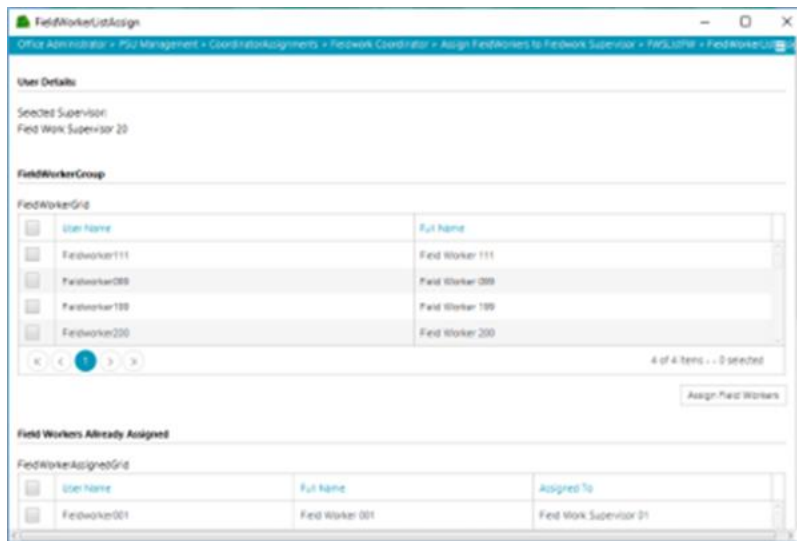
3:Role-based Workforce Management tools simplify task assignment.

Every user/role executes a portion of the workflow with specific tasks configured in the software as required by the project. Each user can only execute the tasks associated with that part of the workflow – nothing else. The software literally guides the user through the steps. Only the software functionality required for execution of that workflow is available to the user. This ensures that all users perform the tasks in the same way, which leads to consistency in the execution of the overall methodology and, ultimately, increased data quality and uniformity.

Enumeration

The Enumeration phase, while quite short – usually two to three weeks – also requires the largest workforce and the most coordination. Over 200,000 people can work simultaneously collecting the enumeration data. To mobilize such a workforce requires a number of solutions.

Simplified Workflows

Since each user only has access to software functionality required to execute the tasks for the assigned portion of the workflow, extensive GIS skills and knowledge are not required to do the work. This is a huge advantage in Africa, where GIS skills among the population are relatively limited. Furthermore, workforce training can be much more focused and task-specific, resulting in significant savings in the training budget and quicker project implementation. Simplified training also makes it much easier to replace staff during the project when required.

Mobile Integration

Many NSOs use third party software to provide the Computer-Aided Personal Interview (CAPI) platform. These third-party solutions utilize mobile devices and laptops to provide the interviewer with a list of questions and then records the results. The mobile component of Smart Census integrates with these third-party solutions giving the NSO the power to choose the provider that is right for their needs.

Fieldwork in Remote Areas

Census mapping software applications for fieldwork must provide the ability to work offline. In addition to openly connecting with third-party solutions for digital collection, HxGN Smart Census uses advanced caching to enable offline use in remote areas where internet access is limited or non-existent. If required, a field interviewer can work offline for days, updating the captured data at intervals when connectivity can be restored.

Rapidly Respond to Changes

With such a short window to collect all the demographic data, the NSO needs to be able to react to changing needs as quickly as possible. With HxGN Smart Census, the data is updated on-the-fly, giving the planning center instant insight into where response may be necessary. Injuries, weather, technical difficulties, and other emergencies can all be mitigated by understanding the situation quickly and then adjusting the workforce as needed.

Processing

Because the entire project is digitized from start to finish, there is no need for a manual data processing step. This eliminates the bulk of the errors – from transcription or illegibility errors to data entry mistakes – from the process. It also eliminates the long lag time from capturing the data until it is processed and ready for analysis.

Post-Enumeration

Utilize Existing GIS

One of the key features of HxGN Smart Census is that is plugs into the existing GIS. The platform is software agnostic and complements high-end GIS software. The strength of HxGN Smart Census is in the workforce and workflow management. There is no need to retrain all of your analysts on a new platform.
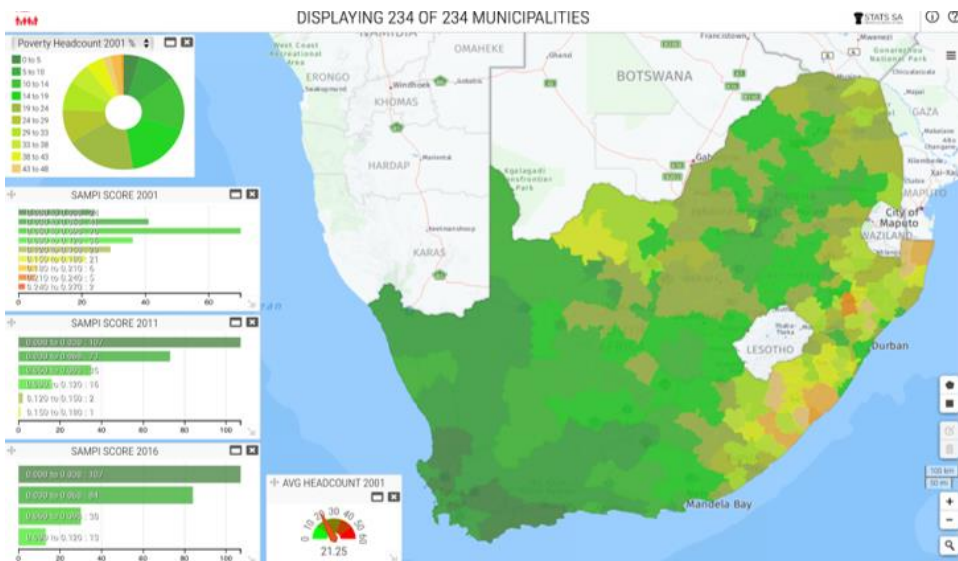
4: Publish the map and get an on-the-fly look at the census data.

Dissemination of Results

One of the keys for census data is making it available to the stakeholders as soon as possible. They need to understand the makeup and needs of their citizens immediately, so they can begin planning and making policy. Census data is displayed in graphics, charts, and on a map simultaneously. This interactive Smart M.App lets stakeholders view both comprehensive statistics and detailed information about specific communities or areas. Results can be filtered based on multiple factors such as housing type or socio-economic status.

5: See the data in charts, tables, and maps.

Post-Censual Surveys

Once the information from the census is made available, the NSO may discover a need to gather more information about a specific pattern illuminated by the census data. Instead of having to wait 10 more years, the HxGN Smart Census infrastructure is already in place and can be used to plan, perform, and disseminate the data for post-censual surveys. These surveys can be done on any scale, whether national or limited to a specific area within the country.

Conclusion

HxGN Smart Census provides an exciting solution to census mapping around the globe. It provides an excellent platform for easy scheduling of work, project tracking, and reporting. It is easy to use and requires minimal training compared to conventional desktop GIS. The flexibility to configure the software to ensure that each user can only access tasks assigned to him/her eliminates duplication of effort and potential differences in methodology interpretation. This improves data quality and consistency.

Since software is installed only on the server, software/application updates are easy and non-disruptive. Each time a user logs in from a client, any updates or changes are automatically reflected. The offline functionality enables fieldwork to be done in remote areas. Advanced caching ensures that relatively small data packages are sent to and from the server, keeping data costs and connection time to a minimum - an important aspect from a fieldwork and budget perspective.

Flexibility of the software enables it to be used for planning and management of all phases of the census project. It can also ultimately be used as a tool to disseminate information to all stakeholders, including the public. HxGN Smart Census complements, rather than replaces, any existing GIS infrastructure; however, it eliminates the need for mobile GIS software, and it reduces the need for high-end desktop GIS software.

The challenge facing democratization of remote sensing and GIS workflows lies not in access to data, but in access to the processes that create the data and the information derived from the data. In this case, democratization of the data is not achieved by free access to satellite data, but rather by empowering NSOs to access technology that can make their processes more efficient, ultimately allowing them to produce more accurate data more quickly. By implementing a streamlined workflow system, the HxGN Smart Census solution empowers workforces of any size to be quickly trained and to focus on their duties instead of navigating through a complex and perhaps overly-powerful GIS system.

Under the hood, of course, there is a lot of specialized processing going on. But that is ameliorated by keeping it under the hood and limited to SMEs who can set up the processes and workflows, and then step back and allow the data to flow into the system. This allows SMEs to focus on QA/QC tasks instead of building map after map after map.

In addition, HxGN Smart Census ensures adherence to standards, simplifies the planning process, and automates report generation at the end of each cycle. Not only does this make it easier on the NSO, but it also makes this data more accurate and more accessible. This higher-quality data can be more quickly disseminated to stakeholders for their use in understanding the makeup of their country or region so they can better discern what is needed to shape smart change in their world.

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About Hexagon

Hexagon is a global leader in sensor, software and autonomous solutions. We are putting data to work to boost efficiency, productivity, and quality across industrial, manufacturing, infrastructure, safety, and mobility applications.

Our technologies are shaping urban and production ecosystems to become increasingly connected and autonomous — ensuring a scalable, sustainable future.

Hexagon's Geospatial division creates solutions that deliver a 5D smart digital reality with insight into what was, what is, what could be, what should be, and ultimately, what will be.

Hexagon (Nasdaq Stockholm: HEXA B) has approximately 20,000 employees in 50 countries and net sales of approximately 4.3bn USD. Learn more at hexagon.com and follow us @HexagonAB.