ENABLING DISTRIBUTED SPATIAL DATA INFRASTRUCTURES

_WHITE PAPER

LUCIAD
CONNECT • VISUALIZE • ANALYZE • ACT

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CONTENTS

I. INTRODUCTION

What is SDI? The definition of Spatial Data Infrastructure (SDI) has changed little since the term first started to be used in the early 1990s: Spatial Data Infrastructure is a "collection of technologies, policies and institutional arrangements to facilitate the availability of and access to spatial data." This includes cadaster, land administration and land planning applications. Typical components of an SDI have also remained unchanged: (i) a repository of land and spatial data; (ii) a network; (iii) a geographic information system (GIS) for data handling and viewing.

SDI Policy. On a policy level, many regional, national and international programs have promoted not only the establishment of SDI's, but also ensuring the compatibility and openness of these SDI's through a set of requirements such as the use of open standards, public availability of the underlying spatial data, and sharing of data between different government agencies and private actors. Standards are needed in land administration, both for initial data acquisition and for data maintenance. And previous experiences have shown that it is not an easy task to design and set up a land administration. Many countries still lack the modelling expertise to set up land administration systems.

Establishing a common standard for the land administration domain was originally an initiative of the International Federation of Surveyors (FIG), which submitted a new working item proposal in 2008 to the International Standardisation Organisation (ISO). Now, Land Administration Domain Model (LADM) is a formal International Standard, known as ISO 19152.

Luciad offers a unique platform for all geospatial content, whether proprietary or open. Luciad software is both commercial off-the-shelf (COTS) and components-based. Thus it is fit for adapting to the evolving requirements of any modern SDI or land administration system.

In Europe, a major recent development has been the entering in force of the INSPIRE Directive in May 2007, establishing an infrastructure for spatial information in Europe. INSPIRE is based on the infrastructures for spatial information established and operated by the 28 Member States of the European Union. The Directive addresses 34 spatial data themes needed for environmental applications, with key components specified through technical implementing rules. This makes INSPIRE a unique example of a legislative "regional" approach.

The worldwide Open Geospatial Consortium (OGC) is the authoritative source for standardization of the geospatial community. Luciad is one of few Technical Members and is thereby at the source of the standardization efforts of the OGC. Luciad helped co-defining new open standards and on many occasions has been the first geospatial vendor to provide open commercial support for these standards. Worldwide, land administration systems and SDI architectures contribute and are essential to goals of public interest such as legal protection of land owners, efficient urban and environmental planning, citizen taxation, and e-government. Luciad is committed to securing these goals.

Available Geospatial Technologies. GIS has always been a crucial element of any SDI infrastructure. However, traditional GIS are not well equipped to fully handle the challenges of today's land administration agencies. And conversely, the wishes and needs of these agencies evolve at such a pace that flexible technology is required that not only meets the needs of today, but also of tomorrow. This Whitepaper aims at pointing out some of the technology challenges ahead – and how Luciad's technologies are available to ensure operational success of a governmental SDI, to the benefit both of the government agents involved and to the wider citizenry. Luciad offers a unique platform for all geospatial content, whether proprietary or open. Luciad software is both commercial off-the-shelf (COTS) and components-based. Thus it is fit for adapting to the evolving requirements of any modern SDI or land administration system.

II. GEOSPATIAL CHALLENGES FOR TODAY'S SDI

Over the past 15 years Luciad has been in contact with policy makers, Chief Information Officers (CIOs) and geospatial specialists of government agencies worldwide. Luciad was able to derive a common thread of the challenges these decision makers all encounter in setting up a successful SDI – and Luciad managed to respond to those challenges with the Luciad components. Below are some of the key points:

A. EXPONENTIAL DATA AND USER GROWTH

Technologies of classical GIS vendors date back 30, sometimes even 40 years in time. Surely these technologies have evolved over time, but still very much carry their initial "DNA": they are based on specialist tools for the individual geo-specialist or planner working on defined, limited datasets.

Today SDI's are evolving towards "Geospatial Big Data" – datasets so large and complex that traditional data processing applications are inadequate. Challenges include analysis, capture, curation, search, sharing, storage, transfer, visualization, and information privacy.

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Also the number of users needing to access SDI's has grown exponentially. Within the government agency, geospatial technology has evolved from a specialist tool to a commodity. And outside the government agency, both citizen expectations and legal initiatives have led to opening up SDI's to the public at large. Today everyone is a potential consumer of and contributor to SDI's – an evolution that classical GIS vendors did not see coming and only responded to very late.

B. PRODUCT AND TOOL MANAGEMENT

SDI users have consistently told Luciad about their need for a uniform product or set of toolsets, with a unique look and feel and an integrated workflow where, from within one single application, all land management tasks can be carried out.

Classical GIS vendors often pay lip service to this idea. They cannot offer all functionality required for an SDI with one single product or product family. In reality it is often concealed that all system and functional requirements of the SDI can only be met by juxtaposing a set of different products. The reason is simple: the majority of the GIS industry as it exists today has been around for decades, and has grown its business not organically but by takeovers and sourcing in third-party software.

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As a result, GIS products are often an amalgamation of poorly or non-compatible products, each offering a piece of functionality in the patchwork of requirements. It is not uncommon for instance to find GIS solutions where an operator must change screens or even applications to switch from a 2D to a 3D projection, or to edit or convert data from one format to the other. In many cases, this inherent weakness of the traditional GIS industry has even become an easy way to sell more and more products to the user – leading to more capital expenses in purchasing and more operational expenses in maintenance.

C. HANDLING TEMPORALITY

Geospatial data used to be static in nature. With the accumulation of sensors and available historical data, users now want to be able to make rapid and easy temporal comparisons between the situation "now"

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and "then". How has urbanization affected availability of land plots? How has weather and climate change affected natural resources?

Classical GIS systems still have trouble integrating a decent 2D and 3D picture into one single application with a seamless operational switch between the two. Whilst users have the reasonable expectation to add the temporal factor and operate in 4D.

D. FLEXIBILITY IN DESIGN

Classical GIS technology is conceived from the outset as a finished, commercial-off-the-shelf (COTS) end-user product. Even when these vendors argue that their end-user product is equipped with an API (Application Programming Interface), that API is typically not modular, but merely configurable. In other words, some basic parameters can be configured but there is no possibility to truly adapt and integrate the technology into the SDI architecture as envisioned by the customer. As a result, classical GIS vendors often need to impose and define their own architectures, with systems architects that need to be involved from the outset in the project to adapt the overall system to the geospatial technology. Whilst of course the overall system architecture should dictate the geospatial technology – not the other way around.

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E. INCREMENTAL GROWTH

The time of monolithic, one-time GIS implementations based on a fixed set of requirements is long behind us. Today, users want their system to evolve continuously, adapting to a changing technical environment, changing user behavior and new requirements. Hard-coded or proprietary systems often do not offer the flexibility required for such incremental growth. And even GIS systems that announce themselves as COTS often need to add a whole suite of different software products or sub-sets of products to deal with specific changes in requirements.

F. SUSTAINABILITY

Many GIS vendors have accepted the inflexibility of their products as an inherent part of their offering. Deprecation strategies are often announced openly, with a product evolving from "generally available" over "extended" and "mature" to "retired". These semantics cover an essential weakness: whilst SDI's and land administration systems are meant to last for decades, the underlying GIS technology has only a very limited life cycle, and platform dependencies often cause the need to change the GIS technology.

G. TOTAL COST OF OWNERSHIP

Total Cost of Ownership (TCO) is a logical corollary of all of the above. For government agencies it is of paramount importance that their geospatial infrastructure has a logical, foreseeable cost structure without hidden liabilities that can suddenly impact budget planning and cash management.

III. CONNECT, ANALYZE, VISUALIZE AND SHARE: LUCIAD AS A SINGLE SDI PLATFORM

A. CONNECT, ANALYZE, VISUALIZE AND SHARE

Luciad offers a complete COTS ecosystem with server, cloud, desktop, browser and mobile technology to supply integrated solutions to both current and future challenges of SDI and land administration professionals. All Luciad tools are fit and conceived from the ground up to build OGC, LADM or INSPIRE compliant solutions.

A wide variety of **Data Connectors** allow to ingest every type of data (imagery, raster, vector, survey) in any form (open standards or proprietary standards) and from any source (whether directly from the surveyor or from existing GIS systems, and whether in file form or exposed as a web service). Luciad has purposely chosen not to impose or even have its own data format. This is a radical difference to many traditional GIS vendors that have based their offering on their own proprietary formats. For

instance, Luciad is a driving force behind Geopackage, which is rapidly replacing traditional formats such as ESRI-shp or SDTS formats. GeoPackage was carefully designed to facilitate widespread adoption and use of a single simple file format by both commercial and open-source software applications, on enterprise production platforms as well as mobile hand-held devices. GeoPackage is a standard from the Open Geospatial Consortium. Luciad was instrumental in both defining the standard and in being the first vendor to offer strong, worldwide support.

LuciadFusion is Luciad's high-performance data management and data server solution. LuciadFusion is at the heart of any enterprise-wide SDI architecture. LuciadFusion is a server application equipped with integration components. LuciadFusion is designed to manage, fuse and serve Geospatial data. LuciadFusion consists of a Data Connectivity Manager, a Data Server and a Storage capability. Land administrations can rely on LuciadFusion to access Geospatial data from any database, service or file through an easy-to-use Data Management application.

→ LuciadFusion Data Manager. The data can be managed into different information products or 'Themes' – a combination of different datasets as required by each specific user group. Using the appropriate Themes, the required data is then ready to be easily served to one or more functional applications. This is key to opening up the SDI to the entire government enterprise and even to the public at large. The LuciadFusion Data Manager can be used to prepare authoritative data and data products in the frame of an SDI.

→ Storage Capability. Through efficient and advanced caching and storing mechanisms, LuciadFusion ensures fast retrieval and guarantees that the data is readily available at all times. Benchmark tests carried out against server solutions of traditional GIS vendors such as Google, ESRI and Intergraph have revealed that LuciadFusion has data processing and loading performance behavior that is up to 400% faster.

→ Data Server. The LuciadFusion Data Server serves the data and relevant meta-data directly into LuciadLightspeed based applications by means of a high performance Tile Service protocol. Alternatively, non-Luciad based applications can access the same information through standard OGC protocols.

Customers select LuciadFusion for the benefits of Intelligent Data Management, High-Volume Data Processing & Storage and its ability to serve data to multiple Situational Awareness applications from a central source.

LuciadLightspeed is one of Luciad's flagship products. Thanks to its unique in-memory approach, it is renowned as the fastest geospatial application in the world, able to handle vast amounts of point data (up to 10 million of static points) and dynamic data (up to 500,000 moving objects with a sub-second refresh rate). LuciadLightspeed is the ideal tool in any SDI workflow to easily edit, plan and analyze data. LuciadLightspeed can function as a separate desktop solution for advanced users to ingest the data of LuciadFusion for further data exploitation. If required, it can also function as an integrated part of LuciadFusion such that all data exploitation is carried out on the server-side. It boasts all the capabilities required by land administration and cadastral users in terms of

→ management of imagery, vector and survey data
→ easy transformations
→ all reference systems and projections
→ full 2D, 3D and 4D capability integrated within one single application and one single screen view
→ platform-independence.

As all Luciad products, LuciadLightspeed is fully web-services-enabled.

LuciadRIA is Luciad's fully web-based tool, following HTML5 standards and not requiring any plug-ins. It can allow tens or even hundreds of thousands of users to publicly access SDI data. Luciad was a forerunner in adopting the HTML5 standard and as a consequence has a technology advantage of several years onto

traditional GIS vendors that too long held on to plug-in frameworks such as Microsoft Silverlight (e.g. ArcGIS).

LuciadMobile is Luciad's Android-based solution for mobile users in the field. It has been designed and optimized for field workers needing to work in difficult conditions:

- → full integration with the functionality of the Android device such that the entire workflow (generation of pictures, geotagging, making annotations, sending the data to the server) can be carried out with one device
- → optimized battery and memory usage
- → designed for intermittent connectivity.

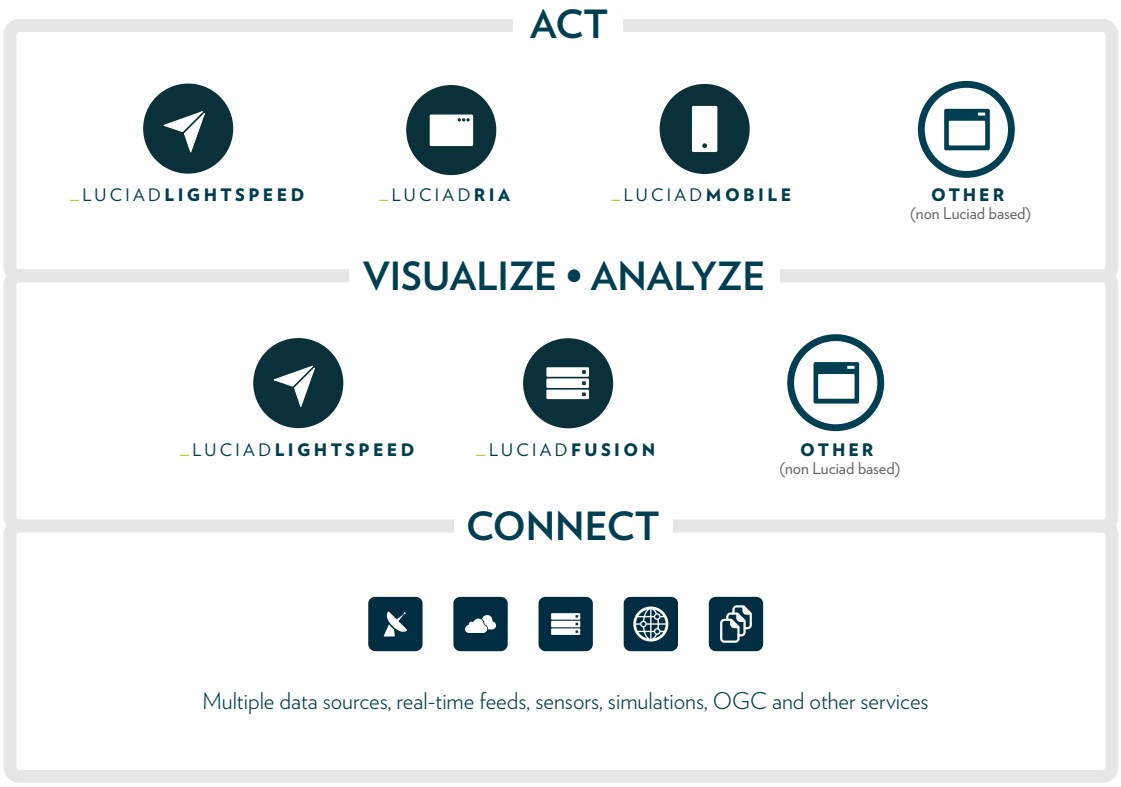

Figure 1: Connecting, Visualizing, Analyzing and Acting with the Luciad product suite

B. LUCIAD IN THE SDI WORKFLOW

The SDI Workflow can be subdivided into various parts:

- → Collection of data
- → Connection to the data
- → Processing of the data
- → Production of data products
- → Sharing of data products
- → Exploiting data products

Figure 2: Luciad in the SDI workflow

Collect. Luciad is unique in its "data-agnostic" approach. This means that Luciad does not impose its own proprietary data model. Instead, it is open to any type of data format or standard and is able to natively connect to this data, i.e. in memory and without the need for pre-processing, thereby avoiding lengthy processing time and transformation errors.

Connect. As shown in the picture above, the Luciad products are fit to handle the entire SDI workflow chain, starting by connecting to the data collected by various sensors, surveying instruments or stored in legacy systems. Even extremely large datasets (e.g. LIDAR) can be handled, in great contrast to traditional GIS (for instance even when these support LIDAR they do not have the processing speed and power required to usefully exploit that data).

Figure 3: Luciad products are suited to process and handle large sets of point clouds (e.g. LIDAR) with unmatched performance

Processing, Production and Sharing. Processing of data and production of data products can be carried out with the various components of LuciadFusion (LuciadFusion Data Manager, Storage Capability and LuciadFusion Server). If any server-side analytics need to be carried out, LuciadLightspeed can be seamlessly integrated within LuciadFusion. LuciadFusion can serve as a geodatabase and/or connect to any commercially available geodatabases, including emerging "big data" databases such as SAP HANA.

Data Exploitation. LuciadFusion can serve out various data products to the most diverse types of user profiles, allowing to set viewing and editing rights in function of both the data types and the user profile involved. This allows for easy integration of new functionality such as crowd-sourced data.

C. LUCIAD EQUIPS YOUR LAND ADMINISTRATION FOR THE API ECONOMY

According to IT research firm Gartner, 50% of business-to-business collaboration will take place through Web APIs by 2017, and by 2016 75% of Fortune 1000 firms will offer public Web APIs. Government agencies are following the same trend, particularly in the SDI and land administration area. Whilst legacy application integration strategies were still able to fit some business needs in the client-server world, they fail to meet today's need for real-time, distributed cloud and mobile applications.

At first sight, most traditional GIS have some useful out-of-the-box functionality – until the moment where that functionality needs to be even slightly changed to meet requirements. The lack of a true API then quickly becomes apparent.

This is where Luciad takes over. Whilst most are only discovering the advent of the API Economy, it has been a reality for Luciad since the company's inception. Luciad's mission statement has been from the outset to deliver software components or API's – rather than finished end user applications. This is a major difference with the traditional GIS companies with an SDI/ land administration offer. At first sight, most traditional GIS have some useful out-of-the-box functionality – until the moment where that functionality needs to be even slightly changed to meet requirements. The lack of a true API then quickly becomes apparent.

D. LUCIAD PREPARES YOUR LAND ADMINISTRATION FOR THE BIG DATA CHALLENGE

Industry leaders in the field of big data, such as SAP, have already selected Luciad as the standardized geospatial application of choice. Together with SAP, Luciad can be found in smart farming applications, insurance applications and also in large Spatial Data Infrastructures.

Big Data will inevitably enter the world of the land management agencies.

Luciad can help you prepare for that challenge. In our historic markets of Defense and Aviation, we have been confronted with "Big Data" challenges before these challenges even got that name. Very heavy point-cloud data such as LIDAR is available since very long in military applications. Similarly, merging tera- or petabytes of imagery, vector and survey data is standard practice in our core markets. And within this ever-growing amount of data, warfighters and pilots rely on Luciad for their mission critical systems that require sub-second reponse time and maintained data accuracy through any number of data transformations, reprojections or calculations.

IV. USEFUL REFERENCES

Please contact Luciad for a selection of references in the field of land administration and SDI.

MORE INFORMATION

For more technical information or to find out more about our other products and services, please contact us at **info@luciad.com**.

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