

Initial Inventory of 3D Cadastre Use Cases in the Caribbean

Freddy EVERY (Aruba), Charisse GRIFFITH-CHARLES (Trinidad and Tobago), RiëncyHOLDER (Netherlands Antilles), Mathilde MOLENDIJK (The Netherlands), Peter VAN OOSTEROM (The Netherlands), Rolando OCAMPO ALCÁNTAR (Mexico), Jocelyne Marie Marguerite CROES (Aruba), Christiaan LEMMEN (The Netherlands), Hendrik PLOEGER (The Netherlands) and Michael SUTHERLAND (Trinidad and Tobago)

Key words: Cadastre, 3D Cadastre, Land Administration Domain Model (LADM), Caribbean, Public Administration, Marine Cadastre, Small Island Developing States (SIDS), Environmental Protection;

SUMMARY

As argued in many earlier FIG publications, the potential benefits of 3D Cadastre are huge. This is especially true in the Caribbean setting with quite dense urban areas and large and important marine areas, where rights (restrictions and responsibilities; RRRs) in 3D is a prerequisite for the blue economy. The Caribbean with a plethora of 3D use cases present, limited legacy data and systems, and a relative small size, is an excellent site for establishing an integrated 2D/3D Cadastral registration. Such a future system will support sustainable development of the Caribbean in the economic sense, while protecting the environmental values and human values (based on legislation and tools to support this).

This paper will present an initial inventory of 11 different relevant 3D Cadastre use cases in the Caribbean (from Aruba, Bonaire and Trinidad&Tobago). This initial inventory gives an indication of the multi-disciplinary nature and importance of the topic, but will also be used for scoping the future development.

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1. INTRODUCTION

Land administration is the foundation for sustainable economic development. Currently the 3D spatial aspect, or even 4D when including the temporal dimension, requires attention. At the moment no country in the world has a complete 3D Cadastre, incorporating 3D legislation, 3D survey, 3D registration of rights, restrictions & responsibilities (RRRs), 3D management of the parcels, 3D user interfaces and dissemination (van Oosterom, 2013). However, the potential benefits of 3D Cadastre are huge. This is especially true in the Caribbean setting with quite dense urban areas and large and important marine areas, where RRRs in 3D is a prerequisite for the blue economy. The Land Administration Domain Model (LADM), which was accepted in 2012 as the ISO standard 19152, is used as reference models as it supports integrated 2D and 3D representations (on land and water), below, on, and above the surface (Lemmen, 2012).

There has been a rapid increase in the use of space above and below the Earth surface in recent years. Therefore, exploring the benefits of integrated 2D and 3D cadastral registration in the Caribbean is needed. Various types of use cases will be analyzed. Especially in case of apartment complexes and the tourist industry, the temporal dimension via the time-sharing approach as currently supported in Aruba, actually results in what could be called a 4D Cadastre (Van Oosterom et al, 2006). The deep integration of space and time in the representation of cadastral parcels forms a solid foundation for the registration, but also a technological challenge as today's tools (databases, GIS and CAD systems) are limited to 3D geometry.

3D land administration in the Caribbean is important for providing good governance as most of the countries are considered to be Small Island Developing States (SIDS) with vulnerabilities that occur in three dimensions. Climate change, including sea level rise, for example, threatens to inundate many coastal regions that are in large part below 5 metres above the sea level. The countries, by virtue of islands, are required to manage large areas of marine space within their Exclusive Economic Zones (EEZs) and in internal archipelagic waters where multi-layered rights of fishing, leases, licences and reserves for environmental protection, exploitation of resources exist; see Fig. 1. The small islands and dense population in the urban areas must also manage use of vertical space for housing and other constructions, therefore requiring 3D representations and visualisations. The relevance was already illustrated by the early 3D Cadastre LADM activities in Trinidad and Tobago

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(T&T) more than a decade ago (Ng'anga et al, 2001). Explorations were done on the applicability of the LADM (ISO 19152) and its predecessors in T&T including cost benefit analyses. T&T profiles were designed for the 3D Marine Cadastre as well as for the land. Pilot projects were further performed in St. Lucia and St. Vincent and the Grenadines. This resulted among others in the following recommendations to be addressed in future research (Griffith-Charles and Sutherland, 2014): social (meetings to agree on informal or even registered rights that have not been demarcated in cases these rights overlap or are interspersed on land or water), technical (transition between shore and sea), and legal (enforcing in 3D if legislation does not reflect 3D). Knowledge on the legal and organizational context, including the various aspects of public administration, depends on the constitutional status of the islands.

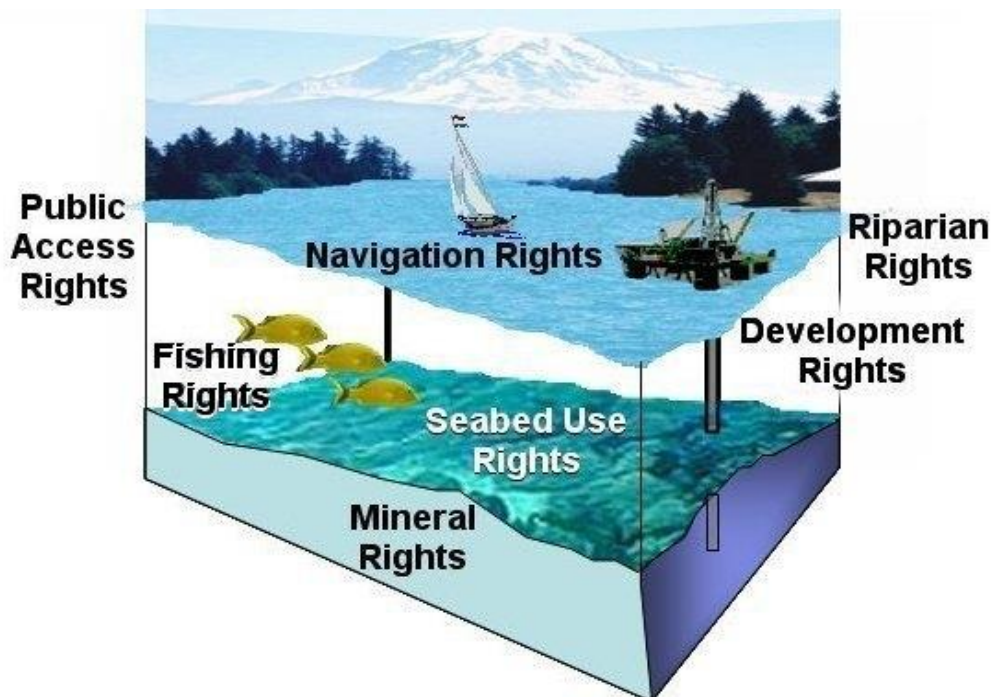


Fig. 1. Various 3D Marine Parcels and relevant rights (Sutherland, 2005); Note that other RRRs in Caribbean would be related to tourism, protection of reef and habitats etc.

Due to the relatively small scale of the cadastral registration on the involved Caribbean Islands and the limited amount of legacy systems and data, the actual implementation of a 3D Cadastre should be very feasible. This operational experience is then also of high value for other countries in their various development stages towards a 3D Cadastre (this is relevant to other Caribbean islands, but also for other countries, including the European part of the Netherlands as 3D use cases will overlap). In the next sections a range of 3D use cases will be presented from respectively Aruba,

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Bonaire, and Trinidad&Tobago in respectively Sections 2, 3, and 4. This is followed by a discussion in Section 5. Finally, Section 6 contains the conclusion and description of future work.

2. ARUBA

From Aruba the following four 3D Cadastre use cases are shortly presented:

- A1. Condominium and apartment rights registration
- A2. Registration of heritage buildings and landmarks
- A3. Land and marine definition and rights management
- A4. Public and private property overlap

Fig. 2. illustrates use case A1 showing the importance to include 3D Cadastre records of individually owned condos and apartments. This is both relevant for legal and taxation purposes. As time-sharing may be involved this actually results into a 4D registration. The use case A2 (see Fig. 3) shows further that Aruba is in need of a 3D Cadastre registration of its several heritage buildings and landmarks spread around the island, a.o. the museum, Willem III Toren, the Public Registry Building, the Gold Mine ruins at Bushiribana and the French Pass, the old phosphate mine in Seroe Colorado.

Fig. 4 shows use case A3 with the challenge for Aruba to transform its Spatial Development Plan into a 3D Cadastre registry to better illustrate and register complex situations of its spatial planning of land and waterways in order to improve the management of commercial development, touristic, residential, protected natural and green areas, waterways usage and exploration. This will help with defining and managing legal rights and taxation in reference to land and waterway usage. In order to better represent how public and private property overlap in Aruba, Fig. 5 shows use case A4 with a 3D transportation infrastructure example, the canal, which goes below the public road, is connecting the harbour with the indoor of the Renaissance hotel (L.G. Smith Boulevard 82, Oranjestad).

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Fig. 2. Use case A1: Condominium and apartment rights registration on Aruba



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Fig. 3. Use case A2: Registration of heritage buildings and landmarks on Aruba

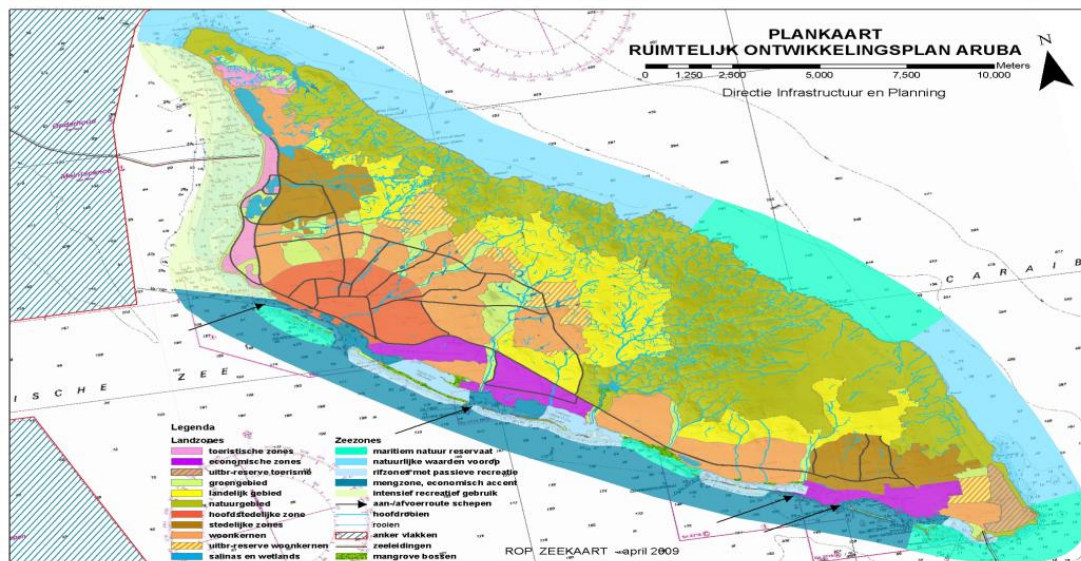
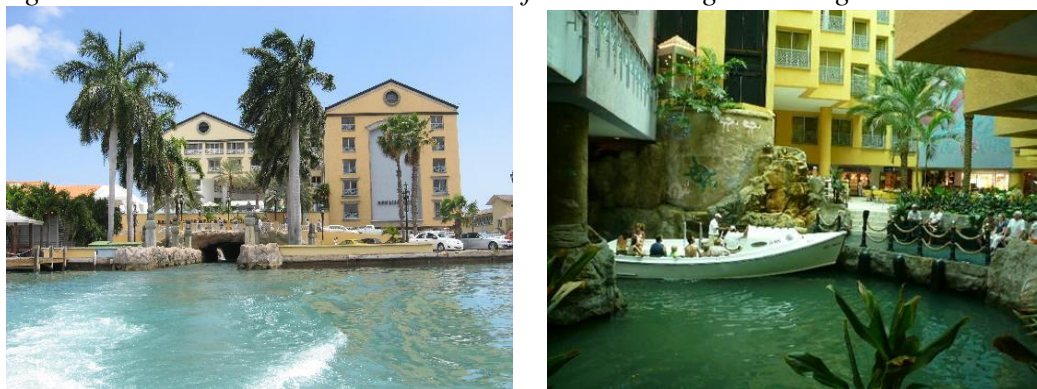


Fig. 4. Use case A3: Land and marine definition and rights management on Aruba



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Fig. 5. Use case A4: Public and private property overlap on Aruba

3. BONAIRE

From Bonaire the following three 3D Cadastre use cases are shortly presented:

- B1. Registration apartment rights
- B2. Registration marine rights
- B3. Registration of utility lines (under and above ground) and sewerage

Similar to many other countries (and use case A1 from Aruba) also in Bonaire the registration apartment rights has 3D aspects; see use case B1 in Fig. 6. Bonaire registers the individually owned apartment rights common area included in complex description and needs to visualize these in 3D Cadastre records. This is also important for taxation purposes. Fig. 7 Illustrates the use case B2 related to marine rights. The seabed and the sea are owned by different entities. Kadaster Bonaire is in need of a 3D Cadastre registry of the layered marine rights to register the piers. This is also important for legal, commercial and taxation purposes.

Registration of utility lines (under and above ground) and sewerage is use case B3 (see Fig. 8). The island government issues licenses for digging, but the utility lines and sewerage are not properly registered. To prevent occurring accidents during the digging Kadaster Bonaire proposes to introduce a 3D registry of the existent and future networks of utility lines and sewerage. In some areas the utility lines are partly under the ground and partly above the ground. Herewith accidents during digging are prevented and it contributes to the future spatial planning of commercial areas, residential areas and protection of the environment.

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Fig. 6. Use case B1: Registration apartment rights on Bonaire



Fig. 7. Use case B2: Registration marine rights on Bonaire

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Fig. 8. Use case B3: Registration of utility lines (under above ground) and sewerage

4. TRINIDAD AND TOBAGO

From Trinidad and Tobago the following four 3D Cadastre use cases are shortly presented:

- T1. 3D data on buildings with overlapping rights
- T2. Layered marine rights
- T3. Complex buildings with above ground tunnels
- T4. 3D Informal rights

Similar to Aruba and Bonaire also the registration of condominium rights is needed in Trinidad and Tobago (use case T1). Fig. 9. shows a building with overlapping rights, located in Falcon Heights (Port of Spain, Trinidad). High rise, and high valued condominiums that are individually owned but interlaced with communal access routes also are required to be defined and visualized in the cadastre. This is also important for taxation purposes. Note that here the law needs to be amended and the processes need to be defined for managing these rights. Next, use case T2 is related to marine rights, similar to use case B2 Bonaire. Fig. 10 shows the many layered rights that the state is required to manage in the marine areas within its territorial waters. T&T derives much of its income from leasing large areas of the seabed to different private, international oil exploration companies. These areas must be well defined to avoid encroachment of one over the other. Shipping lanes run over these areas. Trawling and traditional fishing also occur. Protected and environmentally sensitive areas occur in the west where mangrove swamps provide sanctuary for scarlet ibis birds that are a tourist attraction. All these rights are required to be defined in 3D, visualized so that decisions on licenses and leases can be made, and disseminated to the public and the stakeholders making the actions transparent.

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Fig. 11 shows use case T3: complex buildings with overhead access walkways exist where rights need to be managed and restrictions visualized. On Richmond Street, Port of Spain, there is a walkway above the street from the car park on the right to the office building on the left. Private rights to the access over the public rights to use the streets exist. Fig. 12. Illustrates use case T4, concerning the 3D informal rights on T&T (Laventille on the outskirts of Port of Spain): Spatial planning encounters complex situations where informal rights must be recognized and preserved while management decisions must be made. Informal rights are tightly and intricately woven together with communal access and easements included. The state would like to regularize occupation and improve the living conditions. This cannot happen without mapping of all the rights in 3D as overlaps and overhangs can be observed. Valuation of all would also be needed to ensure that equitable reallocation of space occurs after readjustment.

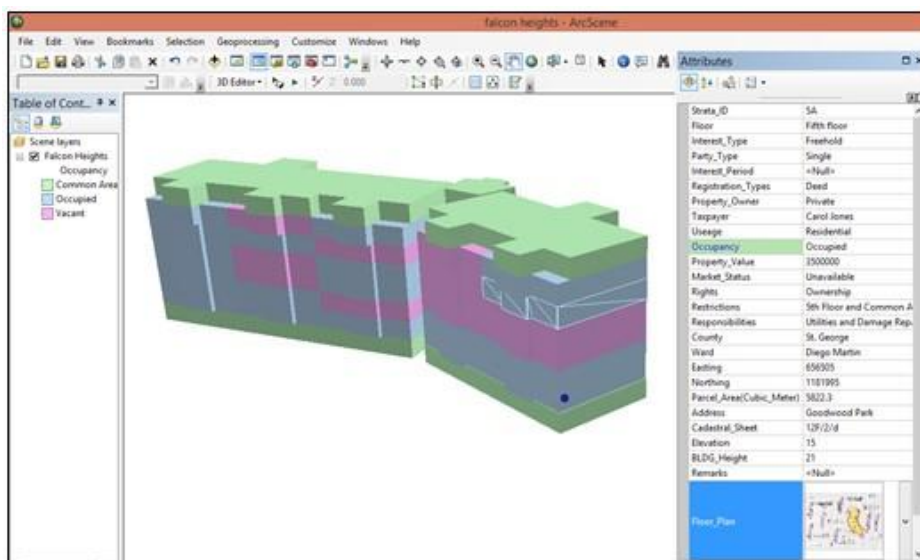


Fig. 9: Use case T1. 3D data on building with overlapping rights

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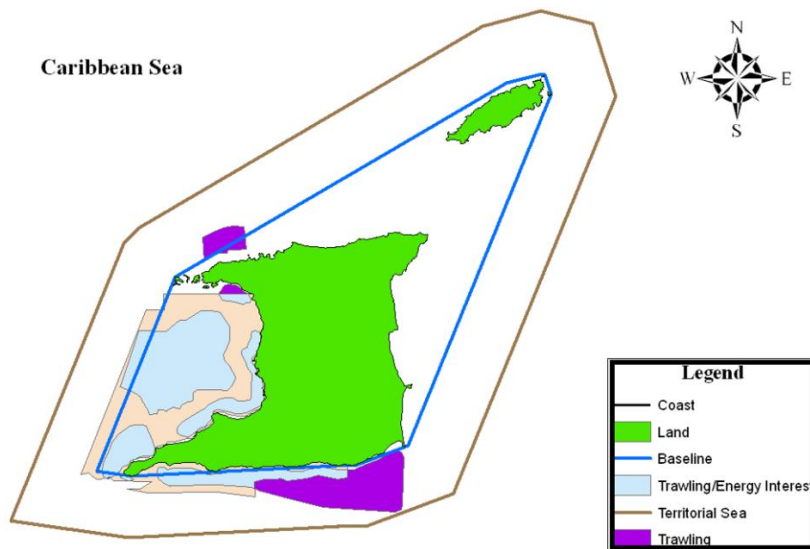


Fig. 10: Use case T2. Layered marine rights on T&T



Fig. 11: Use case T3. Complex buildings with above ground tunnels on T&T

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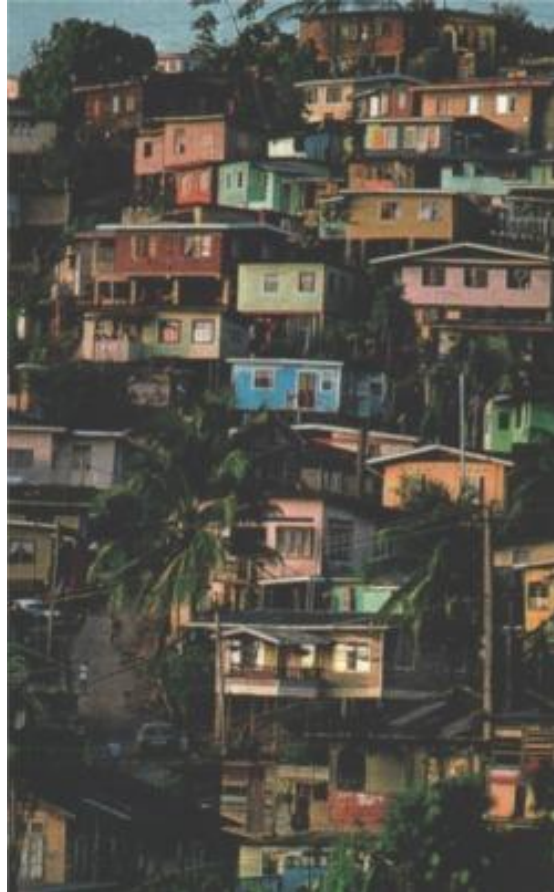


Fig. 12. Use case T4: 3D Informal rights on T&T (Laventille on the outskirts of Port of Spain).

5. DISCUSSION

Our use case driven research approach aims to provide input for the design of the overall system architecture and individual components needed for a 3D Cadastre. Multi-purpose land administration serves several goals: legal security, taxation, spatial planning etc. An integrated holistic view is needed when designing and implementing this: including land, building, utilities, protected areas (restrictions due to environmental policies, ecology, and cultural history), natural resources RRRs (groundwater, mining), marine resources etc. Land administration is often considered a prerequisite for sustainable economic development (De Soto, 2000, Williamson, 2009, FIG and World Bank, 2014), nearly all developed countries have a proper cadastral registration, avoiding conflict and disputes, providing the access to financing, forming the basis for spatial planning, and being the starting point of fair taxation. Many of the mentioned types of cadastral objects have a 3D nature, which is currently not reflected in the registration. Registering these cadastral objects in a 2D based system is often quite confusing and complex (due to fragmentation at the surface of ‘overlapping’ 3D cadastral objects, each with their own list of RRRs).

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The registration of subsurface utilities also helps to avoid digging accidents and related damage (human, ecological and economical). Protecting the marine and land ecosystems, or the monuments, cultural heritage, archeology objects in legislation is one step, but how to realize this in practice? Here also, a 3D Cadastre is a crucial tool. By registering the relevant objects, all actors involved are able to obtain up-to-date and correct information, including easy and optimal insight in the spatial aspects, in order to get full insight in the protected areas and the restrictions in land use involved. Having a 3D description does clearly have many benefits over the more traditional 2D representations (subsurface, airspace or marine spaces). In the marine environment, layered and interspersed registered and unregistered rights that have developed for fishing, trawling, and recreation need to be included in a 3D Marine Cadastre (enabling the blue economy). This is a crucial aspect for the Small Island Developing States (SIDS) in the Caribbean (Ng'anga, Sutherland, Cockburn and Nichols, 2001, Griffith-Charles and Sutherland, 2014).

In recognition of Aruba's track record in the area of sustainable development and in particular in the area of renewable energy, the United Nations Development Program has chosen Aruba to host a Center of Excellence (COE) on Sustainable Development for SIDS. The Center of Excellence for Sustainable development of SIDS seeks to facilitate strengthening of capacity for SIDS. In addition providing in country technical assistance to a selected group of SIDS, the COE will also establish a Sustainable Development Virtual Platform (arranged according to the Sustainable Development Goals, or SDGs in short) and develop and document knowledge products and learning tools. The SDGs which have been adopted by the United Nations in September 2015 are in line with the sustainability vision (sustainable and shared prosperity) of the government of Aruba. The Government of Aruba intends to cooperate with the United Nations Development Program to implement the SDGs in Aruba and will soon develop a project proposal and implementation plan to realize the 2030 Sustainable Development goals in Aruba. In line with the objectives of the SDG role out, sound measurement system and statistical information on all levels are imperative to support the 17 SDGs and the success of the project. The proposed 3D Land Administration for Sustainable Development and Good Governance in the Caribbean would be of great benefit to the SDG role out and especially in setting indicators and monitor and evaluate the implementation.

6. CONCLUSION AND FUTURE WORK

Given the wide range of relevant 3D cadastral objects, as possible candidates of registration, as presented in this paper, it is proposed to have a critical and innovative look at synergies and conflicts between economic, biodiversity and socio-cultural perspectives. This does provide an integrated and complete approach in contrast to isolated, single aspect approaches.

In future work these various types of use cases will be analyzed in more detail. Especially in case of apartment complexes and the tourist industry, the temporal dimension via the time-sharing approach as being supported in Aruba, actually results in what could be called a 4D Cadastre. Further future

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work includes analyzing existing law (and proposals for new law where needed), 3D data collection for the sample use cases, developing an Caribbean 3D LA information model (based on the ISO standard 19152 LADM), prototype system development (including 3D visualization) and a cost-benefit analysis.

The final goal is to design and to establish an integrated multi-purpose 3D Cadastre, covering legal, organizational and technical aspects. Within this highly multi-disciplinary this includes two key aspects: law (analyze and design legislation: juritecture) and geo-ICT (including support for non 2-manifold polyhedrons, 3D parcels with curved surface boundaries, partly unbounded 3D volumes, which are currently all non-existent in database and GIS/CAD systems). The Caribbean with a plethora of 3D use cases present, limited legacy data and systems, and a relative small size, is an excellent site for this. The future system will support sustainable development of the Caribbean in the economic sense, while protecting the environmental values and human values (based on legislation and tools to support this). Large parts of the results will also be useful for 3D Cadastre solutions elsewhere in the world.

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BIOGRAPHICAL NOTES

Freddy Every is Chief of Staff at the Aruba Government, The Ministry Spatial Development, Infrastructure & Integration.

Charisse Griffith-Charles is currently Senior Lecturer in Cadastral Systems, and Land Administration in the Department of Geomatics Engineering and Land Management at the University of the West Indies, St. Augustine, Trinidad and Tobago.

Riëncy Holder is director of the Stichting Kadaster & Hypotheekwezen Bonaire. He was responsible for the implementation of the Automation systems KADOR and KADOR-WEB, in respectively the years 2009 and 2015.

Mathilde Molendijk works as a Manager at Kadaster International. She focusses on land administration in the region of Latin America and the Caribbean, where Kadaster is involved in projects in Guatemala, El Salvador, Suriname and Colombia.

Peter van Oosterom is professor at the Delft University of Technology, and head of the ‘GIS Technology’ Section, Faculty of Architecture and the Built Environment. He is the current chair of the FIG Working Group on ‘3D Cadastres’.

Rolando Ocampo Alcántar is the Vice Chairman of the Governing Board of the National Institute of Statistics and Geography (INEGI, México). He is UN-GGIM Co-Chair and President of UN-GGIM Americas.

Jocelyne Marie Marguerite Croes is Special Advisor to the Prime Minister, Oranjestad, Aruba. She advises the Prime Minister and his cabinet on strategic policy issues with a special focus on foreign policy and strategic commutations.

Christiaan Lemmen is international consultant at Kadaster International, The Netherlands. He is chair of the Working Group ‘Fit-For-Purpose Land Administration’ of FIG Commission 7, and director of the FIG Bureau of Land Records and Cadastre, OICRF.

Hendrik Ploeger is associate professor at Delft University of Technology, ‘Geo-information and Land Development’ Section and holds the endowed chair in land law and land registration at Free University of Amsterdam.

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Michael Sutherland is currently Senior lecturer in Land Management in the Department of Geomatics Engineering and Land Management, and the Deputy Dean (Undergraduate Students Affairs), Faculty of Engineering, University of the West Indies, St. Augustine, Trinidad and Tobago. He is also an adjunct professor in the Department of Geodesy and Geomatics Engineering, University of New Brunswick, Canada.

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CONTACTS

Freddy Every
Ministerie van Ruimtelijke Ontwikkeling, Infrastructuur en Integratie
L.G. Smith Boulevard 76
Oranjestad
ARUBA
Tel.: +297 528-4944
E-mail: f.every@arubagovernment.aw

Charisse Griffith-Charles
Department of Geomatics Engineering and Land Management
Faculty of Engineering
The University of the West Indies, St. Augustine
TRINIDAD AND TOBAGO
Phone: +868 662 2002 ext 82520
Fax: + 68 662 2002 ext 83700
E-mail: Charisse.Griffith-Charles@sta.uwi.edu

Riëncy Holder
Stichting Kadaster & Hypotheekwezen Bonaire
Kaya Irlanda 17
Bonaire
NETHERLANDS ANTILLES
Tel.: +599 7961337; +599 7178646
E-mail: riency.holder@kadorbonaire.com

Mathilde Molendijk
Kadaster
Hofstraat 110
7311 KZ, Apeldoorn
THE NETHERLANDS
Tel.: +31 88 183 2412
E-mail: mathilde.molendijk@kadaster.nl
Website: www.kadaster.nl

Peter van Oosterom
Delft University of Technology,
Faculty of Architecture and the Built Environment
Julianalaan 134, 2628 BL Delft
THE NETHERLANDS

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Tel.: +31 15 2786950
E-mail: P.J.M.vanOosterom@tudelft.nl
Website: <http://www.gdmc.nl>

Rolando Ocampo Alcántar
Instituto Nacional de Estadística y Geografía – INEGI
Patriotismo 711, Torre A San Juan, Benito Juárez,
03730, Distrito Federal
MEXICO
Tel. (55) 5278 1226
Email: rolando.ocampo@inegi.org.mx
Web site: <http://www.inegi.org.mx>

Jocelyne Marie Marguerite Croes
Office of the Prime Minister of Aruba
L.G. Smith Boulevard 76
Oranjestad
ARUBA
Tel.: +2975947741
E-mail: jocelyne.croes@gmail.com

Christiaan Lemmen
Netherlands Cadastre, Land Registry and Mapping Agency, Kadaster International
PO Box 9046, 7300 GH Apeldoorn
THE NETHERLANDS
Phone: +31 88 183 3110
E-mail: Chrit.Lemmen@kadaster.nl
Website: www.kadaster.nl

Hendrik Ploeger
VU University Amsterdam/Faculty of Law
Delft University of Technology
Faculty of Architecture and the Built Environment
Julianalaan 134, 2628 BL Delft
THE NETHERLANDS
Tel.: + 31 15 2782557
E-mail: h.d.ploeger@tudelft.nl
Website: www.juritecture.net

Michael Sutherland
Senior Lecturer & Deputy Dean (Undergraduate Affairs),

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Department of Geomatics Engineering and Land Management
Faculty of Engineering
University of the West Indies, St. Augustine,
TRINIDAD & TOBAGO
Phone: +1 868 662 2002 Extension 82564/ 82061
E-mail: michael.sutherland@sta.uwi.edu / michael.d.sutherland@unb.ca

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