MARINE CADASTRE DATA MODELS WITH TEMPORAL ASPECT – REVIEW

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ABSTRACT:

A full 3D cadastre that supports volume parcels is one interpretation of the phrase "3D cadastre", whereas traditional cadastres that maintain only a limited amount of information about 3D circumstances are another. Three-dimensional (3D) cadastres are sometimes referred to as the 3D computerized illustration of real estate rights, constraints, and obligations. These include all the portions of legal objects, below or above the earth. The paper attempted to clarify the idea of developing 4D marine cadastral data models by evaluating and synthesizing the existing literature on how operators and stakeholders influence the applications of these models in the management of marine objects and properties. In this paper, the authors will identify the phases of marine cadastre models and their current status and more curiously seeks to update the current dimension of the time component to the existing 3D marine cadastre model. The current 3D marine cadastral data model for example in Malaysia and in other countries is still at the conceptual level. This paper will also highlight the peculiarities of marine cadastre components and their interactions with stakeholders, and addresses the practice and appropriate method to make those cadastral objects appear in 4D (3D + t). This study is structured around theories and models that have already been developed by scholars to explain temporal variations in these objects and properties. The result of the study shall give an in-depth discovery of what is known about the proposed 4D model and proffer key areas of interest that further studies can investigate to integrate the time aspect leading to a new 4D marine cadastre data model.

KEY WORDS: 3D Model, 4D Model, Spatiotemporal, Marine Cadastre

1. INTRODUCTION

Because the land and maritime sectors have separate functioning processes, cadastre in the marine environment is still not completely cleared (N. A. A. Zamzuri & Hassan, 2021). Multiple uses of coastal and maritime areas frequently result in disputes over overlapping claims to the water's surface, water column, and bottom as well as disputes over how to manage stakeholders and the law (Rahman et al., 2012; Duncan & Rahman, 2013; N. A. A. Zamzuri & Hassan, 2021). Each cadastre, once established, functions as a support mechanism for land, financial, and agricultural policies (Rahman et al., 2012). The creation of cadastral systems may be made more efficient and successful with the use of cadastral models, which also make it possible for parties concerned to interact with one another both inside and beyond national borders. Van Oosterom and others (2006). New developments, constructions, and reconstructions take place in most marine environments and cities; and have an impact on the 3D building models are an example of 3D cadastral items (Kuper et al., 2016). Feature items on parcels such as buildings, marine objects changes with time and to ensure that the data is applicable for future analysis, these changes need to be structured using procedural approaches.

Cadastre also emphasizes that strata property otherwise refers to as physical objects must be linked with her attributes for proper documentation within the cadastre database. 2D (Dimensional) land parcels, and 3D (Dimensional) Cadastre would also give spatial information linked to rights, responsibilities, and; restrictions (RRR) for 3D objects, such as vertical buildings and subterranean structures (Aien et al., 2012; MohdHanafi et al., 2022). The ability to store, alter, query, analyzes, and display 3D land rights, constraints; and duties is a requirement for a 3D cadastre. There are several unanswered 3D questions. (Rahman et al. 2012). Principal amongst is the problems of rights, responsibilities, and restrictions, (Bennett and Wallace 2007) associated with the interest of several players within the marine environment, (Manandhar et al. 2018). Four basic types of rights have been identified and are: - ‘State rights, Public rights, Environmental RRR (rights, responsibilities, restrictions) and finally the Usage and Exploration rights’ respectively. The State rights is on jurisdiction or control of affairs, Public rights on the hand is on constitutional rights of citizen and the unlimited access to the marine space without hindrance, Environmental(RRR),(Salleh et al.,2022), refers to the protection and conservation of water resources, preserved areas and cultural heritage. (Fulton et al., 2015; Alberdi & Erba, 2020). These rights, responsibilities, restrictions’(RRR) include among others the 'protection of archaeological and historical objects found at sea, the protection of Marine Protected Areas and the general marine spatial planning (MSP) (Zaucha and Gee 2019) restrictions while the usage and exploitation is concerned with the use of only space with exploitation rights only associated with resources (Athanasiou et al. 2016). The grant of rights is associated with specific stakeholders. Three-dimensional (3D) is referred to as the 3D digital depiction of real estate rights, constraints, and obligations (legal items) and include all such legal objects, which may be below or above the earth (Ng'ang'a et al., 2004; Hassan & Ahmad-Nasruddin, 2008; Kemec et al.,2009; Ali et al.,; Janecka Karki, 2016) A three-Dimensional (3D) marine cadastre data model for the Malaysian Land administrative domain model was developed (N. A. A. Zamzuri et al., 2021; A. Zamzuri et al., 2022). Currently, most publications address the concept of marine cadastre, however, the real implementations on three-dimensional (3D) are still lacking (Zamzuri et al., 2021) as well as existing software not been able to answer 3D cadastral, issues bordering on overlapping rights, responsibilities and restrictions, Challenges of linking both 3d objects and legal,(Polat et al. 2020) properties (attributes), difficulty of 3D topology due to different geographic space, intersection, inefficient data storage, use of single database to store 2D and 3D cadastral parcels within water and land volumetric boundaries.(MohdHanafi et al., 2022). 3D marine cadastre can improve coastal and marine areas' governance and information system by portraying an accurate representation of rights(van Oosterom et al. 2006). Although other nations, like Greece and Canada, have used this 3D maritime cadastre model, it does not integrate physical and legal items. A marine cadastre data model that integrates spatial and non-spatial components in a 3D marine cadastre could aid marine administration in Malaysia using the same concept. This particular effort will present the 4D Marine Cadastre Data Model's (MCDM) preliminary results. The model would have three(3) parts: geographical, ownership, and administrative. The characteristics and spatial data component for maritime resources, also include fishing grounds and aquaculture zones. The ownerships component includes the people and organizations. The proposed model will be connected to the Country Profile for the Malaysian Land Administration Domain Model (LADM) (Zulkifli et al., 2014; Rajabifard et al., 2018). The classifications of marine resources found in the coastal zone and the integration of data between legal spaces would be highlighted in the proposed 4D marine cadastre data model (Sthagen, 2020); spatial unit features, through external classes as well as administrative sources and would create databases, make provisions for temporal aspects of valid time(Oosterom, Karki, and Thompson 2019), transaction time and decision time components in the proposed 4D (3D+t) marine cadastre data model vie spatiotemporal model to solve problems of rights, responsibilities, restrictions, and other unresolved 3D marines cadastre questions which are largely due to inadequate documentations of activities within the marine space. We will attempt to develop a prototype model,(Zulkifli et al., 2014; Višnjevac et al., 2019); to demonstrate the data model concept and depict the rights, obligations, and constraints related to the marine objects. The data model will facilitate marine space and coastal space management. The 4D model would be contained within the Land Administration Domain Model framework (LADM). The Universal Modelling Language of Enterprise architect software, (Bente et al., 2012; Yomralioglu & Mc Laughlin, 2017) would be employ to model the structural schema for the logical and physical modelling respectively. Time or temporal aspect when integrated,(Döner et al. 2010) into any three-dimensional model (3D+T) =4D would definitely document activities within the marine space and enable data query, visualization since data is already in the database,(Shojaei et al. 2013). The next section of this paper discusses the current status of the marine models, section 3 talks about the challenges of the marine cadastre model, section 4 discusses the proposed model and framework and section 5; discusses the conclusion, finally, section 6 the references.

2. CURRENT STATUS OF MARINE CADASTRE MODELS

Malaysia witness the creation of a 3D data model for a marine cadastre in 2022 by Zamzuri but that model remain only at conceptual level. The model three packages, namely the party, administrative and geographic unit packages based on Land Administration Domain Model (LADM) standard.

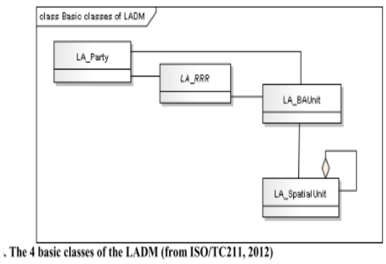

Figure 1. The LADM's four fundamental classes (ISO/TC211, 2012)

The nation of Israel on cadastre created a model for registering property rights in all three spaces, built models for handling spatial cadastral data, and created the geodetic-cadastral foundation for a legal framework for utilizing all available land space. For Morocco is the implementation of a 3D cadastre using integrated method based on BIM and 3D GIS,(Salleh et al. 2022). The methodology shows the value of such integration for the effective administration of cadastral data (Sun et al., 2020). In Croatia republic is the enhancement of 3D cadastre registration by cadastral resurveys. The purpose of such resurvey is to better and improve records of public rights and individual components of real estate (Vučić et al., 2020; Zamzuri et al., 2021). Activities in Delft, the Netherlands, ware focused on the documentation and property rights are displayed in the combined underground train station and City Hall, as well as several technological installations and underground bicycle parking (Stoter et al., 2016; Sun et al., 2019). The Dutch is the documentation, listing of property record in a 3D PDF document that contains legal and border information, solution for 3D cadastral registration that sheds more light on multi-level ownership(Zulkifli, Abdul Rahman, and Van Oosterom 2011).

Legal descriptions of documents with respects to ownership and her conversion into volumes based on architectural drawings of buildings, and also the visualization in 3D rights and the registrations in PDF formats, (Armstrong-Taylor, 2016 ; Sun et al., 2019). The country of Portugal uses real estate registry 3D model (de Almeida et al., 2013). Countries like Norway, Sweden, Queensland and British Colombia have a declared lack of absence of a complete 3D cadastral registration for 3D property units with respect to separate ownership from the legal point of view (van Oosterom 2013). Turkey is looking at the implementation of a suitable way of realizing LADM-based 3D cadastral object registration by concentrating on creating a 4D (3D + t) depiction of those cadastral items having time attributes that are consistent with the jurisdictional framework, Additionally, the management of data in an open-source PostgreSQL database and the type of cadastral item usage displayed on a CesiumJS platform for visualisation are both discussed. (Gürsoy Sürmeneli, Koeva, and Alkan 2022), The importance of 3D cadastres is illustrated by Singapore Land Authority's (SLA) with new vision statement containing an explicit 3D component, (van Oosterom 2013). A computerized prototype model named ePlan Victoria was created in Victoria Australia. The model is interactive and designed to display both the real-world and legal objects. It is a Cadastre to provide a precise and digital 3D cadastre, which will allow the interested community to locate and measure all RRRs relating to land and real estate (Lemmen et al., 2019). China developed a 3D cadastral management prototype, although there are still many difficulties and hurdles, it is claimed that the 3D cadastral administrative system has advanced significantly in practical applications for 3D data integrity and more thorough legal assistance are mentioned in the work, (Pouliot et al 2018). Another advancement concerns the potential for linking 3D lawful RRR locations that were created using LADM (Land Administration Domain Model, ISO19152, 2012), describing the physical reality of 3D objects CityGML, IFC, and InfraGM, that are connected to the 3D models, (Lemmen et al., 2019; Gürsoy Sürmeneli et al., 2022). The development of a cadastral data model for planning marine areas with the support of information technologies using Geographic Information System (GIS) for a sustainable management of marine area was reported in 2019 by (Bilgi Sistemleri ile Deniz Alanları İçin Kadastral Veri Modeli & İli Örneği). In addition, the discovery and use of VersionedObject class properties (beginLifespanVersion and endLifespanVersion), which allowed the regeneration of a dataset at an early stage and produced a 4D representation of the marine cadastre (Griffith-Charles et al., 2014; A. Zamzuri et al., 2022). A prototype of 3D cadastral system based on NoSQL database and a Javascript visualisation application was developed (Vinjevac et al., 2019). From the foregone, it should be noted the integration of temporal components which is time was not given a considerable attention and the eventual 4D cadastre data model to handle issue of rights, responsibilities, restrictions, and other 3D unresolved questions can better be address by the integration of time components of spatiotemporal, designing and creation of a new 4D marine cadastre data model with databased components as proposed in this work. The next section of this paper discusses challenges of 3D Marine cadastre data model and 3D models generally.

3. CHALLENGES

Every model, like every sphere of activities, has peculiarities and challenges; 3D models generally, and 3D marine cadastre data model has several questions that remains unanswered. (Rahman et al., 2012 ; van Oosterom, 2018).

Chiefly is the issues of numerous interest, appropriate method to collect and register these interests, the laws that defines those interests, and their hierarchical categorization that exist within the marine environment. Here legislations must be issued through a Marine administration system that has the ability to detect any resulting Rights, Restrictions, and Responsibilities (RRRs) and automatically define their boundaries. Another challenge is how to incorporate the nature of marine rights, restrictions, and responsibilities (RRRs) in the fourth dimension (Athanasiou et al., 2016). Defining maritime parcels, deliminating them, demarcating them, and capturing the three-dimensional parcel are difficult tasks for the fundamental reference unit (van Oosterom, 2018). The inability of current technologies to respond to 3D cadastral inquiries pertaining to rights, obligations, and limitations. The difficulties of 3D topology(Zulkifli et al., 2011 ; Kitsakis & Dimopoulou, 2014) owing to distinct geographic spaces, overlapping, and intersection, as well as the usage of a single database to hold 2D and 3D cadastral parcels within water and land volumetric borders are all issues that need to be addressed, (Rahman et al. 2012). There is lack of dynamic spatial and temporal relationships and frameworks in the marine environment to allow accurate and effective updating of marine spatial data (Nazirah et al., 2015; Knoth et al., 2020); absence of virtual registry of the marine; as well as a wide range of marine activities and stakeholders. The limitation on existing 3D models including the current Malaysia 3D marine cadastre data model is at a conceptual level (A. Zamzuri et al.), 2022; Gürsoy Sürmeneli et al., 2022). Others are challenge of implementation of three-dimensional (3D). Issues bordering on legal status of marine(Alberdi and Erba 2020), land parcel within the coastal area which requires the use of the 4D = (3D + time) cadastre (Siejka, Ślusarski, and Zygmunt 2014). Legal data integration with geographical data that is consistent, high-quality, and fully optimized for better and more comprehensive services via maritime spatial data infrastructure presents a problem. Also the inability to integrate logical data model into 3D data model because of its conceptual nature, (Gürsoy Sürmeneli et al. 2022). Additionally, there are financial limitations for intricate registration systems since cadastral authorities find it challenging to register water bodies. Equally, in coastal and maritime spaces there are conflicts in technical, legal, and stakeholder management. Inadequacy of standard regulation or laws to assist marine property rights allocation, delimitation, registration, valuation, and adjudication forms part of future works as recommended by (A. Zamzuri & Hassan, 2021). There is poor licensing system as only temporal licenses,(Peuquet 1999) are issued to prospecting investors especially in Malaysia, Issues of multiple agencies, responsible for the issuance of licenses and other permissions in Malaysia leading to conflicting, multiple instructions, and guidelines on marine operations within the marine communities. There are also challenges on how to represent; manage, and evaluate 3D spatial geo-objects that changes in shape and attributes overtime using geospatial database architectures (Kuper et al., 2016). Equally is the non-integration of time aspect, to 3D models for a 4D cadastre data model as a modeling data systems, using Spatio-temporal opportunities to keep tracks and records histories of marine parcels, routing systems that determines potential routes for ships, boats, vehicles, and evaluate changes in marine objects fields respectively. The next Section discusses, the proposed conceptual framework for this work is as in fig.2, while the proposed 4D marine cadastre data model using spatiotemporal data modeling is in fig 3 below. Our conclusions respectively follow, then the references.

4. THE PROPOSED MODEL

The model is made up of five main components: maritime space, time, interest (RRR), spatiotemporal components, and regulatory components. Three primary components make up the maritime space components: ownership, attributes, and administrative units. Ownership is divided between the government, the community and the stakeholders. There are three sub-components of the Attributes that make up marine space; the Temporal Attributes Sub-Component, the Thematic Attributes Sub-Component, and the Spatial Attributes Sub-Component. Cadastres deal with entities, made up of land interests namely; spatial(spatial units), legal papers, and parties (Athanasiou et al. , 2016). The land administrative domain model (LADM) packages, also known as LA Party, LA BAUnit, LA RRR, and LA SpatialUnit correspondingly, make up the third major component. They are taken from ISO/TC211, 2012. The interest component is the fourth and primarily addresses property rights, obligations, and constraints (RRR). The phrase "marine interests" or "property interests" (RRR) is used to refer to any formal and unofficial interests that exist between people and the land and are protected by popular authority. Interest here can be categorized into public and privates in properties. Government introduced legislations to manage the RRR. However, the interest is characterized by three problems which are one; some interests were poorly designed and are practically unenforceable, lack of incentive(s) to those who were supposed to adhere to them by the authority concerned, here we may distinguish between private and public interest in properties. To handle the RRR, the government created laws, but the interest here is characterized by three issues, of which amongst them is that ‘certain interests were not well thought through, little incentives were either offered to individuals who were expected to follow them or the laws were almost impossible for authorities to execute;’ ‘Secondly, certain interests continue to be badly managed; there are administrative delay in processing of license and permit applications, limited public access to information, which run completely independently of other relevant interests; and finally, some interests did not exist where they should have since there are only a few restrictions that prevent individuals from constructing on hazardous ground, Bennett and Wallace (2007). The temporal aspect and the temporal databases are both a sub-component for the time aspect main component spatiotemporal, (Sulistyah and Hong 2019), respectively. Provisions are included for recording the validity of time, transaction time, and decision time, respectively, within the temporal aspect. As for the temporal databases, we have three sub components of databases namely the Uni-temporal, the Bi-temporal and the Tri-temporal databases. However, it should be highlighted that the database's primary function in this situation is to give each application a consistent representation of the data, preventing duplication and any inconsistencies that may arise if each programme maintained its data independently. The spatiotemporal component,(N.G., Vinh, and Duy 2012; Polat et al. 2020), which is the fifth major component, is present on the major components' left and right sides. A database that maintains both location and time information, including the monitoring of moving objects that occupy a single place at a given time, is known as a spatiotemporal database. A spatiotemporal database keeps track of moving objects that are present in a specific location at a certain time, as well as space and time data. One issue that has to be resolved is the fact that data regarding marine items from the past that aren't now in the main section of the database are being monitored and recorded from the backup or file. The long-standing practice of updating the value and overwriting the original whenever an attribute reflecting an object's property is going to be changed will now be fixed; (Kvet & Matiako, 2013). The combination of geographical or spatial and temporal databases is known as spatiotemporal databases. From the proposed model, the spatiotemporal database consists of both a spatial database and a temporal database, and the database is anticipated to include the same data and deal with moving items databases or real-time locating systems in addition to their geometry. Under the Time sub-components, temporal data record the time of creation, loss of the space object and history,(Pivac et al., 2021; A. Zamzuri et al., 2022) of the changes are stored in the database. Time dimension as positioned in the model, records valid time, transactions time or decision time of activities with respect to the real world or database (N.G. et al. 2012). Models that capture real data, data whose validity has expired in the past, and data that will still be valid in the future are typically needed for data processing. Additionally, it is anticipated that the database would be updated automatically when a new event happens. The data in the proposed bi-temporal model,(Radjai and Rassoul 2016) and the unrecorded past events in the oceans are both valid in the suggested Uni-temporal model,(Steenbeek et al. 2021), however the transaction time box would give the opportunity to store and update unrecorded past events. (2013) Kvet and Matiako, positioned that a unified approach for spatial and temporal information activities would be achieved by combining the concepts of purely spatial modelling based on two-dimensional simplicial complexes with concepts of purely temporal modelling incorporating the two orthogonal time dimensions of transaction and valid time. The spatiotemporal components as seen in the proposed model are dependent on the aforementioned activities. The model's formal foundations are bitemporal elements,(Güting and Schneider 2005a) and simplicial complexes. Transaction times and valid times are calculated along two orthogonal time axes using bitemporal components, (Song and Yang 2013). “The model's geometric component is based on algebraic topology, algebraic topology, also known as combinatorial topology(Güting and Schneider 2005b), is significant in the study of algebra it explores algebraic methods for categorizing and formally characterizing point sets using topological structures”. The regulatory elements as proposed will serve as the enforcement body for various property rights, obligations, and restrictions (RRR) connected to the interests of various players and stakeholders, such as state rights, public rights, environmental rights, obligations, and restrictions, as well as usage and exploration rights within the marine environment, respectively. “All official and informal employees, the legislation, policies, regulations, processes, and guidelines in the administration of correct rights, obligations, and limitations in the marine cadastral environment will serve as the road map for how to conduct proper operations in the marine cadastre”. Here, standards of conduct and conditions that must be met before stakeholders, operators, and everyone else within the cadastral environment can utilize their rights in a way that generates products or services that are guaranteed to be of a specific caliber must be preserved or upheld The legal and security systems, as well as

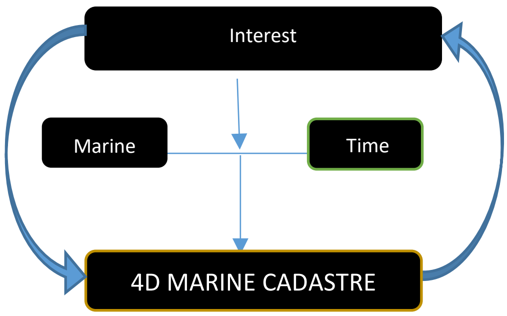

Figure 2. Conceptual Framework For The Proposed 4d Marine Cadastre

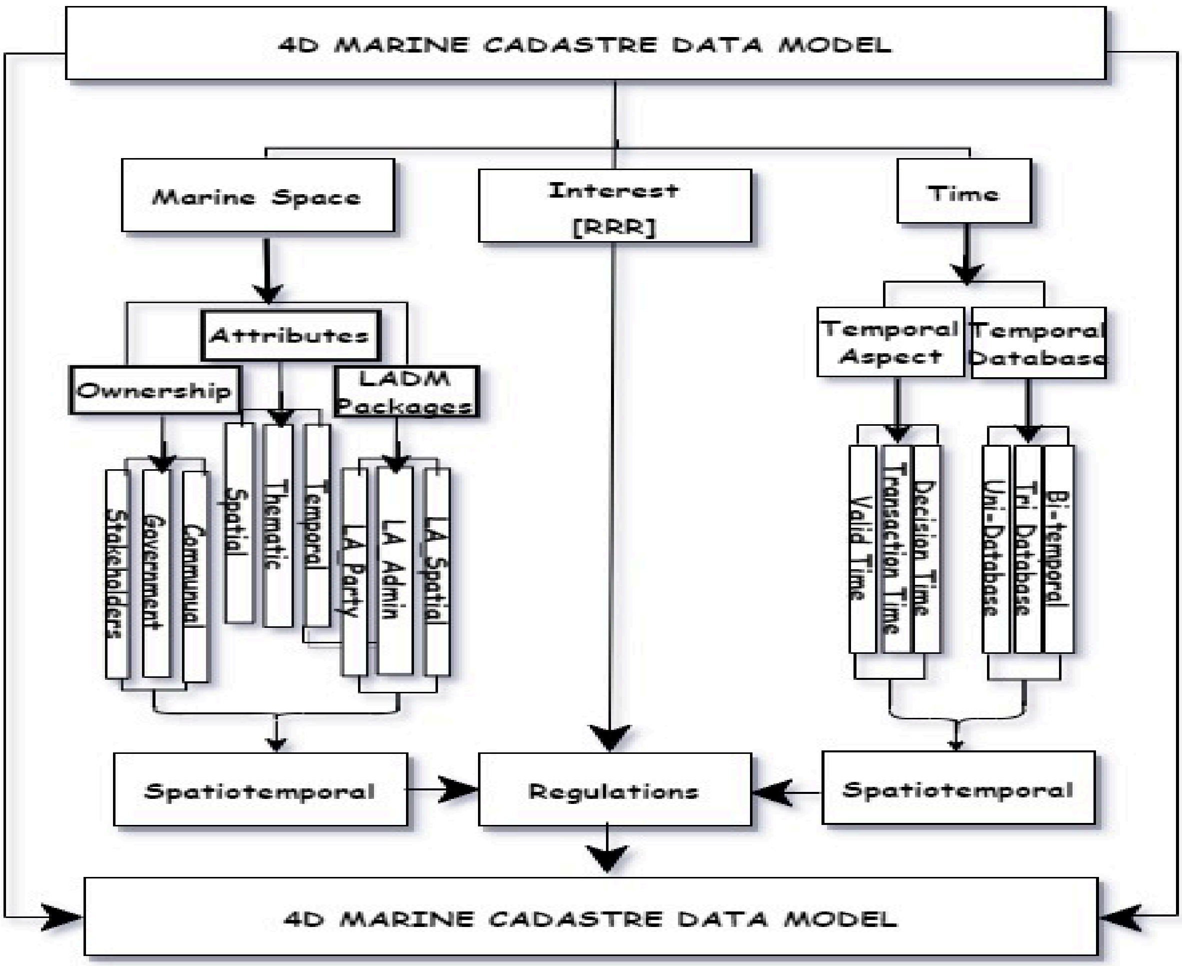

Figure 3. Proposed 4D Marine Cadastre Data Model

the military, police, and navy, which patrol maritime borders and fight marine crime at all levels of operations, are other institutions that make up the regulations.

5. CONCLUSIONS

The objective of this paper is to integrate and combine the developed 3D marine cadastre data model with the temporal aspect (T) to create a 4D (3D + t) model. A 4D model achievable within the Land administrative domain model-based 3D cadastral object registration and will review and enhance the standard of the 3D marine cadastre model for quality objects' assessment, changes in appearance, appropriate regulation, and management for, revenue generation, compensation, and benefits and modelled with the spatiotemporal aspect,(Evans et al., 2010; N.G. et al., 2012), is the desire of this paper. Spatial data define the shape, size, and position, while Temporal data keep track of the formation and loss of space objects, and history of modifications are saved in the database (N.G. et al., 2012). The proposed 4D marine cadastre data model (spatiotemporal) is presented in fig.3 above. Spatiotemporal is a combination of marine space and the temporal aspect with interest as the regulating point for rights, responsibilities, and restrictions (RRR) components respectively. The two components has other sub-components, with Time having Temporal aspect, Temporal databases while Temporal database has components dealing majorly with various forms of databases such as Uni-temporal databases, Tri-temporal databases and Bi-temporal database, all functioning in various capacities to store various forms of data respectively. Temporal aspect has sub-components such as Valid Time, Transaction time, and Decision time all to function accordingly their names. The marine space components has three main elements including, Ownership, Attributes, and the Administrative units, ownership consist of the Government, Communal, and the stakeholders respectively. Attributes consist of the Spatial attributes, Thematic attributes, and the Temporal attributes, and the LADM packages of the party, the Administrative and spatial unit respectively. Above is further illustrated in fig 1 above. Other sub-components will subsequently be developed. The 4D marine cadastre model addresses some of the gaps in the 3D marine cadastral model, which will greatly improve the core intentions of the 3D marine cadastre data model and would be useful for future marine cadastral modeling. Further studies to investigate integration of the time aspect leading to a new 4D marine cadastre data model is hereby recommended. However, it should be emphasized that the development of the new prototype would involve numerous design decisions, further research, technological challenges, and challenges that might arise in subsequent work. Integration of the time aspect into the current model for a four-dimensional marine cadastre data model would enhance the management of the marine environment and within the land administration domain model (LADM 1&2), (Lemmen et al. 2019). 3D cadastre support is absolutely necessary with right integration with time via 4D spatio-temporal primitives) might be justified as being advantageous (Döner et al., 2010). This study contributes to filling the knowledge gap between conceptual and logical models, (Gürsoy Sürmeneli et al. 2022). The proposed 4D marine cadastre data model is attached in fig 3 above. References is next.

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