

Is LADM ready for the Maritime Domain? – Case study Croatia

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Key words: LADM, Maritime Domain, Schema Matching

SUMMARY

Onshore and offshore areas share a lot of common features, but also have some significant differences, which reflect in the way they are defined and registered. Traditionally, land administration key registers emerge from the onshore area, they have been developed and technologically improved during many decades because of daily demand for their data and nowadays are in a stable and mature evolution phase. Registers covering offshore area, i.e. maritime domain, are usually derived from onshore registers or developed on purpose, and they are generally on various technological and operational levels. Analysis of the current nautical International Hydrographic Organization (IHO) standards shows the lack of steadily increasing and highly demanded tenure information on maritime areas.

In this paper, an analysis of maritime areas registration in Croatia has been performed by using Unified Modeling Language (UML) as a modeling tool. The analysis includes key land registers, Cadastre and Land book, Register of territorial units, Register of concessions on maritime domain, Register of cultural property, Register of protected areas, Register of approved mineral resources exploration areas and Register of established mineral resources exploitation fields, Register of issued licenses for fish and other marine organisms farming, Environmental pollution register, as well the fishing zones, explicitly defined by the relevant law. Registration of administrative units, parties and rights, restrictions and responsibilities often involves more than one register, which is included in the models.

The relevant LADM classes and attributes were identified in class diagrams and the model of registration was compared to LADM using schema matching methodology, by identifying semantically equivalent classes, attributes and structures. The suitability of using LADM as a conceptual model for registration of maritime areas in Croatia has been evaluated, including the possible upgrades and extensions of the current model.

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1. INTRODUCTION

The need for regulation and registration of marine activities has been growing through centuries, from regulation of navigational and fishing rights in ancient times, to the multitude of intertwined activities present in marine areas today. United Nations Convention on the Law of the Sea (UNCLOS) from 1982 established a widely accepted legal framework for determination of national sovereignty on the seas and oceans, allowing the extension of competent public administration instruments on the state's marine area.

Inclusion of marine areas in national governance caused some integration issues which should be resolved. One of the first issues to be discussed is the proper spatial identification of marine areas. Determination of maritime boundaries and limits is different from their land counterparts because they have some distinct features as uncertainty, mobility and difficulties in demarcation (Sutherland, 2005). Definition of boundaries is based on stakeholders agreement, purpose, presence on the ground, existence in time, and their graphical and textual representation (Bennet et al, 2009), which in marine environment shifts from visible natural or artificial border objects to numerical definitions based on imagery and GPS. Creation of marine information systems from existing digital data in the USA was discussed and revealed the lack of proper geographical and legal definition of marine areas (Fowler and Tremel, 2001), institutional multiplicity and complexity of competences South Korea were detected as obstacles to an efficient marine cadastre system (Lee and Shin, 2010). Several maritime states are considering models of marine cadastral systems, like Malaysia (Abdullah et al, 2014), Israel, where using marine cadastral blocks is considered (Srebro, 2015) and Indonesia, relying on experiences on existing marine cadasters (Astor et al, 2017).

Marine data are an integral part of National spatial data infrastructures (NSDI) Integral coastal management (ICZM) approaches, and Marine spatial planning (MSP) activities. Integral administration of land (onshore) and marine (offshore) areas would benefit from extending the competences of onshore institutions to offshore areas (Ng'ang'a, 2006) eventually leading to a more consistent and integrated system (Vaez, 2010). In France, issues in implementing land strategies in MSP were pointed out (Trouillet et al, 2011). Considering the differences in legal status, competent institutions, boundary definitions and social component, extending land-based approaches to marine area should be deliberate and cautious (Gazzola et al, 2015). An efficient land management system needs up to date information about the tenure that exists on marine areas. The sources of that information are the official public registers, established and regularly updated upon laws and regulations, so they could be considered as key registers. They share some distinct features, as legal foundation, obligation of use for public purposes, institutional responsibility for the data, publicity, avoidance of redundant data etc. (Bakker, 2009).

2. LADM AS MARINE DOMAIN MODELING TOOL

Development of land administration systems can be observed in four levels of their maturity: standards, connectivity, integration and network (Van Oosterom et al 2009). As a first step for achieving next levels in maturity to put the land administration in a broader context, standardization is crucial and the obvious tool for achieving it is LADM. Since marine administration cannot be separated from land administration in general, LADM should be used either as-is or by its extension. Extending of LADM to domains and implementations not originally conceived is based on its flexible and open concept and universal and straightforward core structure. LADM as description of people-to-land relations is widely applicable, especially considering that most of the registers used in marine areas is either extended or derived from onshore based registers.

When using LADM out-of-the-box some classes and packages of LADM are important given the specificity of the marine areas. According to (Sutherland et al, 2016), LADM is applicable for marine use; complex interests in the marine areas can be fully accommodated using *LA_RRR* class, with the corresponding sub-classes; stakeholders in marine areas are defined by *LA_Party* class; marine area borders and limits can be modeled as 2D and 3D borders; metadata and data sharing is included in the model. An extension of Administrative package could contribute to better modeling of non-spatial data and laws, regulations, conventions, agreements and other on which the tenure on the marine areas relies.

Due to a prominent 3D character of marine activities, which reflect in 3D character of marine areas which are subject to tenure, and due to distinct rule of laws rather than transactions in establishing of tenure on marine areas, some new classes could be added to better suit the marine administration needs. Rights can have two specialization classes, *MA_StateRight* (marine state right) class referring to sovereign interests, and *MA_PrivateRight* (marine private right), referring to granted rights. In modeling of spatial extents, classes *MA_NaturalResources* for accommodating of natural resources or *MA_LegalSpaceTunnel* for modeling of complex spatial relations can be useful (Athanasios et al, 2017a).

Tenure on marine areas is commonly not related to ownership and private rights, due to their public nature. Some of proposed new types of specialized rights are applicable for closely defining the tenure on marine areas, like the classes of *Common right*, which belongs to the object of registration, and not to the party, *Latent right*, for rights that have not yet been realized, and *Public regulation* for the interests defined in a public document (Paasch, 2012). *Common right* class can be widely applied in cases where the interest is inseparable from the spatial extent, usually in the form of encumbrances. *Latent right* represents the time span of validity of interest, and can be applied as an interest in spatial planning, or in the concession agreements that are not yet effective. *Public regulation* refers to interests established in a public document, for example, the spatial plan, or a regulation, in the form of restrictions or privileges. By introducing of classes *Customary right* and *Informal right* (Paasch et al, 2015) it is possible to further expand the model to tenure that has not been formalized or registered.

Standards emerging from the offshore area were generally aiming at hydrography and navigation. The leading institution in the standardization of hydrographic data and navigation

charts is the International hydrographic organization (IHO). Tenure on marine areas in general is not significant for navigation and is not of hydrographic interest, and generally is not displayed on nautical charts. After the first widely accepted navigation standard IHO S-57 follows the S-100 standard, which along with hydrographic data includes other sea related spatial data. Of particular importance is the adoption of standards published by the ISO/TC 211, the Technical committee for geographic information / geomatics, making the S-100 standard suitable for marine areas data integration in land administration system.

The openness of the S-100 standard to extensions that go beyond the basic needs of hydrography has induced initiatives to upgrades that would allow a better inclusion of hydrographic standards in marine management systems, by including maritime borders and limits into the standard. By including the limits and boundaries, the spatial coverage of the marine areas is defined, opening the possibility of linking with the registers and databases of spatial data, and thus joining to tenure registers. Since the S-100 is based on the ISO/TC 211 standards and LADM, adopting LADM elements for extension is a natural and logical choice. The emerging S-121 standard (Canadian Hydrographic Service & Geoscience Australia, 2016) relies on LADM in fields not defined by S-100, as the tenure (*LA_RRR* class and specializations), parties (*Party package*), and uses new spatial objects that S-100 does not recognize (*LA_BoundaryFace* and *LA_BoundaryString*) defined by using the expansion of available spatial elements. With such approach the standards of registration and representation of marine and land data are equalized, opening the way to their easier integration in spatial data infrastructure and spatial management systems. Application of S-121 was tested in legal framework of marine administrations of Greece and the Republic of Trinidad and Tobago (Athanasiou et al, 2017b). Marine limits and boundaries, legal descriptions of marine objects, 3D legal and physical objects were used for modeling, resulting in extensive code lists related to marine environment for both countries, useful in future development of national marine administration systems.

3. REGISTERS COVERING THE MARITIME DOMAIN

The first step in this research was to identify the relevant registers and other sources containing definitions and records related to marine areas. Official registers are defined by laws and regulations published in the Official Gazette and available to public either accessible on internet or on demand. Extension of competence of land-based registers led to a variety of registers (Flego and Roić, 2017). The registration procedure can be showed in a UML use case diagram, with relevant registers depicted as actors Figure 1 below.

Generally, marine areas are registered if they represent a cadastral parcel, therefore appertaining to real property registration system, if they are part of an established protected area or area with a granted concession, as territorial units (parts of administrative subdivision), defined by law as fishing zones or planned in some level of spatial plans.

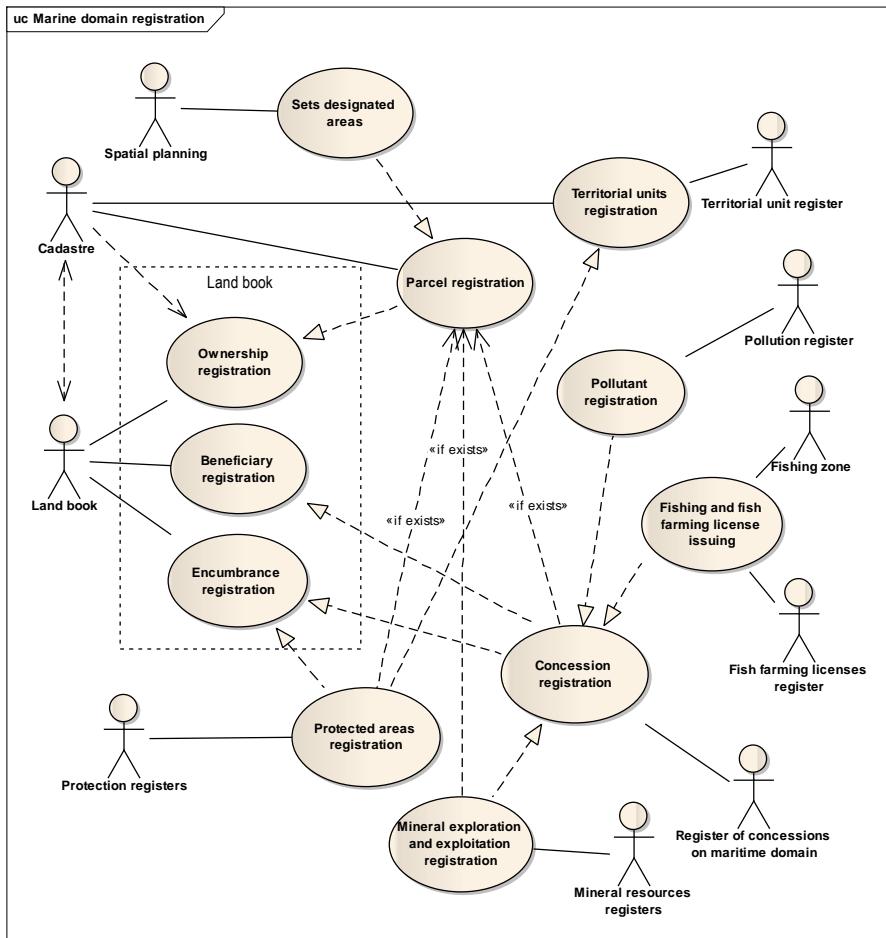


Figure 1. Marine domain registration UML use case model

Maritime facilities and objects, like fish and shellfish farms, buoys, underwater works, underwater cables and pipelines, which could affect the safety of navigation, are recorded on nautical charts and pilots for whose creation and maintenance is competent the Hydrographic institute of the Republic of Croatia (HHI). Investors or concessionaires dealing with projects and works in the maritime domain are required, after construction or reconstruction, to submit to HHI a hydrographic study of the completed works to update the nautical publications. The competence of the HHI also includes describing and mapping the sea boundaries of the sovereignty of the Republic of Croatia.

3.1 Real property

Registration of real property is based on two closely related registers, Cadastre and Land book. They are based on cadastral parcel as registration unit, with cadastral district as a higher level unit. Establishment of marine cadastral districts is prescribed by the relevant law, which includes internal coastal sea (internal waters and territorial sea), continental shelf of the Republic of Croatia and the part of the sea coast, which is under maritime domain regime. Regulations provide that the extents, the boundaries and the name are determined by the State

geodetic administration (SGA) in agreement with the Ministry of the sea, transport and infrastructure. Although, almost ten years from the adoption of the law have passed, no marine cadastral district has been established to date, and it is very likely that this legislative solution will not take hold because, in practice, cadastral parcels at sea have already begun to emerge, mostly physically in contact with the mainland, but also offshore, registered in existing cadastral districts on the mainland (Figure 2). Those parcels are mostly established for concession granting.



Figure 2. Cadastral parcel on the sea (URL 1)

3.2 Territorial units and address model

Register of territorial units is kept in the SGA and its regional offices and contains data on Croatian administrative subdivision units, statistical and census units, settlements, streets and house numbers (i.e. the address model), jurisdictional subdivision, mail delivery areas and protected areas. It is composed of maps, lists of territorial units and collections of documents. Administrative sources for this register came from very heterogeneous sources, and for some territorial units, like protected areas and mail delivery areas, this register cannot be considered a key register since those units are registered in their original registers. The way of updating is vague and unclear, so this register should be considered only for the administrative subdivision, statistical and census units and the address model, which are mandatory updated and periodically revised.

Boundary lines of local administration (counties, cities, municipalities) on the sea shown on maps are for informational purposes only and do not represent the legal borders. Actual belonging of islands, islets and rocks to local government is determined through attribute identifiers and not through map coordinates.

3.3 Concessions

Maritime domain consists of internal waters and territorial sea, its seabed and subsoil, and part of the land that is by its nature intended for general use or is declared as such, and everything with that part of the land permanently connected to the surface or below it, including the coast to the highest wave mark (at least six meters inland from coastline), harbors, embankments, shoals, cliffs, reefs, beaches, rivers mouths and channels, buildings and structures. (Official gazette, 2003). Maritime domain is a public good, ownership rights are not applicable and maritime domain cannot be subject of real property transactions. Concessions are registered in a range of registers, depending on the concession provider, resource type, scope and the object of concession (Table 1 on page 314).

Register of concessions on maritime domain is a general register containing records on granted concessions on infrastructure, ports, harbors and marinas, commercial use, beaches, sports and leisure facilities and other ways of regulated usage of marine areas. Concessions on maritime domain are granted in accordance with the regional spatial plans and with a determined border of maritime domain registered in the Cadastre and Land book. In the Primorsko-Goranska County the register data on county level area are available through a web browser (Figure 3 showing the same area as on (Figure 2).



Figure 3. Area of granted concession on maritime domain (URL 2)

Specific types of concessions are registered within dedicated registers in competent institutions. Integral information system on mineral resources, kept in the Ministry of economy, business and trade, includes two registers, the Register of approved mineral resources exploration areas and the Register of established mineral resources exploitation fields, with associated collections of documents and a list of mining businesses entities. The

competence of the registers is divided between the Ministry and the regional government, depending on the type of mineral resource. The Ministry of agriculture issues privileges for fish and other marine organisms farming. Privileges are, among other requirements, issued based on the concluded concession contract, individually for each part of maritime domain granted for concession or onshore area where farming takes place.

Environmental pollution register is an information system managed by the Croatian environment and nature agency. There is the obligation of registration defined according to the regulated business activities and on the amount of discharged waste substances, those activities are subject to concession. Financial agency (FINA) holds the Register of concessions, a public register of all concessions in the Republic of Croatia, with focus on financial aspect, which does not contain any spatial information.

3.4 Protected areas

There are two registers related to registration of protected areas. Register of protected natural values is kept by the Ministry of environment and energy. Registration act is issued by the competent authority, depending on the level of protection, and each protected area has its chronological assigned registration number. Each record consists of registration number, name, category of protection, main features, location (including the city/municipality and the county), area, a description of the boundaries, a list of cadastral parcels included in the protected area, a digital map, and information about legislation based on which the area was declared as protected.

The register of cultural property is a public book that is kept in electronic form in the Ministry of culture. It consists of several lists depending on the level of protection, containing, among the other, the ordinal number of entry, entry date, preventive care expiration date, basic information on the property, name, type of property, dating, typical photo, and other information related to protected property. The register contains records about the county, city/municipality, location, address, toponym and coordinates of the protected property. Marine areas are classified as immovable cultural property types "underwater archaeological site" and "underwater archaeological zone".

3.5 Fishing zones and spatial plans

Although they are not registered in a form of an official register, fishing zones and spatial plans cover an important set of information on marine domain. Fishing zones are defined in the relevant regulation (Official gazette, 2011); they have a legal descriptive definition according to prominent geographic elements such as headlands, reefs, shoals, points defining the borders of the territorial sea, points identified with geographic coordinates, by azimuths and intersections. Fishing zones are recorded in the fishing privileges that are issued to owners of vessels and other documents and reports related to fishing.

Spatial planning is a way of setting up the designated use of maritime areas by establishment of zones, infrastructure layouts, conditions and restrictions for implementation of the planned interventions in space. In coastal area, due to the significance and value, there are special restrictions and conditions for interventions. The protected coastal area zone covers all

islands, an inland zone of 1000 m from the coast, and an offshore zone of 300 m from the coast.

4. MODELING OF REGISTERS

Marine areas are registered in several registers, in different institutions and on various institutional levels. The laws and regulations which are defining them use different terminology depending of the competent institution and related laws, but also on technological and organizational environment from the time of law adoption.

In the first step, registers are modeled with UML as modeling language, to identify the main classes, relevant attributes and relations between classes. Registers are modeled according to their definition in laws and regulations. Connections with related registers are included in the models. The example model shows the class model of the Register of concessions on maritime domain ([Figure 5]). In the model of Register of concessions on maritime domain two classes of parties are included, *HR_ConcessionProvider* and *HR_ConcessionBeneficiary*, which are related to classes *HR_Concession* as a RRR specialization and to *HR_ConcessionArea* as basic administrative unit. Model includes the *HR_CadastralParcel* class appertaining to Cadastre and included in cadastral and land book class models.

5. SCHEMA MATCHING BETWEEN LADM AND REGISTERS

Schema matching is a tool for identifying correlations of schemas as an essential phase in data integration (Alwan et al, 2017). In this research models were analyzed using manual schema matching in structure level and element level (Rahm and Bernstein, 2001).

Structure level matching showed that the registers follow the same core LADM schema containing classes representing parties, administrative units and rights, restrictions and responsibilities. Element level matching compared semantically identified classes in models to LADM classes. Summary of registers is shown in Table 1 below, where classes from models are matched to basic LADM classes. Some registers may have instances of more than one basic class. Although not recorded in registers, fishing zones and spatial plans are included in the analysis because they are an integral part of the administration of marine areas. Class comparison shows a terminological diversity, but the basic roles can be identified. For further analysis, existing schemas defined by UML models were decomposed and new schemas created, based on core LADM classes.

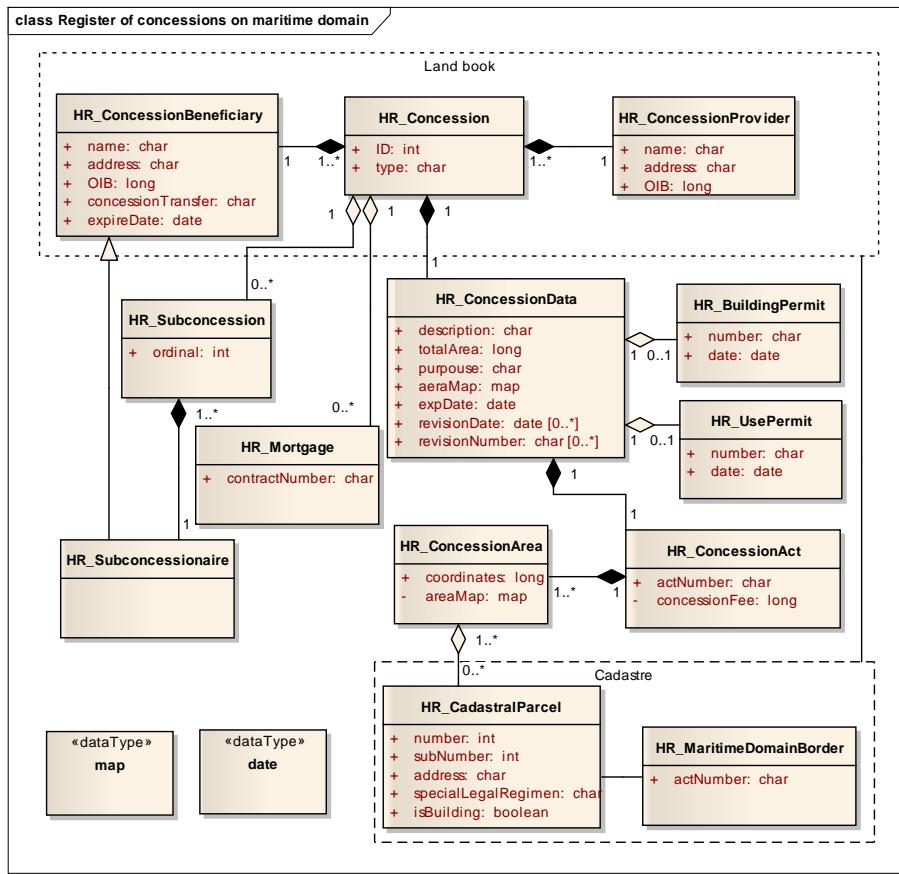


Figure 4. Class model of Register of concessions on maritime domain

Table 1. Basic LADM classes in registers

Register	Administrative unit	Main RRR	Party
<i>Cadastre</i>	parcel	tenure	tenant/owner
<i>Land book</i>	parcel	ownership	right holder
<i>Territorial units</i>	territorial unit	jurisdiction	administrative authority
<i>Concessions on maritime domain</i>	concession area	concession	concession beneficiary
<i>Exploration fields</i>	exploration field	permit	permission beneficiary
<i>Exploitation fields</i>	exploitation field	permit	permission beneficiary
<i>Fish and other marine farms</i>	farm	privilege	privilege holder
<i>Pollutants</i>	outfall	concession	registration subject
<i>Protected areas</i>	protected area	protection restrictions	competent authority
<i>Cultural heritage</i>	site/zone	protection restrictions	competent authority
<i>Fishing zones*</i>	fishing zone	privilege	privilege holder
<i>Spatial plans*</i>	designated area	right of use (latent)	beneficiary

In the Croatian marine domain, 11 specializations of *LA_BAUnit* class were identified (Figure 5). Concessions can have different administrative units depending of the resource granted to concession.

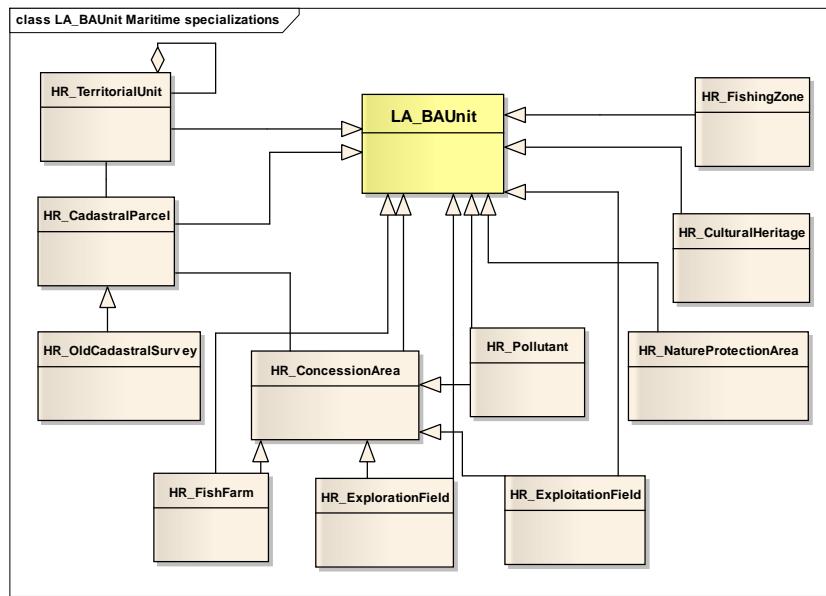


Figure 5. LA_BAUnit specializations

Since maritime domain is a public good, rights are generally concessions registered as encumbrances, with two specializations (Figure 6). Establishment of protection areas usually invokes some restrictions and responsibility on the proclaimed area. Designated use is a form of latent right, registered in spatial plans.

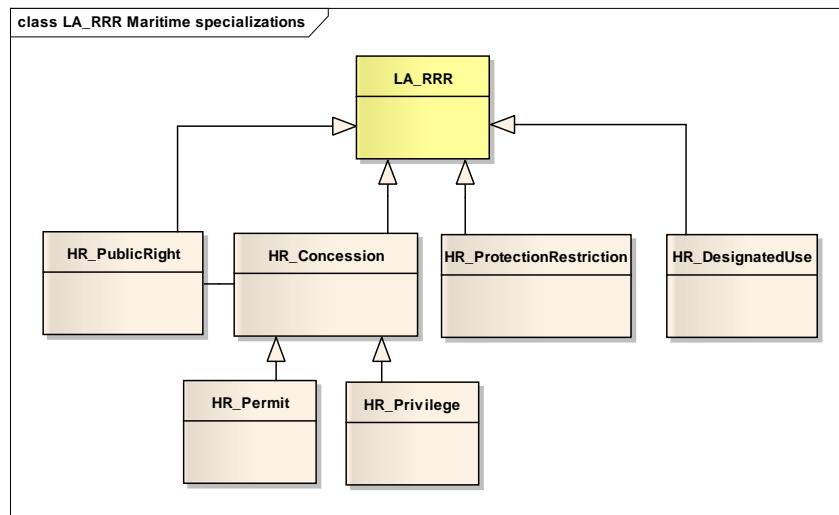


Figure 6. LA_RRR Specializations

Parties in maritime domain include a special class representing the (RRR) record in the Land book and the specializations of various types of granted rights on public good (Figure 7).

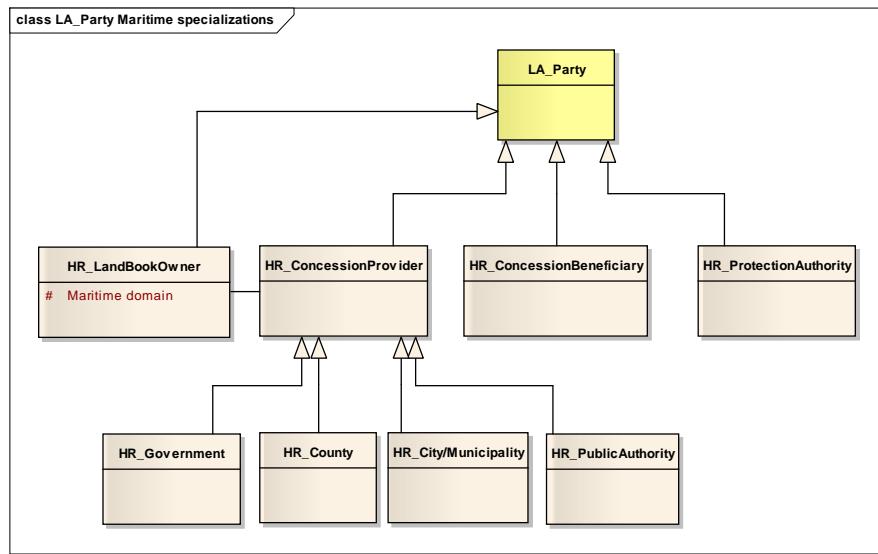


Figure 7. LA_Party specializations

The core LADM class model (Figure 8) can be extended by adding classes that better depict the nature of parties and rights in the maritime domain. Since those classes usually belong to different registers, the modeling of the whole system should be more straightforward.

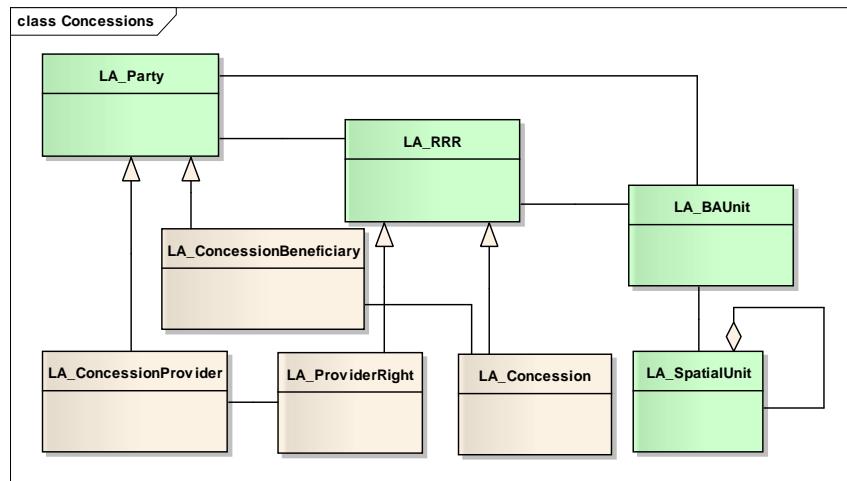


Figure 8. LADM core concession model

6. CONCLUSION

The analysis revealed several registers covering the maritime domain which reflects a matrix of complex relations present on maritime domain and a complex registration system which includes registers besides Cadastre and Land book. LADM showed up as an appropriate model in the maritime domain, as the pattern party – administrative unit – RRR can be applied to all relevant registers, although they are not all typical land administration registers. A refinement of some LADM classes could be useful in modeling of some distinct features of marine areas, like special *RRR* and *Party* types. Further research and expansion should consider using LADM in multi register environment, and modeling of temporal aspect of marine activity relations.

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BIOGRAPHICAL NOTES

Veljko Flego graduated at University of Zagreb, Faculty of Geodesy in 1990. He worked in two surveying companies as licensed land surveyor and IT administrator, and in State geodetic administration as head of IT department in Regional cadastral office in Rijeka, working on CAD and GIS support, cadastral map digitalization and AutoLisp programming. Currently he is a co-owner of a small surveying company and a PhD student on Faculty of Geodesy, doing a research on marine areas registration.

Miodrag Roić graduated in Geodesy from the University of Zagreb, Faculty of Geodesy. In 1994, he received a PhD from the Technical University Vienna. Since 1996, he is a professor at the University of Zagreb, Faculty of Geodesy. He was Dean of the Faculty 2011-2015. The topics that he specializes in are Cadastre, Land Administration Systems, Engineering Geodesy and Geoinformatics. He is a corresponding member of the German Geodetic Commission (DGK) and many other national and international scientific and professional institutions.

Irena Benasić graduated at University of Zagreb, Faculty of Geodesy in 1990. After graduation she worked as Oracle database developer, in a surveying company as licensed surveyor and in State geodetic administration where is currently head of Regional cadastral office in Rijeka. She was chosen as Individual Consultant to support the introduction of electronic submission of digital geodetic reports in SGA. Currently she is a PhD student on Faculty of Geodesy with her main interest in modeling of territorial units.

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