NATIONAL TECHNICAL UNIVERSITY OF ATHENS

SCHOOL OF RURAL AND SURVEYING ENGINEERING

INTERDISCIPLINARY POSTGRADUATE PROGRAM

GEOINFORMATICS

A 3D HELLENIC ARCHAEOLOGICAL CADASTRE BASED ON LADM

MASTER THESIS

GOGOLOU CHRISTINA

ATHENS, FEBRUARY 2016

ΕΘΝΙΚΟ ΜΕΤΣΟΒΙΟ ΠΟΛΥΤΕΧΝΕΙΟ

ΣΧΟΛΗ ΑΓΡΟΝΟΜΩΝ ΚΑΙ ΤΟΠΟΓΡΑΦΩΝ ΜΗΧΑΝΙΚΩΝ

ΔΙΑΤΜΗΜΑΤΙΚΟ ΠΡΟΓΡΑΜΜΑ ΜΕΤΑΠΤΥΧΙΑΚΩΝ ΣΠΟΥΔΩΝ

ΓΕΩΠΛΗΡΟΦΟΡΙΚΗ

ΣΧΕΔΙΑΣΜΟΣ ΕΝΟΣ ΤΡΙΣΔΙΑΣΤΑΤΟΥ ΑΡΧΑΙΟΛΟΓΙΚΟΥ ΚΤΗΜΑΤΟΛΟΓΙΟΥ ΜΕ ΒΑΣΗ ΤΟ ΔΙΕΘΝΕΣ ΠΡΟΤΥΠΟ LADM

ΜΕΤΑΠΤΥΧΙΑΚΗ ΔΙΠΛΩΜΑΤΙΚΗ ΕΡΓΑΣΙΑ

ΓΟΓΟΛΟΥ ΧΡΙΣΤΙΝΑ

Επιβλέπουσα: Δημοπούλου Ε.

Αν. Καθηγήτρια ΕΜΠ

Εγκρίθηκε από την τριμελή εξεταστική επιτροπή:

Δημοπούλου Έφη	**Κάβουρας Μαρίνος**	**Κόκλα Μαργαρίτα**
Καθηγητής ΕΜΠ-	**Καθηγητής ΕΜΠ**	**Λέκτορας ΕΜΠ**
Αν. Καθηγήτρια ΕΜΠ	**Διευθυντής ΔΠΜΣ**	

ΑΘΗΝΑ, ΦΕΒΡΟΥΑΡΙΟΣ 2016

Table of Contents

Table of Contents 4
Abstract 10
Περίληψη 12
Abbreviations 18
1. Introduction 20
1.1. Overview 20
1.2 Research Scope 20
1.3 Previous and Related Research 21
1.4 Organization of the MSc Thesis 22
2. Land Administration 24
2.1 The State of the Art 24
2.2 Standardization 25
2.3 Spatial Data Infrastructure (SDI) 27
2.3.1 Marine Spatial Data Infrastructure (MSDI) 29
2.3.2 Coastal Spatial Data Infrastructure (CSDI) 32
2.4 The Land Administration Domain Model (LADM) 33
2.4.1 The Party Package 36
2.4.2 The Administrative Unit Package 36
2.4.3 The Spatial Unit Package 37
2.4.4 Surveying and Representation Subpackage 38
2.4.5 Code Lists 39
2.4.6 Interface classes 41
3. Three-Dimensional Cadastres 43
3.1 Need for a 3D Cadastre 43
3.2 Adjustment of Cadastral Systems in 3D Registration 45
3.3 Legal Constraints in the Development of 3D Cadastre 47
4. The Administration of the Cultural Space 51
4.1 Standards in Cultural Management 52
4.1.1 The CIDOC-CRM Standard 53
4.2 The Archaeological Cadastre of Slovenia (ARKAS) 53
4.3 SITAR- The Geographic Archaeological Information System of Rome 56

4.4 The Dutch Cadastre (Kadaster) 57
4.5 The Hellenic Archaeological Cadastre Project 58
4.5.1 The Archaeological Space in Greece 58
4.5.2 The Archaeological Cadastre 64
4.5.3 The Database System 65
4.5.4 The Database Operation 65
5. A 3D Hellenic Archaeological Cadastre based on LADM 67
5.1 Possibilities for Implementation 67
5.2.1 Party Package 71
5.2.2 Basic Administrative Unit Package 73
5.2.3 RRR Package 77
5.2.4 Spatial Package 81
5.2.5 Subpackage of Surveying and Representation 86
5.2.6 Versioned Objects 88
5.3. Applications 89
5.3.1 Case Study 1: Way Servitude in Archaeological Parcel 89
5.3.2 Case Study 2: Antiquities in the Basement of Horizontal Property 90
5.3.3 Case Study 3: Land and Marine Archaeological Site Declaration 92
5.4 Requirements for the Adjustment of the Third Dimension to Archaeological Cadastral Data 93
5.3.1 Legal Framework 94
5.3.2 Jurisdictional Framework 95
5.3.3 Technical Framework 96
6. Conclusions 98
6.1 Feasibility of the Proposed Model 98
6.2 Interoperability of Archaeological Cadastral Data 100
6.3 Future Development 102
References 103
Electronic Sources 106

Table of Figures

Figure 1 , Layers of a Multipurpose Cadastre, (source www.fgdc.gov/) 30
Figure 2 , Graphic Representation of Maritime Zones, (source: Riccardo Pravettoni, UNEP/GRID-Arendal, 2009) 31
Figure 3 , Coastal SDI Components in Regional, National and Global SDIs (source http://library.oceanteacher.org/) 32
Figure 4 , A Seamless Administration System (source: Strain L., Rajabifard A. & Williamson I., 2004) 33
Figure 5 , Packages and Classes of the LADM (source: Text for ISO/FDIS 19152 GI-LADM).....34
Figure 6 , Basic Entities of the LADM (source: Text for ISO/FDIS 19152 GI-LADM) 35
Figure 7 , Versioned Object (source: Text for ISO/FDIS 19152 GI-LADM) 35
Figure 8 , Classes of the Party Package (source: Text for ISO/FDIS 19152 GI-LADM) 36
Figure 9 , Classes of the Administrative Unit Package (source: Text for ISO/FDIS 19152 GI-LADM) 37
Figure 10 , Classes of the Spatial Unit Package (source: Text for ISO/FDIS 19152 GI-LADM).....38
Figure 11 , Classes of the Subpackage of Surveying and Representation (source: Text for ISO/FDIS 19152 GI-LADM).....39
Figure 12 , Codelists for the Party Package (source: Text for ISO/FDIS 19152 GI-LADM) 40
Figure 13 , Codelists for the Administrative Package (source: Text for ISO/FDIS 19152 GI-LADM) 40
Figure 14 , Codelists for the Spatial Unti Package (source: Text for ISO/FDIS 19152 GI-LADM) 40
Figure 15 , Codelists for the Subpackage of Surveying and Representation (source: Text for ISO/FDIS 19152 GI-LADM) 40
Figure 16 , Interface Class LA_PartyPortfolio (source: Text for ISO/FDIS 19152 GI-LADM).....41
Figure 17 , Interface Class LA_SpatialUnitOverview (source: Text for ISO/FDIS 19152 GI-LADM) 42
Figure 18 , Interface Class LA_RegionalMap (source: Text for ISO/FDIS 19152 GI-LADM).....42
Figure 19 , The Gate Tower Building in Osaka, Japan (source www.dailymail.co.uk) 44
Figure 20 , ARKAS System (source: Kokalj Z., Pehani P., Hvala S.T. & Ostir K.,2006) 54
Figure 21 , *ARKAS Server (source: Kokalj Z., Pehani P., Hvala S.T. & Ostir K., 2006)* 55
Figure 22 , ARKAS Web Application (source: Kokalj Z., Pehani P., Hvala S.T. & Ostir K., 2006).....55
Figure 23 , SITAR Layers and Processes (source Serlorenzi M. & De Tommasi A., 2010) 57

Figure 24 , The Region of Astir Vouliagmeni (source: https://enotitasaronikou.wordpress.com) 60
Figure 25 , Declaration for the Archaeological Site of Astir, Vouliagmeni (Law 350/2013) 61
Figure 26 , Topographic Map of the Declaration of Astir, Vouliagmeni (Law 402/2013) 62
Figure 27 , The Archaeological Site of Toroni and the Port of Kofos, Chalkidiki (source: http://www.kastra.eu/) 62
Figure 28 , Declaration for the Unified Archaeological Site of Toroni and Port of Kofos (source: Law 255/2014) 63
Figure 29 , Topographic Map of the Declaration of the Unified Archaeological Site of Toroni and Port of Kofos (source: Law 255/2014) 64
Figure 30 , Basic Components of the Hellenic Archaeological Cadastre Project (source: Vradis C. & Syllaiou S., 2011) 65
Figure 31 , Intermediate collection of archaeological cadastral data sites and boundaries in Plaka, Athens (source: Vradis C. & Syllaiou S., 2011) 66
Figure 32 , The Proposed Model 69
Figure 33 , Classes of the Proposed Conceptual Model 70
Figure 34 , Classes of the HC and the HAC Interacting with LADM Classes (Gogolou C. & Dimopoulou E., 2015) 71
Figure 35 , Arch_Party and Codelists 72
Figure 36 , External Classes of the Party Package 72
Figure 37 , Class Arch_Party Interacting with Classes of the Proposed Model 73
Figure 38 , Classes of the Administrative Package Interacting with Classes of the Proposed Model 74
Figure 39 , Class Arch_BAUnit and Codelist 75
Figure 40 , Class Arch_AdministrativeSource and Codelists 76
Figure 41 , Class extArch_Way_Own and Codelist 77
Figure 42 , Abstract Class Arch_RRR 78
Figure 43 , Class Arch_Right and Codelist 79
Figure 44 , Class Arch_Restriction and Codelist 80
Figure 45 , Class Arch_Servitude and Codelist 80
Figure 46 , Class Arch_Responsibility and Codelist 81
Figure 47 , Class Arch_SpatialUnit and Codelists 83
Figure 48 , Class Arch_Level and Codelists 84
Figure 49 , Class Arch_Building and Codelist 85
Figure 50 , Classes of the Spatial Package Interacting with the Classes of the Proposed Model 85
Figure 51 , Class Arch_Point and Codelist 86
Figure 52 , Class Arch_SpatialSource and Codelist 87
Figure 53 , Class Arch_BoundaryFaceString and Codelist 87
Figure 54 , Class Arch_BoudaryFace and Codelist 88
Figure 55 , Versioned Object in the Proposed Model 89
Figure 56 , Way Servitude in Archaeological Parcel 90
Figure 57 , Horizontal Partition with Underground Antiquities 91
Figure 58 , Land and Marine Archaeological Site Declaration 93

Figure 59 , 3D Modeling of the Acropolis and the Temple of Sounio (source: http://www.ancientathens3d.com/).....97
Figure 60 , Interaction of HC and HAC with the INSPIRE Directive.....100

The following publications have occurred from the author's research:

- Dimopoulou, E. & Gogolou, C. (2013). LADM as a Basis for the Hellenic Archaeological Cadastre. 5th Land Administration Domain Model Workshop, 24-25 September 2013, Kuala Lumpur, Malaysia.
- Gogolou, C. & Dimopoulou, E. (2015). Land Administration Standardization for the Integration of Cultural Heritage in Land Use Policies, Land Use Policy Journal, Vol. 49, p. 617 - 625, December, 2015.

Abstract

Greece is a country that claims a significant cultural heritage that affected the evolution of many cultures and has set the cornerstone for the development of the western societies. As a crossroad of ideas due to its geographical position, Greece has always been a place of creation. This has given marvelous examples of history, architecture, art, philosophy and so on. The Greek State, since its establishment, has a strict legal framework which reflects the importance of the conservation of ancient treasures. Over the years, various public services have been responsible for the protection of different types of culture; movable, immovable and tangible heritage are the three classifications described in the legal framework for the protection of cultural assets. Regarding the management tools, there is a plethora of registries implemented for the administration of national cultural assets, such as the National Monuments Archive and the Constant Catalogue for Declared Archaeological Sites and Monuments. Today, the Hellenic Archaeological Cadastre is an ongoing project for the registration of the ownership status of the immovable archaeological assets with a cadastral approach. The project aims to the development of a modern registry for properties with archaeological an architectural features.

Land Administration is an international good practice followed by public institutions and other organizations for the identification and management of people-to-land-relationships. Land Administration is expressed in the various systems developed around the world for terrestrial and marine territories. In this context, infrastructure for the administration of issues related to the land with spatial reference has been implemented. Spatial Data Infrastructure for specific spatial components provide institutions with valuable management tools, such as Land and Marine Administration Systems, cadastral systems, coastal management registries and environmental assessment tools.

Standardization in Land Administration has also raised as a necessity to the implementation of spatial management systems. Standards are widely used today for the formation of conceptual models and software architecture as they provide possibilities for common development, expression of shared terminology to the systems and compatibility with global structures. Last but not least, standards have enabled the interoperability between different systems, leading to feasible forms of databases and communication between various organizations.

The main purpose of this Master Thesis is the adjustment of the LADM in the basic conceptual schema of the Hellenic Archaeological Cadastre, for the development of a three-dimensional system with extension to marine regions. A second goal is set to the research; the identification of the legal, jurisdictional and technical requirements that are necessary for the three-dimensional spatial representation of archaeological cadastral data in properties with archaeological interest as well as in marine archaeological sites in Greece.

For the above aims, the research comprises two phases. The first phase includes the

analysis of a theoretical background in Land Administration. This combines an attempt to provide the State of the Art in Land Administration Systems, Spatial Data Infrastructures marine and coastal administration systems as well as the investigation of the standardization process, together with an explicit description of the concepts and attributes of the Land Administration Domain Model. The field of 3D Cadastres and the barriers and legal constraints for the definition of 3D property objects are also investigated. At last, a review of the State of the Art in the management of the cultural heritage and a description of efforts for the implementation of cultural property protection systems on a national and international scale are also included.

The second phase aims to the conceptualization of a three-dimensional Hellenic Archaeological Cadastre based on the LADM. A conceptual model that adopts the codification proposed by the core model of the LADM in the complex task of classification of data for the archaeological space of Greece is described in detail. Classes and their attributes, together with codelists for the various types are explicitly presented. Explanations and external classes necessary to the system due to the multiplicity of the Greek archaeological environment are also added to the proposed model. At last, an extensive report to the various legal, organizational and technical reforms that need to be realized on a national scale in order to determine the premises for the assignment of 3D property objects on an Archaeological Cadastre are provided. Several stimulating conclusions for the three-dimensional and marine archaeological cadastral registrations and for the interoperability of systems arise from the description of the developed model, which are extensively presented in the final part of this second phase.

Περίληψη

Η Ελλάδα είναι μια χώρα με σημαντική για το παγκόσμιο γίγνεσθαι πολιτιστική κληρονομιά, η οποία επηρέασε την εξέλιξη πολλων ευρωπαϊκών πολιτισμών, καθώς και την ανάπτυξη των σύγχρονων δυτικών κοινωνιών. Ως σταυροδρόμι ιδεών, λόγω και της γεωγραφικής της θέσης, η χώρα μας αποτελούσε πάντα έναν τόπο δημιουργίας. Αποτέλεσμα αυτού είναι τα λαμπρά παραδείγματα πολιτιστικής έκφρασης, όπως η αρχιτεκτονική, οι τέχνες, η φιλοσοφία κλπ. Από την ίδρυσή του το ελληνικό κράτος καθιέρωσε ένα αυστηρό νομικό πλαίσιο σχετικά με την προστασία της πολιτιστικής κληρονομιάς, γεγονός που αντικατοπτρίζει τη σημαντικότητά της στην σύγχρονη ανάπτυξη της χώρας. Οι σημαντικότεροι νόμοι για την προστασία των αρχαιοτήτων είναι: ο Ν.10/1834 *«Περί των επιστημονικών και τεχνολογικών συλλογών, περί ανακαλύψεως και διατηρήσεως των αρχαιοτήτων και της χρήσεως αυτών»,* ο Ν.5351/1932 με τον οποίο τα αρχαία μνημεία περιέρχονται στην κυριότητα του Δημοσίου ως αποκλειστική και διηνεκής, ο Ν.1469/1950 για την προστασία της ειδικής κατηγορίας οικοδομημάτων και έργων τέχνης μεταγενέστερων του 1830, καθώς και το άρθρο 24 του Συντάγματος του 1975 σύμφωνα με το οποίο καθιερώνεται η προστασία των μνημείων και όλων των ιστορικών, καλλιτεχνικών και τεχνολογικών στοιχείων που αποτελούν την ελληνική πολιτιστική κληρονομιά. Σήμερα το νομικό πλαίσιο έχει ενσωματωθεί στον κωδικοποιημένο Αρχαιολογικό Νόμο (Ν3028/2002 Περί Προστασίας των Αρχαιοτήτων και εν γένει της Πολιτιστικής Κληρονομιάς).

Εκτός από το νομικό πλαίσιο, υπάρχουν σήμερα διάφορες δημόσιες υπηρεσίες και οργανισμοί υπεύθυνοι για την προστασία όλων των μορφών του πολιτισμού. Ο κατεξοχήν υπεύθυνος φορέας για την προστασία και προβολή των μνημείων είναι το Υπουργείο Παιδείας και Θρησκευμάτων, Πολιτισμού και Αθλητισμού. Τα μνημεία υπάγονται στον Τομέα του Πολιτισμού, η διάρθρωση του οποίου γίνεται σε διευθύνσεις, οι οποίες είναι υπό την ευθύνη της Γενικής Διεύθυνσης Αρχαιοτήτων και Πολιτιστικής Κληρονομιάς (πχ. Διεύθυνση Προϊστορικών και Κλασσικών Αρχαιοτήτων, Εθνικού Αρχείου Μνημείων, Συντήρησης Αρχαίων Μνημείων και Νεότερων Μνημείων κλπ). Στη δικαιοδοσία και άλλων Υπουργείων βρίσκονται ακίνητα με πολιτιστικό ή αρχαιολογικό ενδιαφέρον. Την ευθύνη για την προστασία των μνημείων εθνικής άμυνας κατέχει το Υπουργείο Εθνικής Άμυνας, όπως κάστρα, φρούρια και οχυρωματικές κατασκευές. Επίσης το Υπουργείο Περιβάλλοντος, Ενέργειας και Κλιματικής Αλλαγής κατέχει αρμοδιότητες για την προστασία και ανάδειξη της αρχιτεκτονικής κληρονομιάς των παραδοσιακών οικισμών, των ιστορικών κέντρων των πόλεων καθώς και μεμονωμένα σε διατηρητέα αρχιτεκτονικά κτήρια.

Η ελληνική πολιτιστική κληρονομιά αποτελείται από μνημεία κινητά, ακίνητα και άυλα. Για την προστασία τους σήμερα, έχουν αναπτυχθεί διάφορα διαχειριστικά μέσα και εργαλεία προστασίας, όπως το Εθνικό Αρχείο Μνημείων, ο Διαρκής Κατάλογος των Κηρυγμένων Αρχαιολοφικών Χώρων και Μνημείων και το Αρχείο Παραδοσιακών Οικισμών και Διτηρητέων Κτηρίων.

Σήμερα καταρτίζεται το Αρχαιολογικό Κτηματολόγιο, το οποίο θα δώσει τη δυνατότητα καταγραφής της κτηματολογικής διάστασης του αρχαιολογικού χώρου. Το έργο

αποσκοπεί στην ανάπτυξη ενός σύγχρονου αρχείου για δημόσιους χώρους και ιδιωτικές ιδιοκτησίες με αρχαιολογικά η αρχιτεκτονικά χαρακτηριστικά. Στόχος είναι η δημιουργία ενός διαχειριστικού εργαλείου για την προστασία της πολιτιστικής κληρονομιάς με ποιοτικά και ποσοτικά χαρακτηριστικά , το οποίο θα δίνει επίσης τη δυνατότητα ταχείων συναλλαγών μεταξύ των κρατικών υπηρεσιών και των πολιτών. Φορέας υλοποίησης είναι το Υπουργείο Παιδείας και Θρησκευμάτων, Πολιτισμού και Αθλητισμού και συγκεκριμένα η Διεύθυνση Απαλλοτριώσεων και Ακίνητης Περιουσίας. Η καταγραφή των ακίνητων μνημείων περιλαμβάνει περιγραφική και χωρική διάσταση της πληροφορίας, δηλαδή το καθεστώς απόκτησης εγγραπτέων δικαιωμάτων σε ακίνητα με αρχαιολογικό ενδιαφέρον και γεωμετρική περιγραφή των ιδιοκτησιών, δημοσίων και ιδιωτικών. Τα ακίνητα που καταγράφονται κατατάσσονται σε τέσσερις κατηγορίες, σε ακίνητα μνημεία, σε ακίνητη περιουσία του Δημοσίου, σε περιοχές πολιτιστικού περιβάλλοντος και σε ιδιωτικές ιδιοκτησίες με ακίνητες αρχαιότητες. Οι τεχνολογικές αρχές που διέπουν το έργο και την πλήρη εναρμόνισή του με τις ευρωπαϊκές απαιτήσεις περιλαμβάνουν: ανοιχτά δεδομένα, διαλειτουργικότητα μεταξύ κρατικών υπηρεσιών και των συστημάτων τους, περιβάλλον εικονικών μηχανών, ανοιχτά πρότυπα για τη διευκόλυνση της διασποράς της πληροφορίας, πολυκαναλική διάθεση σε ομάδες πολιτών και νομικών προσώπων και υιοθέτηση ελεύθερου λογισμικού. Η υλοποίηση του έργου ξεκίνησε με το αρχικό υποέργο της αρχαιολογικής αυτεπιστασίας, η οποία περιέλαβε τη συλλογή και καταγραφή των αντικειμένων που σχετίζονται με τις ακίνητες αρχαιότητες. Στη συνέχεια ολοκληρώθηκε το ενδιάμεσο διαχειριστικό σύστημα, το οποίο περιέλαβε την ψηφιοποίηση και καταγραφή της αρχαιολογικής και ιστορικής πληροφορίας, καθώς και τη συσχέτισή τους με τη χωρική διάσταση. Το Ολοκληρωμένο Πληροφοριακό Σύστημα αποτελεί το τελευταίο στάδιο κατά το οποίο δεδομένα ιδιοκτησιακού και διοικητικου χαρακτήρα ενσωματώνονται με τη χωρική τους πληροφορία σε ένα διαλειτουργικό σύστημα.

Η Διοίκηση της γης αποτελεί μια διεθνή πρακτική που υποστηρίζεται από δημόσιους και άλλους οργανισμούς για τον προσδιορισμό και τη διαχείριση των σχέσεων μεταξύ ανθρώπου και γης. Η Διοίκηση της γης εκφράζεται μέσω των διάφορων συστημάτων που έχουν αναπτυχθεί ανά τον κόσμο για χερσαίες και θαλάσσιες περιοχές. Για τη διαχείριση προβλημάτων που σχετίζονται με τη γή (ή και το θαλάσσιο χώρο) και γενικά έχουν χωρική αναφορά, έχουν αναπτυχθεί διάφορες υποδομές. Η ανάπτυξη Γεωχωρικής Υποδομής για συγκεκριμένες χωρικές συνιστώσες, έχει οδηγήσει στη δημιουργία πολύτιμων διαχειριστικών έργαλείων, όπως τα Συστήματα Διοίκησης της γης και του θαλάσσιου χώρου, τα κτηματολογικά συστήματα, τα αρχεία διαχείρισης παράκτιων περιοχών και τα εργαλεία εκτίμησης περιβαλλοντικών επιπτώσεων.

Το πιο σύνηθες σύστημα διοίκησης γης είναι το Κτηματολόγιο. Το Κτηματολόγιο είναι ένα διαρκώς ενημερωμένο σύστημα καταγραφής πληροφοριών γης, βασισμένο σε γεωτεμάχια, δικαιώματα, περιορισμούς και υποχρεώσεις που εξάγονται από την ιδιοκτησία. Η ανάπτυξη Κτηματολογίου μπορεί να βασίζεται σε διάφορους σκοπούς, όπως νομικοί, φορορογικοί και βιώσιμης ανάπτυξης. Διάφορα κτηματολογικά συστήματα αναπτύσσονται ως συστήματα διοίκησης γης τα οποία ενσωματώνουν διάφορα δομικά και λειτουργικά χαρακτηριστικά με βάση τον σκοπό της εφαρμογής τους.

Έως και σήμερα, οι περισσότερες χώρες ανά τον κόσμο έχουν αναπτύξει το δικό τους κτηματολογικό σύστημα, με βάση τις τοπικές ανάγκες για κτηματογράφηση. Παρόλο που σε κάθε χώρα οι ανάγκες αυτές είναι διαφορετικές, καθώς η ιδιοκτησία και τα δικαιώματα που ασκούνται σε αυτή εκφράζοντια διαφορετικά, τα κτηματολογικά συστήματα σχεδιάζονται έτσι ώστε να μπορούν να υποστηρίξουν ένα ευρύ φάσμα νομικών, θεσμικών και τεχνικών ζητημάτων, παρέχοντας μια συνεκτική και λειτουργική μορφή Κτηματολογίου.

Στην Ελλάδα η σύνταξη του Κτηματολογίου αποσκοπεί στη δημιουργία ενός μοντέρνου συστήματος για τη διαχείριση της ακίνητης ιδιοκτησίας. Τα κτηματολογικά δεδομένα που καταγράφονται έχουν αποδεικτικό χαρακτήρα, εξασφαλίζοντας τη μεγαλύτερη δυνατή δημοσιότητα και ασφάλεια των συναλλαγών. Το σύστημα του Εθνικού Κτηματολογίου αποσκοπεί στην αντικατάσταση του παλαιού συστήματος Υποθηκών και Μεταγραφών που υποστήριζαν τα Υποθηκοφυλακεία και στη σταδιακή μετατροπή τους σε κτηματολογικά γραφεία. Το Εθνικό Κτηματολόγιο δομείται σε δύο επίπεδα, το περιγραφικό και το χωρικό. Στο περιγραφικό επίπεδο καταγράφονται οι ιδιοκτησίες και τα εγγραπτέα δικαιώματα που ασκούνται σε αυτές, βάσει των συμβολαιογραφικών πράξεων που συντάσσονται για την απόδειξη, τροποποίηση, μεταβίβαση και δημιουργία των δικαιωμάτων και περιορισμών στη δημόσια και ιδιωτική περιουσία. Οι νομικές πληροφορίες που απορρέουν από τα επίσημα ή ανεπίσημα έγγραφα που προσκομίζονται στο σύστημα, καθώς και η ορθή καταχώρισή τους σε αυτό εγγυώνται τη νομιμότητα των τελικών εγγραφών. Στο περιγραφικό επίπεδο καταγράφονται επίσης τα δικαιώματα με Χρησικτησία, η οποία αποτελεί έναν αρκετά συνήθη τρόπο απόκτησης και άτυπης μεταβίβασης κυριότητας. Το χωρικό επίπεδο αναπαριστά την ιδιοκτησία με βάση το γεωτεμάχιο σε δισδιάστατη μορφή σε σχήμα, μέγεθος και θέση. Η κατάρτιση του Εθνικού Κτηματολογίου διέπεται από ένα θεσμικό πλαίσιο το οποίο αποτελείται από δύο βασικά νομοθετήματα, τον αρχικό Ν.2308/1995 ο οποίος οργανώνει τη διαδικασία της κτηματογράφησης και τον Ν.2664/1998, ο οποίος διέπει τη λειτουργία του Κτηματολογίου. Η υλοποίηση του έργου γίνεται από την ΕΚΧΑ ΑΕ (Εθνικό Κτηματολόγιο και Χαρτογράφηση ΑΕ), η οποία λειτουργεί με τους κανόνες της ιδιωτικής οικονομίας και είναι υπεύθυνη για τη δημιουργία και τήρηση των κτηματολογικών γεωχωρικών δεδομένων της χώρας.

Η προτυποποίηση στη διαδικασία της Διοίκησης της γης έχει προκύψει τα τελευταία χρόνια ως αναγκαία για την υλοποίηση των συστημάτων διαχείρισης της γης και τις Γεωχωρικές Υποδομές. Η προτυποποίηση αποτελεί μια διαδικασία η οποία ενσωματώνει διάφορες πληροφορίες γης, όπως γεωτεμάχια, εμπράγματα δικαιώματα, πρόσωπα και χάρτες με κωδικοποιημένο τρόπο. Σήμερα η επιστημονική και τεχνολογική κοινότητα χρησιμοποιεί ευρέως τα πρότυπα για τη δημιουργία εννοιολογικών μοντέλων και αρχιτεκτονικής λογισμικού, καθώς προσφέρουν δυνατότητες ανάπτυξης συστημάτων με κοινή ορολογία και συμβατότητα με διεθνείς δομές. Επίσης η χρήση των προτύπων έχει επιτρέψει την επίτευξη της διαλειτουργικότητας μεταξύ διαφορετικών συστημάτων, γεγονός το οποίο έχει οδηγήσει στην κοινή αναπαράσταση βάσεων δεδομένων και στην ευκολότερη επικοινωνία μεταξύ διαφόρων οργανισμών.

Το διεθνώς αναγνωρισμένο πρότυπο διοίκησης γης LADM είναι ευρέως

χρησιμοποιούμενο για τη δημιουργία κτηματολογικών συστημάτων. Κύριος σκοπός του προτύπου είναι η παροχή μιας κοινής ορολογίας για την περιγραφή των διάφορων απαραίτητων χαρακτηριστικών των πληροφοριών γης, η οποία θα βασίζεται σε σύγχρονες τεχνολογικές αρχές (πχ UML, GIS). Αποτελεί ένα βασικό εγχειρίδιο για την ανάπτυξη αποτελεσματικών συστημάτων διοίκησης γης και επιτρέπει την επικοινωνία μεταξύ των συμβαλλόμενων μερών σε μια χώρα, αλλά και μεταξύ διαφορετικών χωρών. Το παρεχόμενο εννοιολογικό μοντέλο έχει υιοθετήσι μια πρότυπη αρχιτεκτονική δομή (Model Driven Architecture) και περιλαμβάνει πέντε σύνολα οντοτήτων: το σύνολο των συμβαλλόμενων μερών (Parties), το σύνολο των βασικών διοικητικών μονάδων (Basic Administrative Units), το σύνολο των δικαιωμάτων, περιορισμών και υποχρεώσεων (RRRs), το σύνολο των χωρικών μονάδων (Spatial Units) και το σύνολο περιγραφής χωρικών δεδομένων (Spatial Representations). Τα σύνολα του μοντέλου αναπαριστώνται με διάφορες σχέσεις, με τέτοιο τρόπο ώστε να μπορούν να εμφανίζονται δικαιώματα, περιορισμοί και υποχρεώσεις για κάθε χωρική μονάδα που ανήκει σε ένα πρόσωπο και για το οποίο το ιδιοκτησιακό καθεστώς αποδεικνύεται.

Η προσαρμογή του διεθνώς αναγνωρισμένου προτύπου Διοίκησης γης LADM στο βασικό εννοιολογικό σχήμα του Αρχαιολογικού Κτηματολογίου, για τη δημιουργία ενός τρισδιάστατου συστήματος με δυνατότητες επεκτασιμότητας σε θαλάσσιες περιοχές, είναι ο βασικός σκοπός συγγραφής της παρούσας Μεταπτυχιακής Διπλωματικής Εργασίας. Η εργασία επίσης περιλαμβάνει και έναν δευτερεύοντα στόχο: τη διερεύνηση των νομικών, οργανωτικών και τεχνικών απαιτήσεων που είναι απαραίτητες για την τρισδιάστατη χωρική αναπαράσταση κτηματολογικών δεδομένων, τόσο για ιδιοκτησίες με αρχαιολογικό ενδιαφέρον, όσο και για ενάλιους αρχαιολογικούς χώρους στην Ελλάδα.

Για την υλοποίηση των στόχων η εργασία χωρίζεται σε δύο μέρη. Το πρώτο μέρος περιλαμβάνει την ανάλυση του θεωρητικού υπόβαθρου στη Διοίκηση της γης. Περιγράφεται η σύγχρονη αντιμετώπιση στα Συστήματα Διοίκησης Γης, στις Γεωχωρικές Υποδομές γενικά και ειδικότερα για το θαλάσσιο χώρο και τις παράκτιες περιοχές. Επίσης αναλύεται η διαδικασία της προτυποποίησης με ορισμούς και παραδείγματα υλοποίησης προτύπων. Πληροφορίες για το εννοιολογικό μοντέλο του LADM και τα χαρακτηριστικά του περιγράφονται εκτενώς. Ακόμη, οι σύγχρονες τάσεις στον τομέα των τρισδιάστατων κτηματολογίων εξετάζονται στο πρώτο αυτό μέρος της εργασίας. Σήμερα τα σύγχρονα κτηματολογικά συστήματα στοχεύουν στη διαχείριση και καταγραφή των ιδιοκτησιών και των δικαιωμάτων που ασκούνται σε αυτές, βασιζόμενα στη νομική και τεχνική πληροφορία που απορρέει από τα επίσημα ή ανεπίσημα σχετικά έγγραφα. Στη σύγχρονη κοινωνία ολοένα αυξανόμενες ανάγκες έχουν προκύψει για την τρισδιάστατη αναπαράσταση των ιδιοκτησιακών αντικειμένων. Οι ανάγκες αυτές εμφανίζονται κυρίως σε αστικές περιοχές, όπου συνυπάρχουν πολύπλοκες κατασκευές, στις οποίες εμφανίζονται συγκρουόμενα ιδιοκτησιακά δικαιώματα τα οποία ενυπάρχουν σε διαφορετικά επίπεδα, πάνω ή κάτω από την επιφάνεια της γης (ή της θάλασσας). Έτσι λοιπόν, είναι αναγκαία η τρισδιάστατη κτηματογράφηση των δικαιωμάτων αυτών, καθώς και η προσαρμογή των υπαρχόντων δισδιάσταων κτηματολογικών συστημάτων στην τρισδιάστατη εποχή. Η διεργασία αυτή δε θεωρείται εύκολη, καθώς απαιτεί διάφορες αλλαγές σε νομικό, θεσμικό και τεχνικό επίπεδο, όπως την αναθεώρηση του νομικού

πλαισίου προς την κατεύθυνση του νομικού προσδιορισμού των τρισδιάστατων αντικειμένων. Οι νομικοί περιορισμοί για την οριοθέτηση του τρισδιάστατου ιδιοκτησιακού αντικειμένου περιγράφονται στο πλαίσιο αυτό. Ακόμη άλλα ζητήματα, όπως η ενσωμάτωση της τρισδιάστατης ιδιοκτησιακής πληροφορίας στις τεχνικές προδιαγραφές της κτηματογράφησης και η υιοθέτηση της τρίτης διάστασης στο εννοιολογικό μοντέλο και στην κτηματολογική βάση δεδομένων του εκάστοτε δισδιάστατου κτημαολογικού συστήματος αποτελούν ζητήματα προς λύση.

Εν τέλει, γίνεται αναφορά στις σύγχρονες τάσεις για τη διαχείριση της πολιτιστικής κληρονομιάς, καθώς και σε διάφορες προσπάθειες καταγραφής ιδιοκτησιών με πολιτιστικό ενδιαφέρων σε συστήματα με κτηματολογική προσέγγιση, σε εθνικό και διεθνές επίπεδο. Αναλύονται τα χαρακτηριστικά του αρχαιολογικού και γενικότερα του πολιτιστικού χώρου, ο οποίος εμπεριέχει χωρικά δεδομένα για ιστορικούς τόπους, αρχαία ή νεότερα ακίνητα μνημεία, οικισμούς, αρχιτεκτονικά κτήρια και διάφορα άλλα παραδείγματα πολιτιστικής κληρονομιάς. Η πολυπλοκότητα του αρχαιολογικού χώρου δημιουργεί και διαφοροποιημένες ιδιοκτησιακές σχέσεις μεταξύ των αντικειμένων, οι οποίες με τη σειρά τους δημιουργούν ειδικά ιδιοκτησιακά δικαιώματα, καθώς η καταγραφή τους στα διάφορα επίπεδα στα οποία κείνται αποτελεί μια επίπονη εργασία. Επίσης η συνύπαρξη των αρχαιοτήτων με διάφορες σύγχρονες κατασκεύες διαμορφώνει ένα ειδικό ιδιοκτησιακό καθεστώς, καθώς διάφοροι περιορισμοί και υποχρεώσεις εμφανίζονται στις δημόσιες και ιδιωτικές ιδιοκτησίες. Σε πολλές χώρες επηρεάζονται ακόμα και οι χρήσεις γης και η ελεύθερη άσκηση των δικαιωμάτων. Για παράδειγμα στην Ελλάδα ιδιοκτήτες γεωτεμαχίων στις οποίες ανακαλύπτονται σημαντικές αρχαιότητες μπορεί να υποχρεωθούν στη διενέργεια και κάλυψη των εξόδων της ανασκαφής, ενώ ταυτόχρονα μπορεί να χάσουν το δικαίωμα ανοικοδόμησης ή ανάπτυξης άλλων οικονομικών δραστηριοτήτων.

Στο δεύτερο μέρος της εργασίας εντυπώνεται μια προσπάθεια για τον εννοιολογικό σχεδιασμό ενός τρισδιάστατου Αρχαιολογικού Κτηματολογίου με τη βοήθεια του προτύπου LADM. Περιγράφεται με σαφήνεια και λεπτομέρεια ένα εννοιολογικό μοντέλο που υιοθετεί την κωδικοποίηση που προτείνει το πρότυπο LADM, για την πολύπλοκη διεργασία της ταξινόμησης των δεδομένων για τον ελληνικό αρχαιολογικό χώρο. Οι οντότητες και τα χαρακτηριστικά τους, καθώς και οι λίστες κωδικών των διαφόρων τύπων οντοτήτων αναλύονται επαρκώς. Εξωτερικές οντότητες έχουν προστεθεί στο βασικό μοντέλο λόγω της πολυπλοκότητας του ελληνικού αρχαιολογικού χώρου. Τρία παραδείγματα που περιγράφουν τυπικές καταστάσεις ύπαρξης αρχαιοτήτων σε δημόσιες και ιδιωτικές ιδιοκτησίες και στις εφαρμόζεται το προτεινόμενο εννοιολογικό μοντέλο περιλαμβάνονται επίσης. Τα παραδείγματα αυτά διαμορφώνονται για λόγους πληρότητας της περιγραφής του μοντέλου, για την απόδειξη της πολυπλοκότητας των ιδιοκτησιακών σχέσεων που ενυπάρχουν στον αρχαιολογικό χώρο και για τη διερεύνηση των δυνατοτήτων της τρισδιάστατης αναπαράστασης των κτηματολογικών δεδομένων που αφορούν τις επίγειες και ενάλιες αρχαιότητες του ελληνικού χώρου. Για την πληρότητα του προτεινόμενου μοντέλου γίνεται επίσης μια πρώτη ανάλυση των διάφορων νομικών, οργανωτικών και τεχνικών αναμορφώσεων που χρειάζεται να επιτευχθούν σε εθνικό επίπεδο, έτσι ώστε να προσδιοριστούν οι προϋποθέσεις για τη δημιουργία και

ενσωμάτωση τρισδιάστατων κτηματολογικών αντικειμένων στο Αρχαιολογικό Κτηματολόγιο.

Εν κατακλείδι, αξιολογούνται τα αποτελέσματα από την υλοποίηση του προτεινόμενου μοντέλου, τα οποία σχετίζονται με τρισδιάστατες και θαλάσσιες κτηματολογικές καταγραφές στον αρχαιολογικό χώρο, καθώς και με τη διαλειτουργικότητα των συστημάτων. Τέλος περιγράφονται οι διάφορες δυνατότητες του προτεινόμενου μοντέλου για περεταίρω εξέλιξη, όπως η χωρική επέκταση με διάφορα συστήματα και η εισαγωγή του σε σύστημα χωρικών βάσεων δεδομένων.

Abbreviations

CH Cultural Heritage

CMSP Coastal and Marine Spatial Planning

CSDI Coastal Spatial Data Infrastructure

EEZ Exclusive Economic Zone

ENC Electronic Nautical Chart

EU European Union

FGDC Federal Geographic Data Committee

FIG Federation Internationale des Geometres

GII Geo-Information Infrastructure

GIS Geographic Information Systems

GSDI Global Spatial Data Infrastructure

HAC Hellenic Archaeological Cadastre

HC Hellenic Cadastre

HTML HyperText Markup Language

ICT Information and Communications Technology

IHO International Hydrographic Organization

IHB International Hydrographic Bureau

INSPIRE Infrastructure for Spatial Information in the European Community

ISO International Standards Organization

LA Land Administration

LADM Land Administration Domain Model

LAS Land Administration Systems

LUP Land Use Policies

MAS Marine Administration Systems

MDA Model Driven Architecture

MSc Master of Science

MSDI Marine Spatial Data Infrastructure

MSP Marine Spatial Planning

NMA National Monuments Archive

OGC Open Geospatial Consortium

RRR Rights, Restrictions and Responsibilities

SDI Spatial Data Infrastructure

S-57 Special Publication No.57

TC Technical Committee

UNESCO United Nations Educational, Scientific and Cultural Organization

UNCLOS United Nations Convention on the Law of the Sea

USA United States of America

WFS Web Files Services

WMS Web Map Services

XML eXtended Markup Language

2D/3D Two/Three-Dimensional

1. Introduction

1.1. Overview

In Greece, the protection of cultural heritage is of high importance. Monuments are considered to be world heritage assets, a fact that is recognized from the State and from many international institutions, with the most important being the United Nations Educational, Scientific and Cultural Organization (UNESCO). According to the UNESCO's official website: *"The monuments included on the World Heritage List are selected and approved on the basis of their value as best examples of human creative genius. They exhibit an important interchange of human values and bear a unique or at least exceptional testimony to a cultural tradition or to a civilization which is living or has disappeared. They are directly linked to important stages in human history and for this reason they have outstanding universal significance and are a part of mankind's common heritage".*

In terms of protection, remarkable efforts have been done, resulting to modern registries and to better conservation methods. For the first time in Greece a cadastral system is being developed, reflecting the necessity of recording and clarifying the multiplicity of property rights of this special component of the land. Regarding the field of Cadastres, a definition was given by the International Federation of Surveyors (FIG- Federation International des Geometres) in 1995: *"Cadastre is normally a parcel based, and up-to-date land information system containing a record of interests in land (e.g. rights, restrictions and responsibilities). It usually includes a geometric description of land parcels linked to other records describing the nature of the interests, the ownership or control of those interests, and often the value of the parcel and its improvements. It may be established for fiscal purposes (e.g. valuation and equitable taxation), legal purposes (conveyancing), to assist in the management of land and land use (e.g. for planning and other administrative purposes), and enables sustainable development and environmental protection."*

A Cadastre for the archaeological space of Greece is described in this Thesis. The author's research and proposal takes under consideration the modern practice of standardization. The conceptual model adopts the international standard of Land Administration Domain Model. Classes and attributes are implemented with the aid of UML diagrams and incorporate legal and structural considerations for the representation of terrestrial and marine three-dimensional data for the archaeological space of Greece. Premises for the successful configuration of three-dimensional property objects for a system such as the proposed are also described as an integral part of a complete research.

1.2 Research Scope

The scope of this MSc Thesis is to incorporate international good practice of Land Administration in the conceptual schema of the Hellenic Archaeological Cadastre and thus create a modern 3D cadastral system for the efficient management of the terrestrial and submarine archaeological space of Greece. More specifically the topics within the

scope of this Thesis are described below:

- State of the Art in Land Administration (LA) that is; what is considered as good practice, what has been developed so far, modern trends in LA and utilization of standards.
- Research in the field of 3D Cadastres, definition of a 3D property objects and why are there barriers for the representation of such objects, legal constraints related to 3D property objects and rights associated with them.
- The description of the archaeological space of Greece, its special features together with property constraints and the reality today.
- The scientific approach of an Archaeological Cadastre, such as the Hellenic Archaeological Cadastre (HAC) Project, what is the scope, which are the special characteristics and why is it a meaningful tool for the protection of antiquities in Greece.
- The incorporation of the third dimension in cadastral registrations that concern properties with archaeological or architectural interest, how can it serve to clarifying ownership status and what is needed for its spatial representation.
- The general rules and jurisdictions needed for the implementation of Marine Spatial Data Infrastructure (MSDI), the legal framework and the restrictions related to marine archaeological sites in Greece, according to national legislation and to international conventions.
- The research for the inclusion of limited marine jurisdictions to an Archaeological Cadastre and the description of the specific constraints related to possible marine archaeological cadastral registrations.
- The main scope of this Thesis is the formation of a conceptual model based on the standardized schema of LADM for a three-dimensional and marine Archaeological Cadastre of Greece. This requires the adaptation of the LADM's classes to national needs of registration and also the incorporation of legal aspects for the protection of rights, restrictions and responsibilities that appear on properties with archaeological or architectural interest. The effort of incorporating an internationally recognized standard in the basic architectural structure of a relatively new cadastral application such as the HAC Project is worth making.

1.3 Previous and Related Research

There is limited research for the cadastral approach of the archaeological space of Greece. The authors have conducted a significant research in 2013 and in 2015 related to the incorporation of the LADM in the conceptual schema of the Hellenic Archaeological Cadastre and to the integration of standards in the management of the cultural heritage for successful land use policies.

Apart from the above, there is a variety of papers and research projects in the field of 3D Cadastre in Greece. Papaefthymiou et al (2004) have set the legal, physical and practical issues for a 3D Cadastre in Greece. Tsiliakou and Dimopoulou have researched on the possibilities and constraints for the adjustment of the third dimension to the Hellenic Cadastre (2011) and how 2D cadastral data can be transformed into a dynamic 3D model (2013). Dimopoulou and Elia (2012) have conducted an extended research on the legal aspects of 3D property rights, restrictions and responsibilities in Greece and Cyprus. Kitsakis and Dimopoulou have approached the legal constraints and the necessary reforms for the implementation of 3D Cadastres (2013) and how the existing documentation can contribute to them (2014). Finally, Dimopoulou, Kitsakis and Tsiliakou (2015) have investigated the correlation between legal and physical properties.

Furthermore extended research for the incorporation of the LADM in Greek cadastral data can be found. The last years the LADM has been utilized as an appropriate ISO for the formation of conceptual models in Greece in a research level. Kalogianni introduced the model to the Hellenic reality creating a model for the management of the Greek public property (2012) and conducted further research for the development of a multipurpose 3D Hellenic Cadastre (2015). Gogolou (2013) created a conceptual model for the Hellenic Archeological Cadastre, Athanasiou (2014) proposed a conceptual model for the implementation of a Marine Cadastre, Psomadaki (2014) proposed a model for the Harmonization of the Hellenic Cadastre with international standards including LADM and INSPIRE.

1.4 Organization of the MSc Thesis

The present MSc Thesis is organized in six chapters as follows:

- Chapter 1 presents introductive information related to the Thesis. It specifies the main scope for implementation, the objectives, the contribution of the research according to the author and the previous related research.
- Chapter 2 defines the current State of the Art for Land Administration. Definitions that concern Land Administration (LA), systems for Land and Marine Administration (LAS and MAS) and Spatial Data Infrastructure (SDI) are explained. The different approaches for SDI and the types of SDI (Marine and Coastal Spatial Data Infrastructure) implemented are also described. There is also a description for standardization and what is the role of standards in modern Land Administration Systems. Finally, there is an extensive report for the Land Administration Domain Model (LADM), the attributes, the classes of its conceptual model and the functionalities it offers to the formation of regional registries and national cadastral systems.
- Chapter 3 includes the modern approach of 3D Cadastres. There is a description of what a 3D Cadastre aims to satisfy, the most important demands for the formation of 3D cadastral systems and how the conventional cadastres can incorporate the third dimension. Details about the legal and institutional barriers

that have to be overcome in order to implement 3D Cadastres are also described in this chapter.

- Chapter 4 incorporates information about the cultural space, its protection and the means for its best management. The widely used Standard CIDOC-CRM is explained, together with four approaches of cultural management systems, which incorporate new technologies. The description refers to the Archaeological Cadastre of Slovenia, the Geographic Archaeological System of Rome, the incorporation of properties with monumental interest by the Dutch Cadastre and finally the Hellenic Archaeological Cadastre (HAC) Project. A detailed description of the special characteristics of the Greek archaeological space is also provided, as they are taken under consideration for the formation of the conceptual model proposed in this Thesis.

- Chapter 5 focusses on the adjustment of the LADM in the Hellenic Archaeological Cadastre. The proposed model is based on the codification of the LADM for the administrative and spatial classes and describes a standardized cadastral model for the three-dimensional representation of the archaeological space of Greece. Diagrams and codelists are implemented and presented with the aid of UML. The codelists of the classes include a variety of data for the properties in Greece and they follow the Hellenic Cadastre Standards, together with the legal framework for the protection of terrestrial an submarine antiquities. Furthermore three case studies are described in order to imprint the multiplicity of property rights that appear in the archaeological space. There is an extensive paragraph for the description of the legal, jurisdictional and technical requirements that are needed in order to adjust the third dimension in archaeological cadastral data.

- Chapter 6 includes the conclusions of this Thesis, regarding the proposed model and its benefits. Recommendations for reforms and future development of standardized interoperable systems are also presented.

2. Land Administration

2.1 The State of the Art

Land Administration (LA) is defined as the correlation of land and property development on it (Dale and McLaughlin, 1999). The management and administration of the land by government leads to the formation of a land policy by offering a tool for land tenure management and protection of the public property. Furthermore it can contribute to better land planning, control of taxation, security of real estate market and management of natural resources (Lemmen, 2012). In Land Administration Systems (LAS) all over the world we meet geographical information concerning land together with the legislative background of people to land relationships, e.g. inscriptive land rights in Greek National Cadastre.

The implementation of LAS means the management and interrelation of a big amount of data, which constantly changes. LAS are infrastructure that can be utilized by governments as a tool for the formation of land policies and land arrangement, always under the umbrella of sustainable development. For this reason it is important to mention the contribution of modern Information and Communications Technology (ICT). Systems and standards of Land Administration tend to be utilized for the successful integration of Land Use Policies (LUP) in both developed and developing countries. Standardized LAS are also developed for the best management of forests, coastal zones, cultural heritage, for the feasibility of land markets and taxation systems. The degree of their effectiveness mainly relates to the social needs that define how the integration of systems or standards can be accomplished, for instance the financial situation, the flexibility of the legal framework in modern needs of Land Administration (e.g. definition and integration of legal 3D property as mentioned before).

Cadastre is one of the most common types of land administration across countries. A modern cadastre means a registration system of information concerning land and the property rights associated with it. The implementation of cadastres is based on a model that records all the descriptive information of properties, such as rights, restrictions and responsibilities as well as their spatial representation based on spatial parcels.

Cadastral systems are defined as systems which have been developed focusing on management of cadastral registration. Until nowadays most countries around the world have implemented their own cadastral system. However, these systems are very different due to the purpose they serve, the structure and their orientation, always satisfying the needs of each country. For example, there are systems developed for taxation, systems performing title registration, deed registration, centralized or decentralized systems. However, cadastral systems follow the same principle; the registration of people to land relationships that comes from land property or land use. Each system created is dependent on the needs of a national cadastre and should be flexible enough to support in any time and with a precise manner queries, such as who is

responsible for the management of the system, what is the range of rights exercised in land property and how reliable all this information is (Zentelis, 2011). On this direction, modern cadastral systems incorporate sufficient models for supporting a plethora of legal, administrative and spatial queries, so as to transact the continuous flow and alteration of property rights.

Cadastral systems' efficiency is affected by the evolution of technology as they are based on Information and Communications Technology (ICT). Database systems together with Geographic Information Systems (GIS, systems of collection, processing and management of geographic information) have contributed to detailed registration of legal information and possibilities of spatial and topological representation of cadastral records.

2.2 Standardization

The international trends promote the development of standards in the field of spatial data management. Standards are based on the utilization of a common language. According to the SDI Cookbook standards incorporate terminology, this involves the simultaneous consideration of three inextricably linked processes:

- The identification of a concept
- The nomination of a term for that concept
- The construction of a definition for that term that unambiguously describes the concept

The three processes are guided by the objective that, for each concept, there will be a single term-and vice-versa-and for each term there will be a single definition-and vice versa-. Today many standards define Land Administration (LA) in general and modeling cadastral systems as well. The utilization of standards aims to the achievement of interoperability and dissemination of information with common practices between different administration systems. Working within a common framework of standards and tools based on standards also makes it possible to maximize the impact of the total available resources for SDI creation through future co-operation (The SDI Cookbook, 2008). The structure of standards is based on the identification of objects, transactions and relationships between them. Standards support non-centralized systems and describe spatially the geometry of land parcels, leading to the implementation of a common Spatial Data Infrastructure (SDI) concerning information infrastructure for spatial and non-spatial registrations (Dimopoulou and Gogolou, 2013). The data model is the core of a standard. Data circulate using shared terminology and that enables communication between the stakeholders or involved parties. The development of appropriate software for successful cadastral flow and exchange is also important. Most standardized systems are based on a Model Driven Architecture (MDA), which means that models are constructed to be efficient and flexible enough to changes such as addition of extra details or fields to the basic conceptual model or even structural

conversions to the initial entities. As Lemmen (2012) proposes, standardized LAS should make distribution of cadastral data between countries or municipalities easier and should support data quality management so as inconsistencies and double registrations can be avoided.

Effective standardized LAS, such as land registries or national cadastral systems must be able to satisfy the demanding needs for efficient and transparent transactions in combination with the different expressions of people-to-land relationships across borders. Different factors such as the customary law, the different perception of public and private property, as well as the various property rights related with them, the valuation systems and the existence (or not) of a complete and functional cadastral system can affect the successful development of modern LAS. In the opposite, the implementation of successful and efficient land registries or cadastral systems requires the adoption of modern technologies and the integration of LAS on their conceptual model. This fact depends on the degree of flexibility of the interested institutions and the adaptability of the experts and scientists involved to new technologies and trends. All standards developed do not serve all countries' national needs for land registration, thus every interested national organization should study and consider which standardized toolbox will fit better to its own demands.

Standardization of spatial data is much better addressed over the last years due to the extensive work of the International Standards Organization's Technical Committee 211 (TC/211) which is *creating "a structured set of standards for information concerning objects or phenomena that are directly or indirectly associated with a location relative to the Earth"* (http://library.oceanteacher.org). The real contribution of the ISO TC/211 is the development of 40 standards of Geographic Information related to the management of spatial data in land territories.

The Open Geospatial Consortium (OGC) is an international good practice adopted by institutions and organizations in order to support interoperable solutions for the dissemination and exchange of spatial data on the Web. Geospatial interoperability is the main mission of the consortium. OGC is an international industry consortium of companies, governments, agencies and universities participating in a consensus process in order to develop publicly available interface standards (OGC Standards). OGC Standards empower technology developers to make complex spatial information and services accessible and useful with all kinds of applications (http://www.opengeospatial.org/). OGC is an initiative developed with Open Source GIS. Open code and free software, such as MAGIC and PostgreSQL (PostGIS) characterize the Open Source GIS. Web Mapping Services (WMS) and Web File Services (WFS) for the visualization of different types of spatial data can be produced with the utilization of Open GIS.

Extensions of the HTML (Hypertext Markup Language) such as XML can be considered as standardized practices aiming to the interoperability of spatial data. XML (Extended Markup Language) is used to web-based applications and is generally met on the Net in order to classify the massive flow of spatial datasets and for conveying semantic content

of information. XML is a capable language for structural definition documentation including metadata. In recent years work has been completed for the extension of XML to coastline and marine data representation (MarineXML). Other standards developed for marine and coastal data include the Special Publication No. 57 (S-57) which was developed by the International Hydrographic Organization (IHO) International Hydrographic Bureau (IHB) in 1996. S-57 is considered to be a transfer standard for the digital collection and exchange of hydrographic data among national Hydrographic offices. The basic model is a combination of hydrographical data charts and an Electronic Nautical Chart (ENC), appropriate for navigation and monitoring.

2.3 Spatial Data Infrastructure (SDI)

In recent years governments of many countries have been engaged to the obligation of dealing with big amounts of data that occur from many socieconomic problems. Regional and national planning is in need of rethinking as new data for spatial components have appeared. Business development, crime reduction, environmental conservation and natural disasters are some of the various categories with spatial reference. Infrastructure that concerns the successful management of spatial data has already been implemented for this purpose. The development of Spatial Data Infrastructure (SDI) responds to global needs of facilitating access, exchange and effective dissemination of spatial data. SDI aims to the capturing, assessing and sharing of many types of spatial data from and between different stakeholders. Spatial data are classified in different sets with sufficient information about their nature, their purpose and utility. Metadata, searching possibilities (querying), visualization and production of web services are some of the provided products of a successful SDI.

Definitions for Spatial Data Infrastructure (SDI) differ around the world. In Australia SDI, includes the people, policies and technologies necessary to enable the generation and use of spatially referenced data through all levels of government, public and private stakeholders and academic institutions. In USA the SDI implementation is under the responsibility of the Federal Geographic Data Committee (FGDC). The FGDC in collaboration with the Global Spatial Data Infrastructure (GSDI) community has enabled SDI builders by promoting instructions under the name “The SDI Cookbook”. According to the SDI Cookbook the SDI provides a basis for spatial data discovery, evaluation and application for users and providers within all levels of government, the commercial sector, the non-profit sector, academia and by citizens in general. In Europe the INSPIRE Directive includes metadata, spatial data sets and spatial data services; network services and technologies; agreements on sharing, access and use; and coordination and monitoring mechanisms, processes and procedures, established, operated or made available in accordance with legislation. Stoter (2004) gives another approach by matching SDI with Geo-Information Infrastructure (GII) which is often used to denote the collection of technologies, policies and institutional arrangements that facilitates the availability of and access to geo-information to the benefit of many users. A GII consists of the following four components according to Stoter (2004):

- geographic data;
- technology for storing, access, distribution and use of geo-information;
- standards for describing, exchanging and linking geo-information;
- policy and organization

A distributed set-up of registrations within a GII provides the possibility to link information maintained in different databases.

There are many initiatives around the globe for the implementation of SDI. Efforts are made in national level, which is a result of formal mandate of governments, or in international context, which is largely achieved through the collaboration and exchange of data of different and private spatial data providers. National or international initiatives that combine GIS with spatial databases, decision-making tools and web services can be proved more effective and functional in addressing spatial-based problems. Spatial data are collected and classified on different datasets. According to Aalders et al (2001) there are two types of utilization of datasets; the entire data transfer from the provider to the user and the mere data transfer, which means that the resulting images of the datasets are transferred, a fact that gives the provider the advantage of reuse of the dataset. Providers of datasets can be defined as the actors that produce and share datasets of detailed data for specific spatial components. These actors can be non-profit and educational organizations that produce geographic data and provide GIS-related services, public services that have developed regional or national datasets as a result of their collaborative efforts and private companies that produce spatial data on both national or international scale and sell the Web-related or GIS-related services. When SDI is developed on a national scale, datasets are completed by a qualified national organization. Datasets of basic national layers are incorporated such as large scale topographic data, cadastral data, elevation data, national co-ordinate system and all the spatial data that refer to national subdivisions of regions. As a first task, the type of spatial data, meaning their classifying features and their content should be specified. Procedures, technological means and technical experience can be assisting to the integration of datasets, together with coordination of institutions for the maintenance and update of datasets. This can lead to the formation of datasets that include basic features, e.g the national coordinate system or to datasets that incorporate international agreements or guidelines, eg. The matching of national cadastral parcel with the cadastral parcel proposed by the INSPIRE Directive for countries-members of the European Union (EU). On an international context systems can be enhanced by the collaboration between public services and private institutions. Terminology and shared vocabulary can support this effort and promote the semantic compatibility of the systems. Thus, the incorporation of standards in the structure of systems as well as in the structures of metadata is necessary.

Metadata is also important information that occurs after the formation of datasets. Metadata translates as data about the data and include details for the original data, their route and their changes. Therefore, they provide valuable information referring to the attributes of datasets. As Aalders et al (2004) describe, metadata may exist at different levels of abstraction:

- collection level, e.g. descriptions of the characteristics of whole topographic or thematic maps series or datasets;
- product level, e.g. describing the characteristics of photographic images or mosaics;
- data unit level, e.g. giving information about the way a dataset is organized as a vector or raster dataset;
- object group level, e.g. describing attributes and class characteristics of similar objects in a dataset for instance all buildings in a dataset;
- instance level, e.g. describing characteristics specific instances of an object appearing in a database as the descriptions of a specific road.

Furthermore, metadata is an essential requirement for geospatial data, as they provide evaluation of the available data. This fact has many reflections, as they can be an assisting tool to new projects launchers, land administrators, environmental protectors, city planners and other experts in sense of provision and assuring of better results. Benefits of adoption of standards are pretty obvious. They assure that there is a strong structural basis for the development of national or discipline-oriented profiles. They also enable consistency in metadata forms and content, thus the compatibility and exchange of data between different systems can be examined thoroughly. Standards for metadata are widely used, with the most important being the Dublin Core, ISOs for Geographic Information and the Open Geospatial Consortium (OGC).

2.3.1 Marine Spatial Data Infrastructure (MSDI)

The marine environment is a space where various jurisdictions coexist. Williamson et al (2010) refer that the interests of every State are not limited to the terrestrial and maritime borders, but they also refer to the maritime environment. Colier et al (2001) state that there is an increasing realization that the interests of a nation do not stop at the land-sea interface. Activities in the sea include navigation, fishing, and protection of the submarine life, leisure activities and exploitation of natural resources.

Over the last two decades countries with maritime borders and extensive coastline have made significant efforts for the sustainable management of their offshore space. These efforts have resulted to the development of national Marine Spatial Data Infrastructure (MSDI). Leading countries in the administration of the marine environment such as Australia, USA, Canada and the Netherlands have already developed such infrastructure by applying international good practices of Marine Administration Systems (MAS). A Marine Administration System (MAS) can be defined as an information system for the recordation, management and spatial representation of all the jurisdictions, sovereignties and limitations that appear in the maritime environment and which are subjective to strict

legal frameworks and can be exercised by specific stakeholders.

The most common implementation of MAS is the Marine Cadastre. In general a Marine Cadastre is a fully supportive multipurpose tool for MSDI. It supports Marine Spatial Planning (MSP) for the socioeconomic and ecological uses of the maritime environment and also it enables Coastal Spatial Data Infrastructure (CSDI). Furthermore, it provides legal information concerning the jurisdictional boundaries of the coastal State and the types of jurisdictions that are exercised inside those boundaries. Therefore, it can be defined as a system that spatially describes the limits of registrable maritime rights and interests, their contradictory relationships and the involved parties. Maritime cadastral systems should operate under a national legal framework which is in the context of UNCLOS. Fraser et al (2003) also define what a Marine Cadastre can serve for Australia: The specific purpose of a national marine cadastre will be to handle the definition, administration and maintenance of boundaries in the marine environment in accordance with international, national and state legislation. Accordingly, the design of a marine cadastre must reflect the legal regime for defining areas of rights restrictions and responsibilities rigorously and unambiguously.

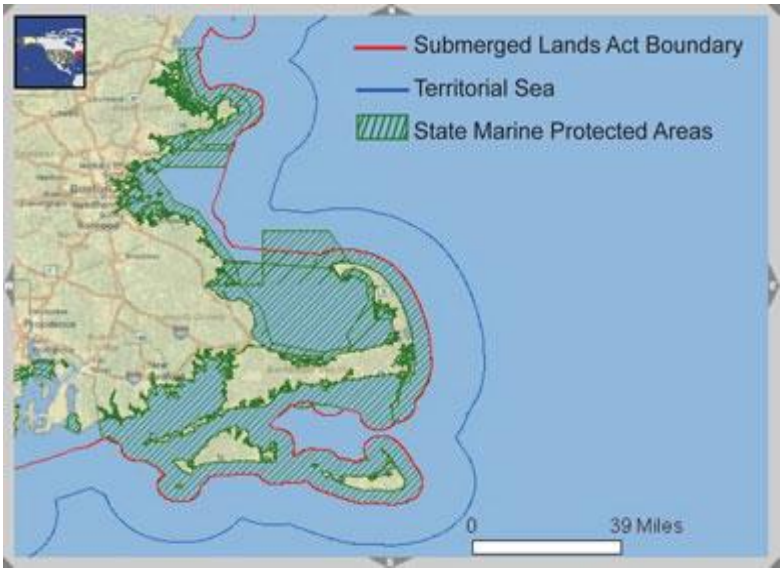


Figure 1, Layers of a Multipurpose Cadastre, (source www.fgdc.gov/)

There are many approaches of the purpose of a national Marine Cadastre. United States of America face the maritime and coastal environment management as interactive with each other. Thus, they have defined the Coastal and Marine Spatial Planning (CMSP) as a comprehensive, adaptive, integrated, ecosystem-based, and transparent spatial planning process, based on sound science, for analyzing current and anticipated uses of ocean, coastal, and Great Lakes areas (Federal Regulation 43023, 2010). CMSP aims to the reduction of conflicts among uses and of environmental impacts, to the facilitation of compatible uses and to the preservation of critical ecosystems. Jurisdictions of the coastal State reflect the rights and restrictions that appear in the maritime environment. The most important jurisdiction of the coastal State is the exercise of sovereignty over maritime zones, waters and coasts. The extent and type of sovereign rights depend on

the marine zone in which they are exercised. Sovereignty is not equal with ownership associated with land properties. Other types of jurisdictions recorded are interests, such as functional interests that express transaction of economic nature and environmental interests, which express the right for protection and scientific research on natural resources, submarine environment and cultural heritage. The three-dimensional spatial representation of the marine space is absolutely imposed, as marine objects such as the water surface, the water column, the seabed and the subsoil coexist and form various overlaps. Incorporation of additional types of geospatial information is also suggested for the better management of marine and coastal problems (geological, biological, hydrobiological, archaeological data, etc.).

Different systems for marine administration function under the legal framework which is a combination of national legislation, special marine constraints and international guidelines. The most important legislative tool for the marine management is the United Nations Convention on the Law of the Sea (UNCLOS, 1982). UNCLOS sets the legal status for the allowed activities that a coastal State can perform in the sea. In other words, it established the formal jurisdictional regime, under which a coastal State claims, manages and utilizes marine territories (Binns, 2004). Maritime zones are being defined by the convention, thus in each zone economic activities and constraints are also classified. There is an extensive description of the territorial sea, the air space over territorial sea and of its bed and subsoil. The Article 2 defines that*: "The sovereignty of a coastal State extends, beyond its land territory and internal waters and, in the case of an archipelagic State, its archipelagic waters, to an adjacent belt of sea, described as the territorial sea. This sovereignty extends to the air space over the territorial sea as well as to its bed and subsoil. The sovereignty over the territorial sea is exercised subject to the Convention and to other rules of international law."* Other economic zones defined in the UNCLOS are the contiguous zone, the Exclusive Economic Zone (EEZ) and the continental shelf UNCLOS also recognized the deep seabed, archipelagic waters and high seas, which are classified as international waters.

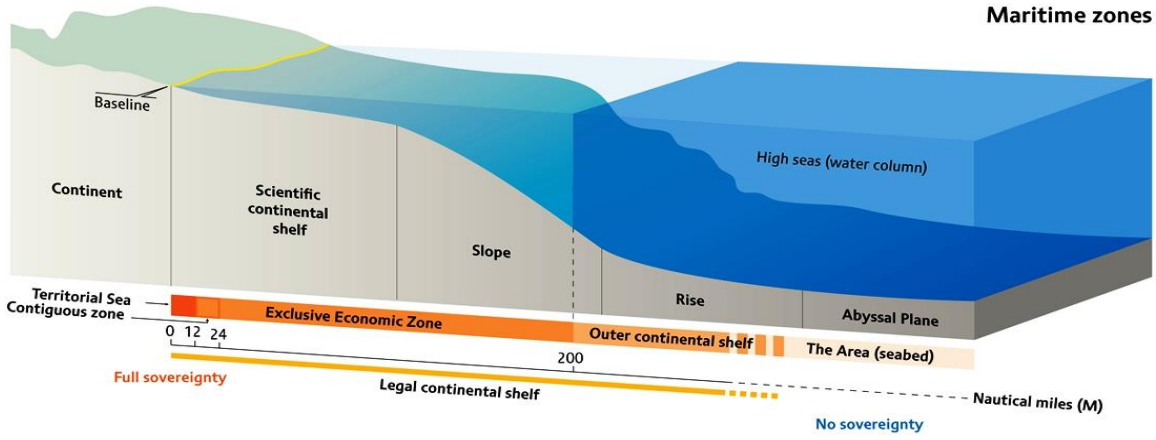


Figure 2, Graphic Representation of Maritime Zones, (source: Riccardo Pravettoni, UNEP/GRID-Arendal, 2009)

2.3.2 Coastal Spatial Data Infrastructure (CSDI)

Coastal Spatial Data Infrastructure (CSDI) reflects international efforts for the collection, classification, processing and dissemination of spatial data for the administration of marine and coastal regions. CSDI can contribute to successful Integrated Coastal Zone Management, through a combination of technologies, policies and institutional arrangements to improve data access and sharing processes (Gourmelon et al, 2012). Pioneer Australian institutions claim that CSDI mainly comprises data sources, standards, enabling technologies and institutional policies. Work in relation to the first two components needs to be carried out with a specific marine or coastal focus, which is sometimes missing from generic SDI initiatives. The latter two aspects apply to the wider requirements of any information infrastructure, not just that of coastal SDI or even for spatial data alone.

SDI Component	USA	Canada	INSPIRE-WFD	APSDI	GlobalMap
bathymetry	yes	yes	yes	maybe	maybe
shoreline	yes	yes	yes	yes	yes
marine cadastre	yes	yes	no	yes	maybe
coastal imagery	maybe	maybe	yes	no	no
marine navigation	maybe	yes	maybe	no	maybe
tidal benchmarks	maybe	maybe	yes	no	no
benthic habitats	maybe	maybe	yes-WFD	no	no

Figure 3, Coastal SDI Components in Regional, National and Global SDIs (source http://library.oceanteacher.org/)

Possibilities and limitations for the development of CSDI have been researched by leading countries in administration systems that have extensive coastal and marine territories, such as Australia and USA. Issues of interoperability between different components of SDI, eg on national or marine level, are amongst others the most important. Approaching the problem, most countries today have developed SDI that mainly covers terrestrial parts of land. In some degree policies have also included the administration of marine territories. The extension of such SDI to marine regions (MSDI) aims to the availability of data and to improvement of exchange of marine related data. The development of SDI based on different standards or policies will cause difficulty in managing the coastal zone. Therefore the initiative of developing a seamless SDI that can include spatial data from all environments should be further researched, as shown in the figure below.

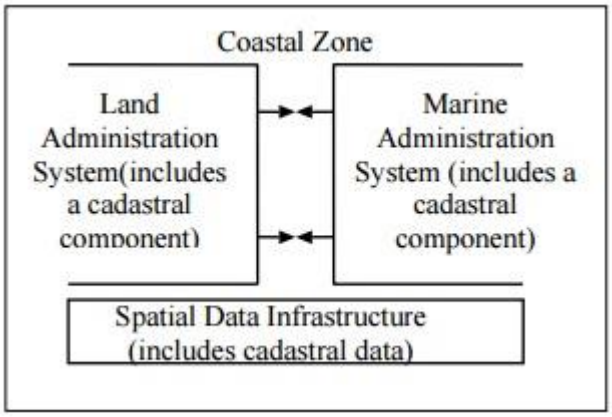


Figure 4, A Seamless Administration System (source: Strain L., Rajabifard A. & Williamson I., 2004)

Coastal zones are characterized by complex relationships between physical objects and are ruled by sensitive legal frameworks that include definitions related to the coast, ports, protection zones, environmental constraints, natural species behavior and guidelines concerning coastal engineering. Issues that CSDI cover are set by Gourmelon et al (2012), who conducted a research for the coastal management in Brittany, France. Issues of updating the shellfish cadastre, the quality of bathing water, the maritime and coastal regulatory framework, erosion, coastal flooding and use conflicts were set are prior for management. CSDI also refer to the implementation of systems for predicting, monitoring and assessing the permanent situation in coasts.

2.4 The Land Administration Domain Model (LADM)

The Land Administration Domain Model (LADM) is officially recognized as an ISO for geographic information since the 1st December 2012. The standard is developed to provide a conceptual model for the standardization of (existing or not) land administration and cadastral systems. Furthermore it aims to share an international code for describing land administration semantics under a basic framework.

The main scope of LADM is to define a reference model that will cover all the basic information- related components of Land Administration, including elements above, below and on the surface of the earth and those over water (Text for ISO/FDIS 19152). Land Administration terminology is also inside the scope of the standard. Terms arise from various existing LAS and aim to describe different practices and procedures in various jurisdictions.

The conceptual model is arranged in three basic packages and one subpackage as below:

- Parties, involving people and organizations that take part in all kind of transactions.
- Basic administrative units, including all the administrative information for

cadastral registrations.

- Spatial units, mostly representing parcels, legal space of buildings and utility networks.
- Rights, restrictions and responsibilities (RRRs), which mean property rights associated with spatial units.
- Spatial sources and spatial representations, such as geometry and topology of spatial units.

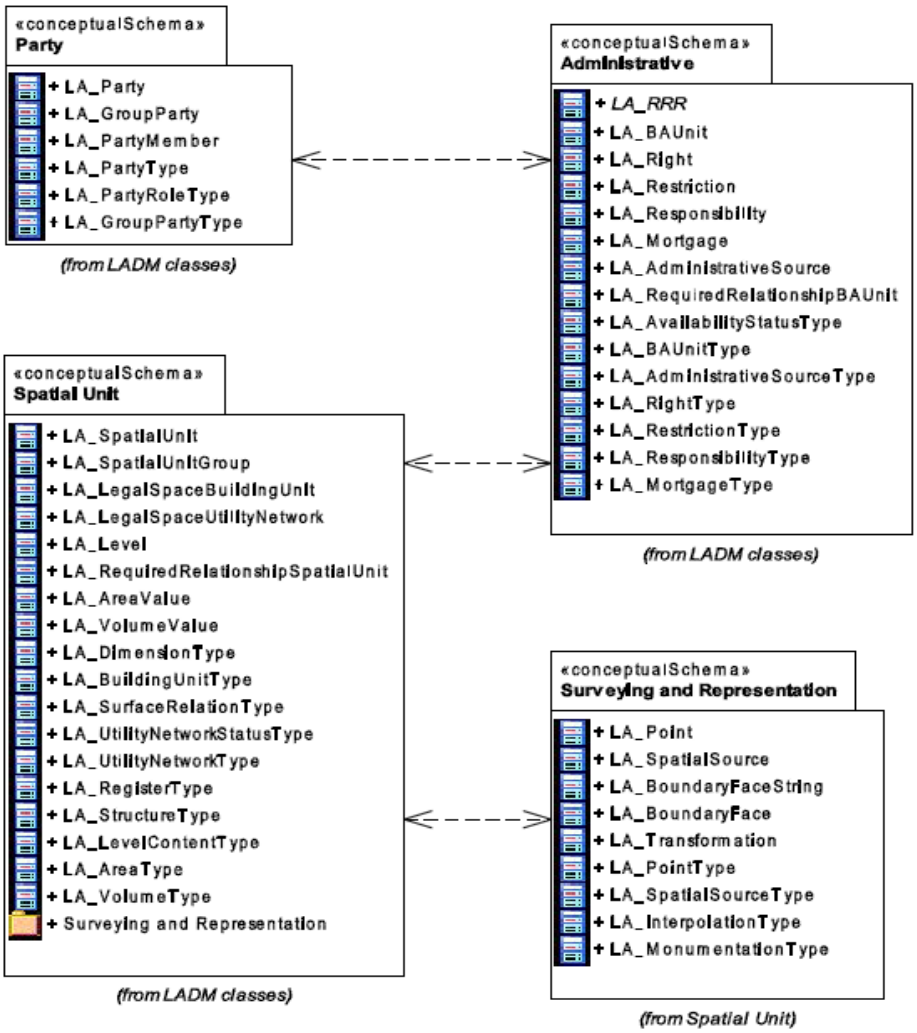


Figure 5, Packages and Classes of the LADM (source: Text for ISO/FDIS 19152 GI-LADM)

It is important to mention that applications of the LADM in a particular country means the implementation of a country's national or regional profile, which means that changes, new attributes or classes would be accepted or even needed on the basic conceptual schema.

In the core model of LADM all four basic packages are associated as below. Objects and classes are given the prefix LA_. So, as the schema presents below (Figure 1), the package of property rights, meaning rights, restrictions and responsibilities (LA_RRR) are associated with a spatial unit (LA_SpatialUnit) that belongs to a party (LA_Party). These RRRs include administrative information which means that there is information about the ownership status, transactions, constraints or jurisdictions represented with the administrative unit (LA_BAUnit).

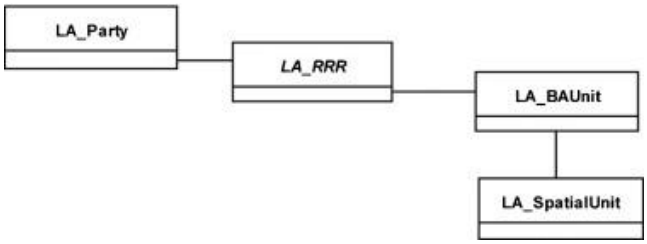


Figure 6, Basic Entities of the LADM (source: Text for ISO/FDIS 19152 GI-LADM)

The versioned object class is a special class that can be used in order to represent the cadastral database a single moment in the past. The class VersionedObject reconstructs maintained historical data given a certain time-stamp. Most of the classes of LADM can be subclasses of a VersionedObject stamp as the figure shows below:

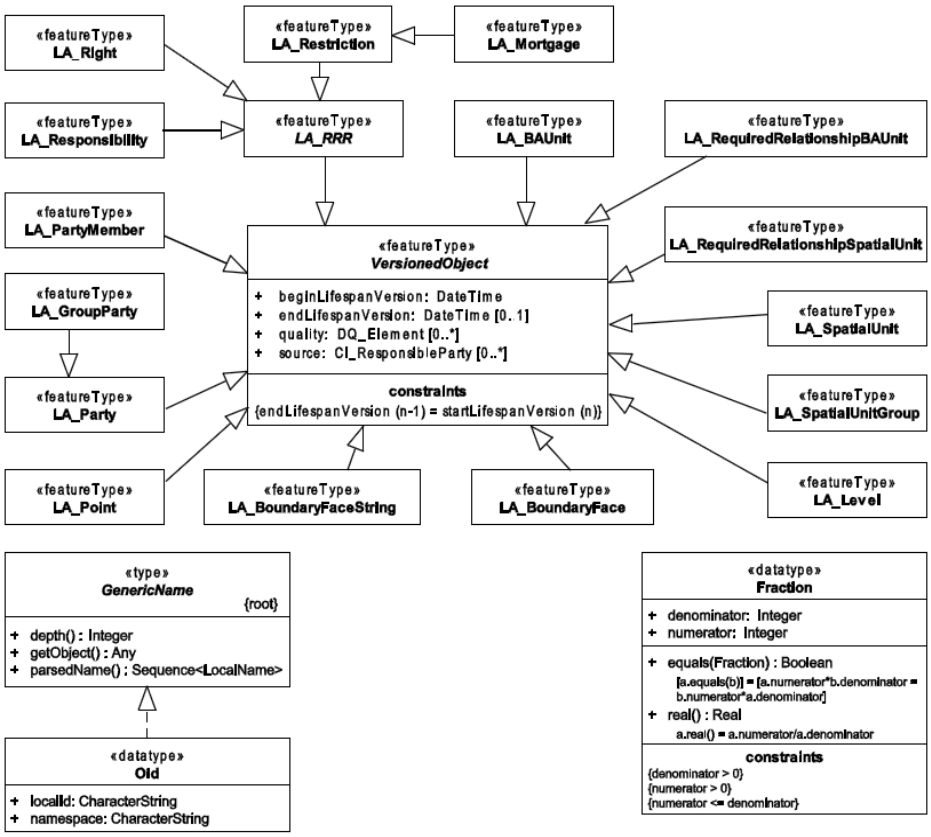


Figure 7, Versioned Object (source: Text for ISO/FDIS 19152 GI-LADM)

2.4.1 The Party Package

A party (LA_Party) is a physical person or an organization, eg a company, the State, a whole tribe, that takes part in a transaction with land property rights. The most common attributes registered for the party are the unique identifier of the Party, the name of the Party, the role of the Party (LA_PartyRole), the type of the Party (LA_PartyType).

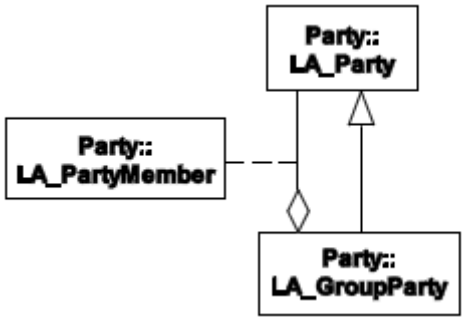


Figure 8, Classes of the Party Package (source: Text for ISO/FDIS 19152 GI-LADM)

2.4.2 The Administrative Unit Package

A basic administrative unit (LA_BAUnit) represents an entity which includes all the descriptive information concerning land ownership rights. It is subject to the legislation that refers to the registration of property rights, restrictions and responsibilities in each national land administration or cadastral system. The basic administrative unit has a spatial reference via the spatial unit.

The Administrative Unit Package is referred to two classes, class LA_BAUnit and class LA_RRR. Class LA_BAUnit describes the ownership status of properties through the class LA_AdministrativeSource. The administrative sources (Class LA_AdministrativeSource) can be deeds, titles, laws, mortgages, acts of the State and all formal documents that prove property for a party. Administrative sources describe the rights, restrictions and responsibilities associated to a basic administrative unit. Class LA_RRR is an abstract class that represents the three categories of property rights as described below:

- Class LA_Right, which mainly describes ownership as referred to each national legislation. For example in Greek Legislation there is full ownership and limited ownership associated with property. The content of LA_Right is explained with its attribute LA_RightType.
- Class La_Restriction is a class that introduces constraints in the rights exercised on land properties. Restrictions arise from the formal obligation to avoid doing something related to land property. Constraints reduce the power of property status of the owner and introduce hurdles to the free use of property. For

example, in Greek legislation urban planning laws may forbid constructions within special buffer zones of forests or archaeological sites. The attributes needed for the descriptive (and also spatial) representation of restrictions are the required party (LA_PartyRequired) and the type of the restriction (LA_RestrictionType).

- Class LA_Mortgage is a subclass of the class La_Restriction and is associated to the class LA_Right. This means that the rights are the objects of mortgages.
- Class LA_Responsibility refers to the responsibility of the owner to do something.

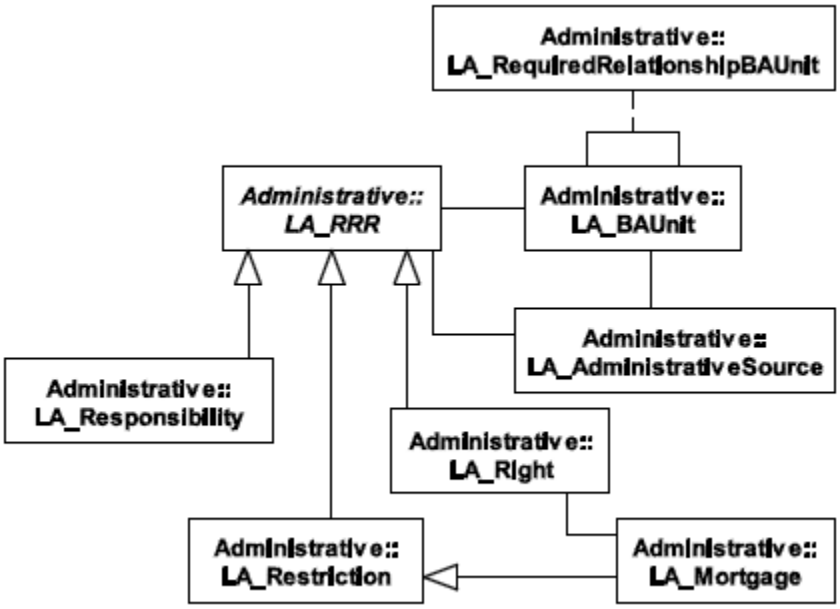


Figure 9, Classes of the Administrative Unit Package (source: Text for ISO/FDIS 19152 GI-LADM)

2.4.3 The Spatial Unit Package

The Spatial Unit Package consists of the main classes for the geometrical description of spatial units:

- Class LA_SpatialUnit is represented through the alias LA_Parcel. The spatial unit is an area of land or water or a simple or complex defined space. There are two types of the class: the LA_SpatialGroup, which can represent larger spatial unit groups of parcels and the LA_Level, which describes a level of thematic or geometric cohesion. In spatial parcels there can be further representations of objects such as buildings (floors, parking spaces) and utility networks (pipelines, special constructions cables) with their boundaries. Those objects appear as special classes in LADM.
- Class LA_LegalSpaceBuildingUnit refers to buildings and their legally recorded or informal space and

- Class LA_LegalSpaceUtilityNetwork. Refers to utility networks and their legally recorded or informal space

For the description of explicit spatial relationships between the spatial units there is the class LA_RequiredRelationshipSpatialUnit. It is used when there is not enough information about the geometry of spatial units in cases of overlapping objects, eg spatial representation of easements or spatial design of a building that is not inside the boundaries of a spatial parcel.

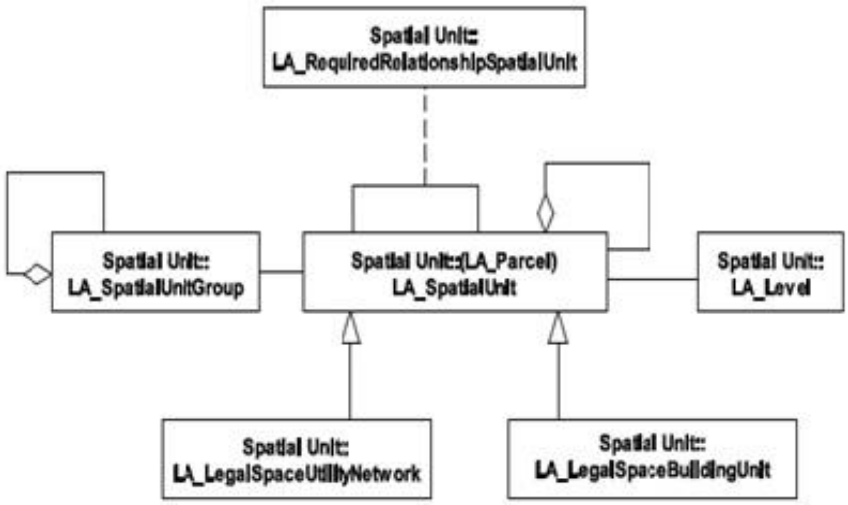


Figure 10, Classes of the Spatial Unit Package (source: Text for ISO/FDIS 19152 GI-LADM)

2.4.4 Surveying and Representation Subpackage

This subpackage is assisting to the Spatial Package described above and consists of classes for the technical representation of the spatial units. It is worth mentioning that there is a class for the description of the third dimension of spatial units:

- Class LA_Point includes points, lines and surfaces that can be acquired with classical or modern surveying methods or compiled from spatial sources such as topographic maps and sketches. The objects represented with the LA_Point can be utilized to the identification of spatial units in orthophotographs, aerial images and maps.

- Class LA_SpatialSource includes all the spatial sources registered for the identification of spatial units. These can be documents related to survey, such as a topographic diagram, an aerial photograph or a part of an urban survey. Spatial sources can be formal or informal documents and play an important role in a land administration system. Spatial sources are related to the objects of the class LA_Point and to control points in space, which can be expressed in a formal coordinate system supported by the LADM.

- Class LA_SpatialSource is a subclass of the general abstract class LA_Source.
- Class LA_BoundaryFaceString represents a two-dimensional aspect of a spatial unit.
- Class LA_BoundaryFace represents the third dimension on a 2D registration of a spatial unit. The LADM does not put additional burden on already existing 2D representations and by introducing LA_BoundaryFace there is no mismatch between 2D spatial units and their 3D representations (Text for ISO/FDIS 19152, 2012).

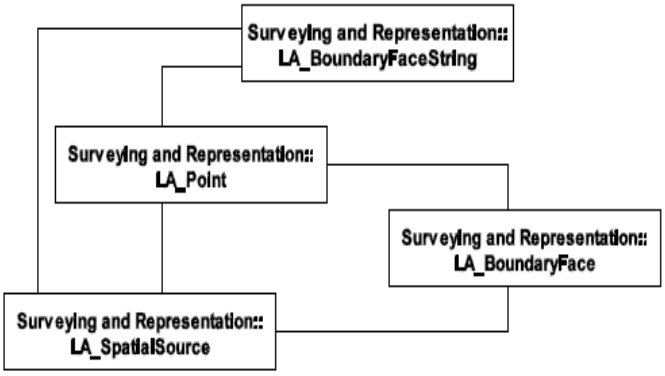


Figure 11, Classes of the Subpackage of Surveying and Representation (source: Text for ISO/FDIS 19152 GI-LADM)

2.4.5 Code Lists

The attributes of every class are imprinted with the aid of code lists. Code lists aim to allow the utilization of regional, national or international terminology that is relocated to elements and information about the entities of packages and subpackages. For example, the code list of class LA_Right in the Basic Administrative Unit Package describes the different types of rights such as ownership, common ownership, condominium, etc. together with extra attributes such as the unique code of right (based on the LADM codification).

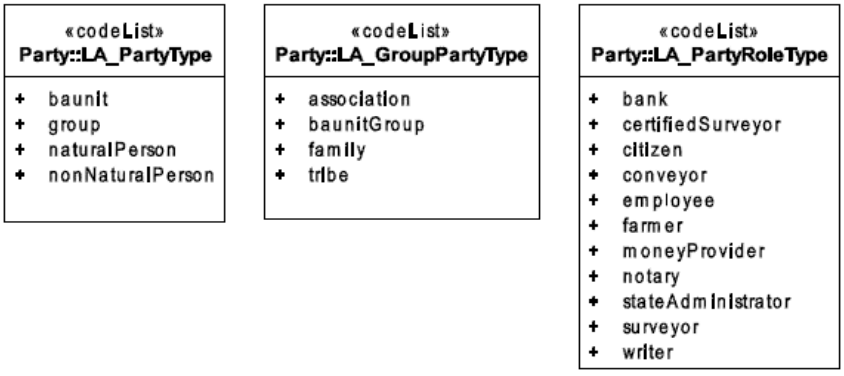


Figure 12, Codelists for the Party Package (source: Text for ISO/FDIS 19152 GI-LADM)

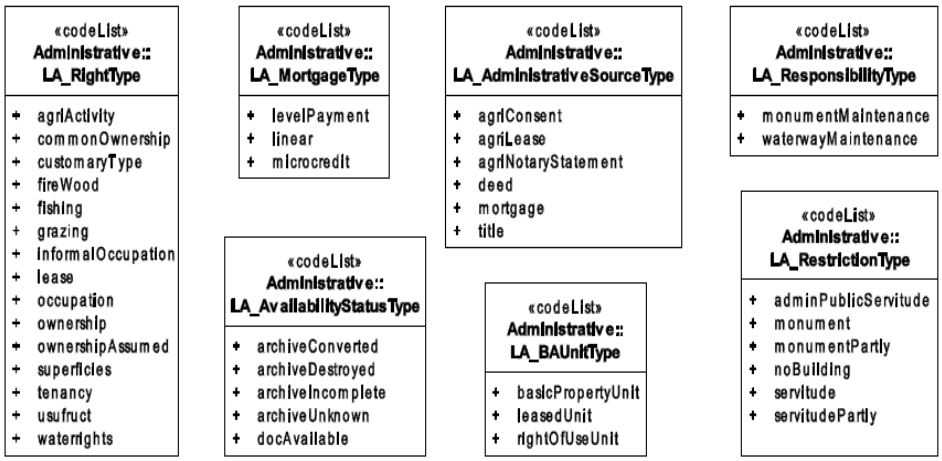


Figure 13, Codelists for the Administrative Package (source: Text for ISO/FDIS 19152 GI-LADM)

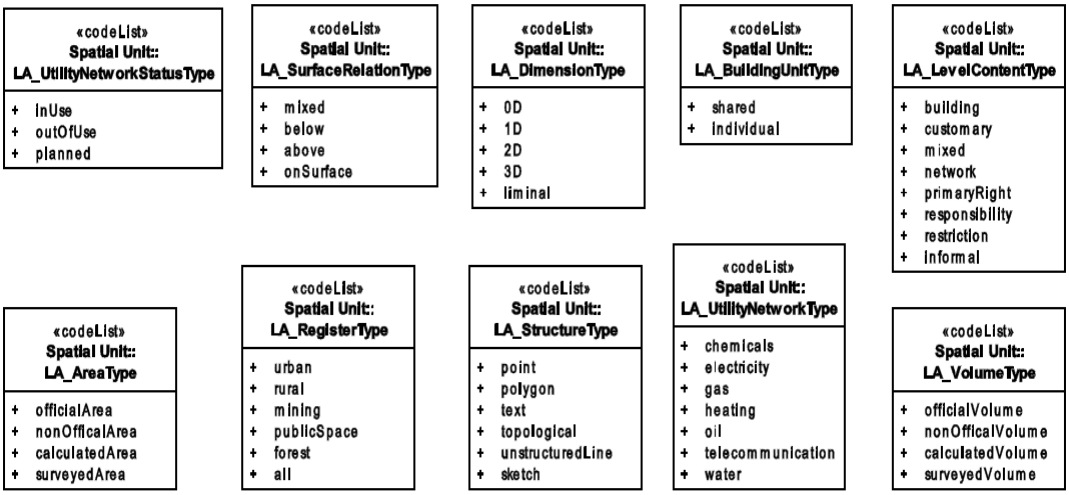


Figure 14, Codelists for the Spatial Unti Package (source: Text for ISO/FDIS 19152 GI-LADM)

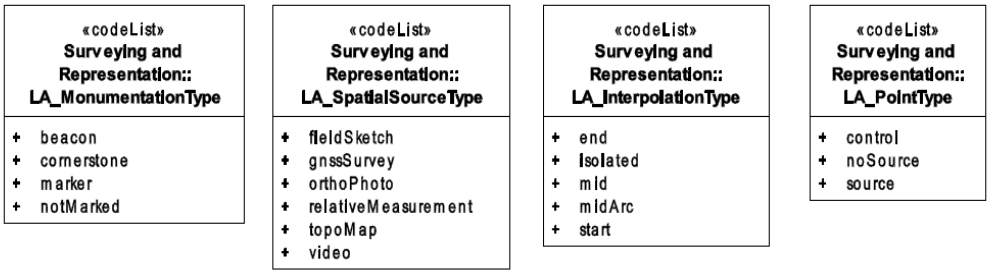


Figure 15, Codelists for the Subpackage of Surveying and Representation (source: Text for ISO/FDIS 19152 GI-LADM)

2.4.6 Interface classes

They are additional classes to the basic proposed conceptual model supportive to the management of the final product and services. The interface classes can be formed by the user of the conceptual model or the specific profile based on the LADM:

- Class LA_Portfolio produces information for the classes LA_RRR, LA_BAUnit and LA_SpatialUnit related to a specific party (LA_Party). The class represents a cadastral table of parties in the system.
- Class LA_SpatialUnitOverview produces information for the classes LA_RRR, LA_BAUnit and LA_Party related to a specific spatial unit (LA_SpatialUnit). The class represents a cadastral table for all spatial units in the system.
- Class LA_RegionalMap, which is actually a cadastral map that provides information about the spatial units of a specific region in levels. If there are no levels defined in the system, the map shows all the spatial units of the region.

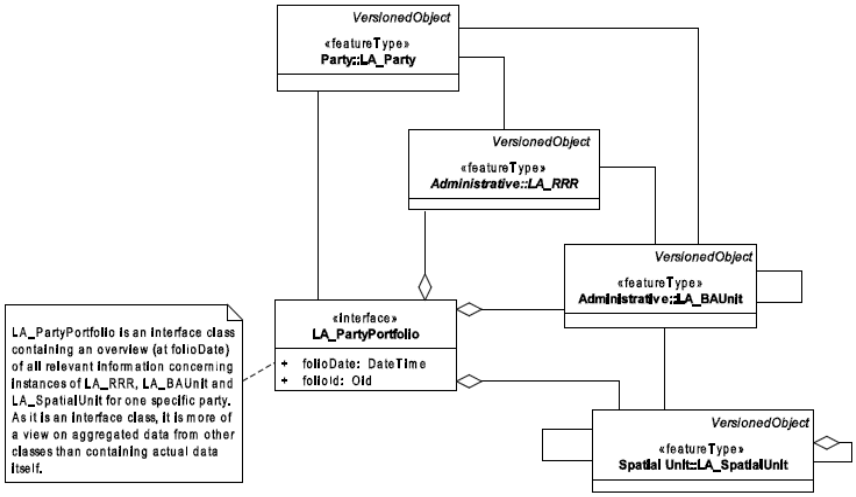


Figure 16, Interface Class LA_PartyPortfolio (source: Text for ISO/FDIS 19152 GI-LADM)

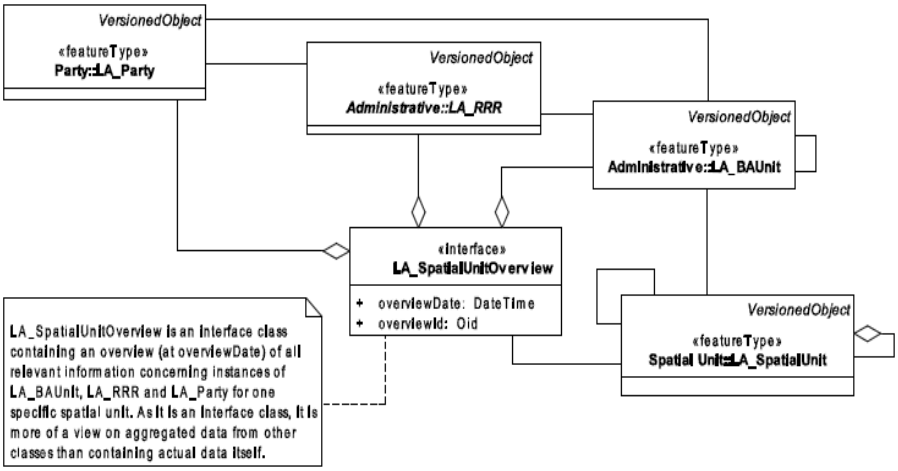


Figure 17, Interface Class LA_SpatialUnitOverview (source: Text for ISO/FDIS 19152 GI-LADM)

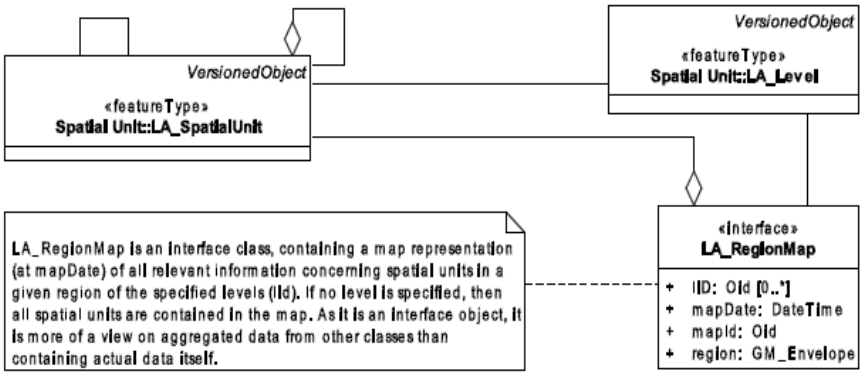


Figure 18, Interface Class LA_RegionalMap (source: Text for ISO/FDIS 19152 GI-LADM)

3. Three-Dimensional Cadastres

3.1 Need for a 3D Cadastre

Over the last decades the situation in urban regions has changed radically. The phenomenon of urbanization has led to overpopulated areas and in many countries to the formation of mega cities. In such regions, needs (of every aspect) have been multiplied. It is clear that space uses and land management are in need of a new perspective, concerning urban plans, constructions and utility networks. In other words properties and all the related features are in need of a protective and regulatory framework for their successful management. A complex urban situation means that different property objects appear. Therefore, a variety of property rights is associated with these property objects. On this direction cadastral systems and also land registries are in challenge of providing special information for the nature of the properties and the rights. New attributes incorporate spatial information of the third, the fourth or even the fifth dimension of properties. As Stoter (2004) refers, the challenge is how to register overlapping and interlocking constructions when projected on the surface in a cadastral registration that registers information on 2D parcels. Although property has been located on top of each other for many years, it is only recently that the question has been raised as to whether cadastral registration should be extended into the third dimension.

Today cadastral systems aim to the management of properties by registering their legal and technical information concerning the rights associated with them. Property rights can be associated with different parts of space. The growing demands for 3D spatial representation of cadastral objects are based on a number of factors. Private property values and national valuation systems are increasingly making use of the third dimension in order to calculate the commercial values. Apart from that, in modern cities, there are many complex constructions below, on and over the surface of the earth or underwater usually not recorded in conventional 2D cadastral systems and demand a multilevel registration. In such constructions appear different and contradictory property rights or constraints, in several parts of land (or not), which means that they have (or not) spatial dimensions on the ground. Therefore, such rights or restrictions are not necessarily associated with a unique parcel. Many types of these rights are in need of recording of the third dimension, which translates to the volumes or the depths above or below the surface of the earth (or water). These constructions can be multi-level buildings, balconies, tunnels, bridges, underground railways or highways, cables, parking spaces, utility networks, special property objects such as ancient ruins of cities and marine parcels, which impose the need or representing the third dimension. Therefore, there is an ultimate need for a three-dimensional registration of property objects. This need lays to the fact that traditional two-dimensional cadastres cannot register details of special parcel or non-parcel based property rights in terms of spatial and legal representation. As Stoter (2004) concludes, a 3D Cadastre should cover the need for:

- Registration of 3D information on rights (what is the space to which the person with a real right is entitled) and making this information available in a straightforward way
- Establishing and managing a link with external databases containing objects of interest for the cadastre (infrastructure objects, soil pollution areas, forest protection zones, monuments) that will incorporate the location (and other information) of these objects in the cadastral registration.
- Utilization of the information in order to support registration tasks, for example to detect and correct errors or in the process of registering and viewing the legal status of 3D situations. Are all intersecting parcel encumbered with a right for the infrastructure object?

Development of 3D reality in other scientific fields, such as 3D modeling and 3D GIS has enabled the possibility of implementing 3D cadastral objects, at least at a technical level. Furthermore research on spatial querying and 3D visualization of geo-objects using web technologies has resulted in several prototype systems.

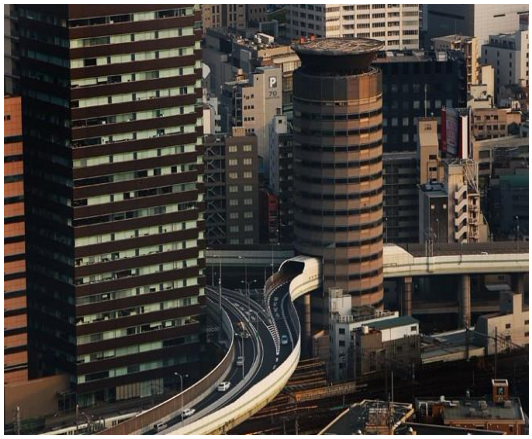


Figure 19, The Gate Tower Building in Osaka, Japan (source www.dailymail.co.uk)

Apart from the spatial representation, there are multiple land rights and restrictions exercised on those special property objects, the management of who is one of the most important challenges that land administration systems face today. As Rajabifard et al (2011) refer that *"a 3D Cadastre should be capable of storing, manipulating, querying, analyzing, updating and visualizing 3D cadastral objects and their associated land rights, restrictions and responsibilities".* Elias and Dimopoulou (2012) set the categories of the property rights that appear in the above constructions or in other special property objects:

- Airspace rights, a relatively new type of development rights that refer to the 3D space above a property, which can be reasonably used or occupied. Airspace ownership has to be legally limited and 3D displayed, not to interfere with air

travels, as derived by the aviation law.

- The “building-within-a-building” is a new concept in the commercial office market (of New York) that recaptures and exploits spaces in office towers that were not fully used, in order to accommodate different tenancies benefiting separate entrance and minimizing costs.
- Rights to exploit mines and produce minerals lying below the surface of the property, depending on each jurisdiction.
- Littoral and riparian water rights in front of properties, according to relative national legislation.
- Special constructions above or below freeways, railroad tracks, such as bridges, tunnels etc.
- Telecommunication and electric conduits and utilities on land ownership.
- Rights that comply with zoning and planning regulations for urban growth, management and protection of environment and cultural heritage.

Proceeding to a 3D Cadastre is gradually necessary in short-term and absolutely essential in long-term (Papaefthymiou et al, 2004). The necessity for the development of 3D Cadastres can lead to better results in the cadastral registration, such as registration of rights of volumes, as the third dimension of every space will be explicitly represented and to functional and accessible legal status of 3D objects, including all their legal and jurisdictional constraints.

3.2 Adjustment of Cadastral Systems in 3D Registration

Traditional cadastral systems support functions for a two-dimensional registration of spatial information. According to Papaefthymiou et al (2004) the current development in social, technological and economic aspects of modern life require cadastral systems with 3D enabled geometrical and topological models for property registration. The spatial representation of both vertical and horizontal dimensions means that cadastral systems should incorporate a sufficient model that will technically support the third dimension and the regulations needed for the acquisition, modelling and representation of 3D data, as well as the reforms needed on a legislative level in order to support defining the legal aspects of 3D property objects. The integration of such descriptive and spatial information into a national cadastral system is considered both technically and legally as a very challenging task (Elias and Dimopoulou, 2012). Of course, each country should adopt different standards on both legal and spatial level, transforming its cadastral system in 3D in order to register the different property objects together with the land rights exercised on them. There are three frameworks that need to be taken under serious consideration for the successful incorporation of the third dimension in the existing cadastral systems, according to Stoter (2004):

- The jurisdictional framework, which is related to the establishment of the legal

status of 3D objects, to the delimitation of 3D objects ant to the types of property rights associated with them

- The cadastral framework, which is related to the main tasks of a cadastre, such as the registration of the rights of 3D property objects and the ways of providing information on the legal status of them
- The technical framework, which deals with the conceptual schema and the database architecture and with what is needed to support cadastral registration of 3D property objects concerning software hardware and data structures. It is also related to the capability of maintaining large amounts of spatial data.

Discussing about conceptual schemas and data architecture, it is important to say that the initial structure of a cadastral system will enable the three-dimensional representation. A modern 3D supporting cadastral system should incorporate:

- a 3D cadastral data model that will be able to accept primary data for the 3D representation of objects and
- a 3D cadastral representation and registration model. That means that the database system should be designed based on standards and regulations (set by each country) that will support the various aspects of the descriptive information of 3D data (e.g. parallel representation of multiple ownership rights exercised on different heights belong and on earth), together with special tools for the spatial implementation of the third dimension.

A combination of the above is absolutely necessary in order to develop a flexible and functional 3D Cadastre. As cadastral systems around the world have similar fundamental characteristics, directions for the adjustment of 2D to a 3D system can assist all institutions that are interested on the three-dimensional representation of cadastral records. However, it should be mentioned that many minor differences are present between cadastral registrations in different countries due to dfferent legislation and different implementation history. Overall, a 3D Cadastre should be able to deal with the complexity and difficulty of the urban reality. This fact means that an evolving cadastral system should incorporate changes and new techniques in order to add the third dimension to the existing data (both administratively and spatially). Furthermore it should be based on a clarified legal framework related to 3D objects and 3D ownership status. Adjusting two-dimensional cadastral records to the third dimension contains many legal constraints that have to be overcome in order to define 3D cadastral objects. The adaptability to international good practices is also important for a cadastral system, for example the adoption of international standards (ISOs), the possibilities of reconstruction of cadastral objects based on guidelines (INSPIRE), the efficiency for Land Administration etc.

The level of adaptability to the 3rd dimension is absolutely related to the initial data provided by the basemap. The quality of spatial information, such as the projection of the plane, the incorporation of the vertical plane the elevation and the depth should be sufficient in order to identify the spatial extend of objects and achieve a three-dimensional representation. Concerning the descriptive information, data should cover

all untypical situations (for both public and private parcels) with all the related conflicts, such as overlapping ownership, separate ownership in levels (or not), fragmented horizontal property, customary rights that need 3D representation etc. of course such data cannot be produced only by the basemap. Institutions that implement and maintain cadastral databases, which are usually national services, are responsible for the conduction of extra surveys in the field if needed, in order to receive sufficient primitive data for the three-dimensional representation of property objects.

3.3 Legal Constraints in the Development of 3D Cadastre

A national cadastral system should support an appropriate conceptual and operating model in order to include the third dimension. Property rights are based on multiple legal frameworks such as statutory, customary, case and local laws which co-exist, interacting with each other. The nature of property rights sets the framework for the formation of laws and the modification of property legislation in general, a fact that radically increases the tenure status confusion and the owners' uncertainty, especially the less favored in society. These results also affect the legal evolution and definition of 3D properties in a meaning that Rights, Restrictions and Responsibilities (RRRs) are associated with them. For example RRRs deriving from the horizontal fragmentation of property, such as condominium (division of ownership in different apartments or floors), demand the registration of 3D space, thus an efficient legal framework is required for both administrative description and spatial representation. Customary rights require caution, especially if the law is modified concerning 3D property. Customary law is still strong in different places around the world and keeps control of relations between the members of a society and also in ownership of properties. Customary rights are among others an important reason for the implementation of 3D cadastres. As Elias and Dimopoulou (2012) refer, in many islands of the Aegean Sea in Greece and particularly in Cyclades, customary law exists and reflects the lack of space, the socioeconomic conditions and the protection of family and tradition. A special horizontal property ruled by customary law and producing customary rights was developed; “separate ground floor (katoi) and upper floor (anoi) can be in the possession of different owners, the owner of the ground floor also owns the land parcel while the owner of the upper floor owns the roof and the air upon it, but has no rights in land. This property type that obviously resulted to co-ownership is associated with separate property rights that can be transferred and registered.

There are several legal barriers that arise from different aspects and applications of law that have to be overcome on the way of implementing a 3D Cadastre. Until nowadays there is few research conducted concerning legal or organizational issues for the implementation of 3D Cadastres. However, Ho et al (2013) have conducted a research so as to identify legal issues that will be discussed the following years as below:

- what a 3D property is, the legal status and the classification of the associated rights
- what is the legislative framework required in order to support autonomous (or

not) registration of 3D property

- jurisdictional legislative limits and considerations
- means of registration of real property vs physical objects
- effect of public law on private rights and
- common property regimes.

As Caine (2009) mentions: *''using existing tools such as notably leases, easements and condominium laws, without changing their essence and features, would create a huge gap between factual and legal reality."* Another hurdle of legal adaptation is the interaction between parcels and the constructions on them, or around them. For example, in Greece, there are partially or totally overlapping private and public properties and multi-level special property objects in which condominium rights are exercised. The legislator should take under consideration a very complex urban situation and define the legal terms in order to create the standards for a 3D registration.

Legal constraints differ across national cadastral systems, a fact that makes sense as cadastres have been implemented in order to satisfy different needs of registration. Furthermore the legislation concerning the property status differs around the world. Legal aspects required have been studied by Ho et al (2013) who assume that: *"It is highly likely that the main barrier to cadastral innovation lies not in technological or legal issues, but more to fundamental social and cultural issues that make up the institutional framework underpinning cadastral systems and their inherent process."* The biggest challenge faced in implementing functional 3D cadastral systems is to find alternative methods and processes in order to overcome perceived legal issues. Most importantly issues that should be overcome have to deal with categories as below described in the research of Paulsson and Paasch (2013):

- description/ definition of the need of national 3D property
- development of national 3D property legislation
- implementation of national 3D property legislation
- practical application of 3D property concepts
- registration of 3D property
- modeling of 3D property
- standardization of 3D property

Possible solutions proposed by Paulsson and Paasch (2013) refer to the wideness of studies and publications that concern 3D real property, determination of 3D property terminology, delimitation of 3D property and implementation of 3D specific land use or access rights. However, FIG has already defined what a 3D parcel is in 2010; a 3D parcel is a legal object describing part of the space, often related with a physical object

that is also described in 3D. Such a definition could be the guideline for the delimitation of national 3D parcels. The development should overcome several jurisdictional and legal issues, such as:

- the demarcation of parcel's boundaries, both two-dimensional and volumetric
- the reformation of national legislation in order to include a definition of 3D property
- the introduction of changes in contracts, that will have a mandatory description of information of volumes, heights, depths and generally elevation and also in topographic diagrams, that will have to give information about the vertical plane.

Standardization is also promoted in solving the problem of registering 3D real property as it provides a technical framework for the definition of 3D objects and the conceptual model for their spatial representation (e.g. ISO 19152- Geographic Information- Land Administration Domain Model).

In order to face the challenges of transforming the existing operating systems, what is initially needed is an intervention in the law for the implementation of 3D registration. Such legal change is necessary and also beneficial, as rights, restrictions and responsibilities are recorded under a set of rules that impose the registration based on a 2D spatial unit (parcel). In other words, the inclusion of ''height'' in the proposed legislation is interpreted as a legislative amendment in the basic set of rules (standards) used. Caine (2009) also sets the legal solutions a cadastral institution must adopt in order to define the legal status for 3D property objects. At first she proposes the utilization of existing legal tools and their adaptation in 3D parcels. Secondly the adoption of a ''non-invasive'' legal technique, as long as the national legislation background of a country does not create legal obstacles in the implementation of 3D parcels. For example, in Israel the legislation permits the extension of 2D parcels. The introduction of special legislation concerning special 3D property objects is also imposed. Moreover, the establishment of an external 3Dobject registry in which rights to subterranean and aerial objects could be modeled and represented. The legal adjustment should be under the responsibility of a cadastral institution in cooperation with the Public Sector and especially with the Ministries of Environment and Urban Planning and Justice. This fact would make decisions difficult as the legal changes are time-consuming, leading to constraints to already existing 2D cadastral registrations. Furthermore, the classification of cadastral data is important and should also be suggested. As a complicated task, classification should include the management of descriptive information deriving from deeds, titles and spatial sources that could facilitate the definition and delimitation of a 3D property object. For example in Greece most of the contracts that describe horizontal properties (based on the Law N.3741/1929) give valuable information about the volume of each separate space in the building. In general, volumes may represent either physical objects, or volume parcels based on cadastral data. Information such as coordinates, physical dimensions, elevation and reference points could be extracted from existing legal sources and cadastral

documentation of properties in order to quantify an object before its three-dimensional representation. As Kitsakis and Dimopoulou refer (2014), plane coordinates are needed so that objects are properly located horizontally along with elevation data, in order to assign each object's volumetric aspects. Real property units' dimensions may also be required in case that coordinates defining volumetric space are not available. In this way the formation of 3D objects could be a low cost process.

Overall, solutions for overcoming legal barriers should take under consideration the institutional framework of the ownership status of each country together with its socieconomic and cultural situation. Practical issues of facilitating the legal framework should also be examined, eg. the level of bureaucracy, the reduction of time for the administrative process and the eligibility of national cadastral laws.

4. The Administration of the Cultural Space

The cultural space includes the spatial components of the immovable cultural heritage and is composed by historic places, important ancient and modern monuments, settlements, architectural buildings and many other examples of different cultures. It should be treated by nations around the world as an area of protection and special management. As a special area the cultural space displays differentiated land related features. The nature of the built environment that includes cultural assets reflects each people's past, as remains of ancient civilizations, such as parts of ancient settlements and public architectural or religious buildings co-exist with modern constructions, utility networks and facilities. This fact creates complex relationships between the structures and the land itself. The above structures described, both old and modern, can lay on, below or above the surface of the earth or water, a fact that makes their recordation and documentation hard to implement. Special property objects and people-to-land relationships appear. The co-existence of modern and old (or ancient) constructions leads to the formation of a special ownership status, as restrictions and responsibilities come along with properties. These constraints refer to the conservation and management of the discovered monument. In some countries depending on the legal framework land uses may also be affected; owners of parcels with immovable antiquities discovered may be obligatorily charged for the excavation, while at the same time they lose the right to build or develop any other economic activities.

Nowadays there is a great interest for the digital documentation and visualization of cultural objects together with the mass development of new technologies for efficient management of the cultural heritage in general. Digital technology and techniques of documentation of cultural assets such as 3D images, reverse engineering and archaeological GIS tend to be global good practice. Digital archaeology in the 21st century promotes an interdisciplinary approach, which requires to model complex systems in line with the policies of international research and in close connection with the socio-economic conditions of each country. New perspectives of investigation are offered by ICT solutions, through integrated platforms on which methods and resources of different disciplines can be managed simultaneously, contributing in this way to reconstruct cultural and social stratification phenomena.

Most of the implemented information systems for the management of cultural heritage today are integrated databases which follow the circle of data collection and preparation, classification of the collected data, documentation and interpretation of the final information. Data collection usually begins with the utilization of existing sources or repositories, for example the Hellenic Archaeological Cadastre (HAC) Project utilizes the data provided by the Greek Ministry of Education, Religious Affairs, Culture and Sports for the immovable archaeological findings as well as data from the National Monuments Archive (NMA). As there is a big amount of data for the Cultural Heritage, the developed

systems should provide structures that minimize the possibilities of re-entry of primitive data, a fact that could lead to confusion and inconsistency of the system. Furthermore, the structures should simultaneously facilitate the updating of data; since multiple data can be retrieved and saved on a simultaneous way in real time, the incidence of errors can be reduced. Internal processes of recordation, classification and management can be achieved with the aid of sciences such as Photogrammetry, Remote Sensing, Computer Vision and Computer Graphics. The documentation of primitive data is being achieved through the integration of conceptual models. The methods and technologies used are chosen by the institution that holds the project and are based on national or widely used guidelines (e.g. INSPIRE Directive promoted by the European Union) and internationally recognized standards that take under consideration the special characteristics of the cultural heritage and their needs of protection. The interpretation of information is being succeeded with methods of visualization such as 3D modeling, animation and virtual and augmented reality.

Most implemented systems for the protection and management of Cultural Heritage have incorporated or taken under serious consideration the legal framework of protection, such as National Legislation, international conventions (e.g. UNESCO International Conventions) and administrative archives that concern urban or building constraints.

4.1 Standards in Cultural Management

Standardization in documentation of cultural heritage is also promoted, as it provides important tools for its management. Standardization includes the technical framework for the management of entities, metadata and semantics of a system with a standardized procedure. Standards are widely used to form conceptual models for cadastral or other land management systems due to their efficiency and possibilities they offer for communication between information systems based on a common language. Their structure focuses on the collection of data for the identification of spatial objects, on the transactions and relationships between these objects, such as the existing property rights, the land value and the map representation. Standardized methods for the documentation of cultural information are in the front for more than 50 years. They concern the cataloguing, archiving and conserving of antiquities, monuments and generally cultural assets. International Standards (ISOs) are being used over the last few years, aiming to provide a commonly shared vocabulary for the scientific documentation of Cultural Heritage (Dimopoulou and Gogolou, 2013). Due to the lack of organized and fully standardized methods of documenting Cultural Heritage on a national level, good practices imply the integration globally accepted standards. The utilization of these standards leads specialists such as archaeologists, maintainers, ICT experts and engineers to the utilization of conformed methods for the successful recordation of the Cultural Heritage. A standard in modeling the Cultural Heritage can be defined as a set of regulations for the correct development and protection of digital data produced by the recordation and documentation of cultural objects. These standards can help all experts involved in the restoration, archiving and monitoring of the history of mankind and secure

this for the future. (Ioannidis et al, 2005).

4.1.1 The CIDOC-CRM Standard

The CIDOC Conceptual Reference Model (CRM) is a formal ontology that aims to facilitate the integration, mediation and interchange of heterogeneous Cultural Heritage Information (ICOM/CIDOC Documentation Standards Group, Version 6.2, 2015). CIDOC-CRM is developed by the International Committee for Documentation (CIDOC) of the International Council of Museums (ICOM) and the International Standards Organization (ISO) Working Group ISO/TC46/SC4/WG9. The ontology implemented defines the underlying semantics and integrates specific document structures used in Cultural Heritage and museum documentation.

CIDOC-CRM is not a standard that uses or proposes a shared vocabulary to the different cultural organizations, but rather explains the logic of what is needed to be documented, thus it provides the schemas and methods for the achievement of semantic interoperability between heterogeneous sources of Cultural Heritage information. According to the ICOM/CIDOC Documentation Standards Group the CIDOC-CRM aims to support the following specific functionalities:

- Inform developers of information systems as a guide to good practice in conceptual modelling, in order to effectively structure and relate information assets of cultural documentation.
- Serve as a common language for domain experts and IT developers to formulate requirements and to agree on system functionalities with respect to the correct handling of cultural contents.
- Serve as a formal language for the identification of common information contents in different data formats; in particular to support the implementation of automatic data transformation algorithms from local to global data structures without loss of meaning. The latter is useful for data exchange, data migration from legacy systems, data information integration and mediation of heterogeneous sources.
- Support associative queries against integrated resources by providing a global model of the basic classes and their associations to formulate such queries.
- It is further believed, that advanced natural language algorithms and case-specific heuristics can take significant advantage of the CRM to resolve free text information into a formal logical form, if that is regarded beneficial. The CRM is however not thought to be a means to replace scholarly text, rich in meaning, by logical forms, but only a means to identify related data.

4.2 The Archaeological Cadastre of Slovenia (ARKAS)

ARKAS is an internet based mapping application for the archaeological sites and

monuments of the Republic of Slovenia launched in the early 1990s. It consists of a wide digital database that has incorporated special databases of archaeological sites, monuments, bibliography, digital catalogs of preliminary photographs, drawings and geodetic maps of archaeological sites (Tecco Hvala, 1997 as referred in Kokalj, 2006). Archaeological sites and historic places in Slovenia, such as architectural buildings, castles, fortresses, religious and memorial monuments belong to the State. Therefore there is a clear ownership status for CH sites and for monuments of national importance. All units of CH have already been registered in the Cultural Heritage Information System (CHIS) where size and ownership information are recorded. The CHIS can communicate with a land cadastre database as an external class too (Kovacec Naglic, 2001). ARKAS also incorporates spatial information of the monuments registered. More detailed, as the figure shows below the ARKAS System consists of two parts, the ARKAS Core and the Web Application (ARKAS on the Web):

ARKAS Core is the central database which provides archaeological data utilized for Cultural Heritage management, survey planning, research, education, dissemination and exchange of data between the State and regional, national and international partnerships. It includes data for over 7000 cultural sites of Slovenia.

ARKAS on the Web holds a web-based map, which is not static, therefore it offers possibilities of viewing optional archaeological maps based on different queries (available on http://arkas.zrc-sazu.si/) which maps can be exported by combining the different natural and cultural data layers provided. The external end users can browse for archaeological sites, documents, photographs and survey plans through forms also provided by the internet server.

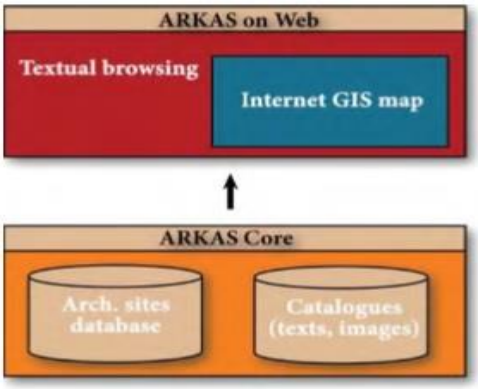


Figure 20, ARKAS System (source: Kokalj Z., Pehani P., Hvala S.T. & Ostir K.,2006)

As Kokalj (2006) refers although database browsing lacked of spatial and visual information, new tools incorporated in ARKAS on the Web, such as AutoDesk Map Guide 6.0 and ArcIMS from ESRI, have eliminated interaction of dynamic archaeological maps between internal and external users. It is worth mentioning that all maps of the server are georeferenced, thus they provide a useful mapping tool for professionals and citizens at the same time. The layer of Slovenian archaeological sites is the most important layer provided, spatially represented by points and covering all periods of local

and national history. Layers assistant to the spatial representation of archaeological sites are the regional and national borders, he topographic raster maps and the elevation layer.

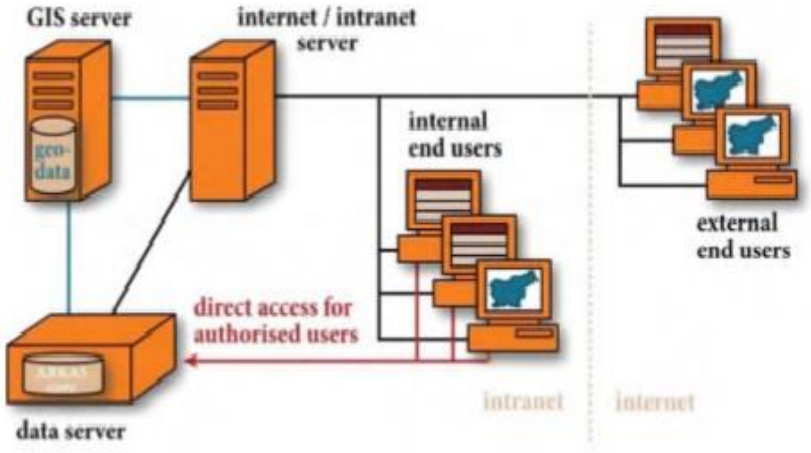


Figure 21, ARKAS Server (source: Kokalj Z., Pehani P., Hvala S.T. & Ostir K., 2006)

Figure 22, ARKAS Web Application (source: Kokalj Z., Pehani P., Hvala S.T. & Ostir K., 2006)

4.3 SITAR- The Geographic Archaeological Information System of Rome

The Geographic Archaeological Information System of Rome, known as SITAR is the first attempt of the Italian Ministry for Cultural Assets and for Tourism to create an “archaeological cadastre” of the metropolitan area of Rome. The general purpose of the project is to implement a multidimensional and up-to-date database that will be capable of recording, managing, archiving and exchanging information about the immovable archaeological heritage of Rome, by combining different sets of data, ranging from large monumental complexes to single archaeological objects found in excavations. SITAR (acronym for the Italian Sistema Informativo Territoriale Archeologico di Roma) has another aim; the integration of a system that will record and provide the exact spatial representation together with all the descriptive and administrative information of archaeological data, which leads to the implementation of cadastral information that concerns cultural heritage. The system functions as a supportive tool for urban co-planning and development, leading to better collaboration between different organizations, ministries and other public organizations and professionals. It was launched by the Soprintendenza Speciale per I Beni Archeologici di Roma (SSBAR) and follows the European Guidelines of the Infrastructure for Spatial Information in the European Community (INSPIRE) as well as the national guidelines of the Italian Ministry of Cultural Heritage. SITAR workgroup has utilized ITC in order to collect, interpret and disseminate archaeological information, such as the Open Geospatial Consortium (OGC) technology, as well as WFS and Web Map Services (WMS) standards for web end users in order to share descriptive and cartographic databases. It consists of five primary information levels which are in reality databases that utilize different archives in order to produce information, as described by Serlorenzi and de Tommasi (2010):

- layer ORIGINI DELL' INFORMAZIONE (literally the sources of information) in which is recorded all the administrative and scientific information of every archaeological excavation or geophysical/ geological survey. Incorporated archives ORIGINI INFORMATIVE guarantee the fundamental data recordation of every single intervention or preservation study carried out in Rome's immovable cultural assets

- layer PARTIZIONI ARCHEOLOGICHE, which includes the scientific description of the archaeological findings even fragmentary, following chronological or functional criteria. Archives incorporated are basically a formed cadastral database for archaeological and historic monuments of Rome. This database includes different types of records that concern properties such as ownership status, intellectual property ownership and the right for privacy

- layer UNITA ARCHEOLOGICHE, that describes an archaeological unity or complex. Archives incorporated correspond to the textual and spatial description of the monuments, their actual boundaries and original dimensions. Information that comes out of these archives has assisted to the topographic reconstruction

of ancient settlements in Rome and has allowed the interconnection of spatial data for the old town and the modern city of Rome. This has been proved as an important tool which serves the analysis of archaeological data that has enabled city planners predict before urban plans are developed and preserve the ancient findings

- layer DISPOSITIVI di VINCOLO, in which are recorded all the legal constraints and laws that protect the important monuments without their context
- layer POTENZIALE ARCHEOLOGICO (which is literally the "archaeological potential"), which is utilized for the logic union and the super- interpretation of the above base layers.

NAME OF THE RECORD	DATA PROCESSING	RESULTS
Origine dell'informazione	Information	Data Origin
Partizione Archeologica	Description	Data Analysis
Unità Archeologica	Interpretation	Data Synthesis
Vincolo Archeologico	Contextualizing UA	Punctual Preservation
Potenziale Archeologico	Estimation	Project

Figure 23, SITAR Layers and Processes (source Serlorenzi M. & De Tommasi A., 2010)

4.4 The Dutch Cadastre (Kadaster)

The Dutch Cadastre (Kadaster) has a provision for the registration of parcels with monumental interest according to the national law for the protection of monuments, which was established in 1961. As Stoter (2004) refers*: "According to this law, it is possible to impose restrictions on the owner of a monument, e.g. not rebuild certain parts of a house. The restriction is registered on the whole parcel when only part of the parcel is encumbered with a restriction, while the geometry (outline of the monument or archaeological site) is not maintained in the cadastral register."* In the Netherlands there are more than 60000 listed monuments, including 1500 protected archaeological sites. Today most of the monuments have been registered together with the property rights associated with them. Detailed information for the special features of monuments can be found in the Register for Monuments (Monumentenregister), which is linked with the Kadaster for the successful registration of monuments. Furthermore details that concern the exact position of the monument inside the parcel are given by public administrative sources (Public Registers) and drawings. The necessity of the correct registration of

monuments in the Netherlands arises from the fact that each private owner of properties with monuments gets funding form the State in order to conserve the monument. Another important fact is that the registration of monuments follows the European rules for the protection of archaeological sites and for the better planning of new urban projects.

There is a different approach of what is considered as a monument in the Netherlands. Many parts of a building can have architectural interest and thus only they will be under protection. For example, often only the facade of a building or just a part of a building is a monument and not the whole building. In Kadaster the whole parcel has been encumbered with a unique code. Therefore, a 2D or a 3D spatial representation of the monument indicates if the whole parcel is (or not) a monument. Furthermore there is a variety of underground archaeological sites that are in need of cadastral registration, which could also incorporate the three-dimensional representation in spatial level. This could lead to better protection techniques and to promotion of the archaeological treasures to the public. Underground immovable antiquities are also registrable in the Kadaster with the entity Underground Object (code OB/OBD in Kadaster). The entity indicates the existence of objects below the surface of the parcel. The Underground Object introduces restrictions to the owner(s) of the parcel, yet it is not considered to be an autonomous right or restriction. To find out the legal status of the underground object, one has to find out what other rights, restrictions and legal notifications are established on the surface parcel. Thus, records of the Register of Monuments would be clarifying in case the Underground Object is an ancient construction.

4.5 The Hellenic Archaeological Cadastre Project

4.5.1 The Archaeological Space in Greece

The archaeological space in Greece is of high importance. It is estimated that 8% of the land territory is covered by declared archaeological sites. Heritage assets met within the territory of Greece, such as archaeological sites, protection zones and traditional architectural complexes are examples an advanced civilization and represent important historic evidence. Furthermore, private properties with archaeological or architectural interest are numerous all over the country. The protection of ancient heritage is under the responsibility of the State and which focuses on the definition, registration and documentation of antiquities, plus the conservation and promotion to the public.

In Greece the main service for the protection of antiquities is the Ministry of Education, Religious Affairs, Culture and Sports. Activities related to the excavation (settlements, ancient cities, temples, fortresses etc.), restoration of aqueducts, ancient objects, mosaics, religious wall paintings, are some of the responsibilities of the Ministry. The documentation and management of all cultural possessions is being implemented in the National Monuments Archive (NMA). The NMA is responsible for the safekeeping of archives related to scientific research and gives the protection guidelines for all movable and immovable treasures. Museums and other organizations such as the Archaeological Company, the Archaeological Resources Fund and the foreign Archaeological Schools are also under the supervision of the Ministry of Education, Religions, Culture and

Sports. Apart from the referenced Ministry there are other services responsible for cultural assets. The Ministry of National Defense is responsible for the protection of the majority of fortresses, castles, military infrastructure and war emplacements as they are considered as monuments of national defense. Moreover, the Ministry of Environment, Energy and Climate Change is responsible for the preservation of the architectural heritage. It is the service responsible for the protection and promotion of traditional settlements, historic city centers, important architectural buildings as well as their restoration.

As there are various management services related to the cultural heritage and its preservation, their coordination and collaboration is not always achieved. This fact shows inefficiency in structures and a confusion that arises from the legislation for the protection of CH. Specifically; there are many problems to everyday transactions and activities created due to the existence of antiquities in the urban space. The protection services operate under a strict legislative frame which introduces restrictions to the free use of property. Furthermore the inefficient coordination has made it difficult to record the extent of public and private property with cultural interest. The strict legislation has also led to another problem. Many private owners of properties with antiquities are forced to specific uses of land and in many cases they are obliged to pay for the excavation of the ancient monument. The problem continues if the revealed monument is an important example of ancient civilization, which can lead to property expropriation and compensation fees for the owner. In many cases the expropriation is a time- consuming process which keeps the property engaged, leading to deprivation of land. Other problems also arise to every private property with antiquities. These problems are related to property rights. Mainly there are restrictions such as urban planning constraints and limitations in construction of buildings, eg every construction should not affect the ancient monument, the commonplace or the underground constructions should be limited and responsibilities of the owner such as protecting measures for the monument and the obligation of free entrance for the public. Any effort concerning the solution of the above problems is often hard to be carried out in terms of cost, time and methodology. The integration of the archaeological space into an interoperable system reflects the necessity for a system that can efficiently manage the special and rich features of the Greek Cultural Heritage.

The State functions under a legislative framework which mainly consists of the Archaeological Law N.3028/2002. Discussing about the legal framework, it is worth mentioning that the above Archaeological Law gives definitions about the movable, immovable, maritime and intangible heritage. Most importantly, it makes clear that monuments dated before 1830 are called ancient and those dated after 1830 are called modern. Ancient monuments dated before 1453 strictly belong to the State and they are out of transactions or any other property rights can be associated with them. Furthermore, the Archaeological Law determines that territorial immovable ancient monuments have two Protection Zones and submarine antiquities have a general Protection Zone. According to the Hellenic Archaeological Cadastre, protection zones and their declaration are defined as follows:

- Declaration of Archaeological Sites: the legal and regulatory framework under which an archaeological site is officially protected by the State. It defines the boundaries of one or more archaeological sites and of their Protection Zones (A and B). A Declaration is an Administrative Act that refers to a site, a monument or both. Every archaeological site might have more than one Declaration, as boundaries can change leading to new delimitation. There are many reasons for the existence of two or more Declarations. In many cases new excavations inside the protection zones reveal important findings, leading to the expansion of Protection Zone A and consequently of the Protection Zone B. Another reason is the omission of important environmental assessments to the Declaration, or the existence of not so important archaeological findings.

- Protection Zone A: the geographical region around a single monument or a total of immovable monuments that are referred in the Declaration. In Protection Zone A lays the main monument, which is strictly protected. Different land uses and property rights are totally forbidden.

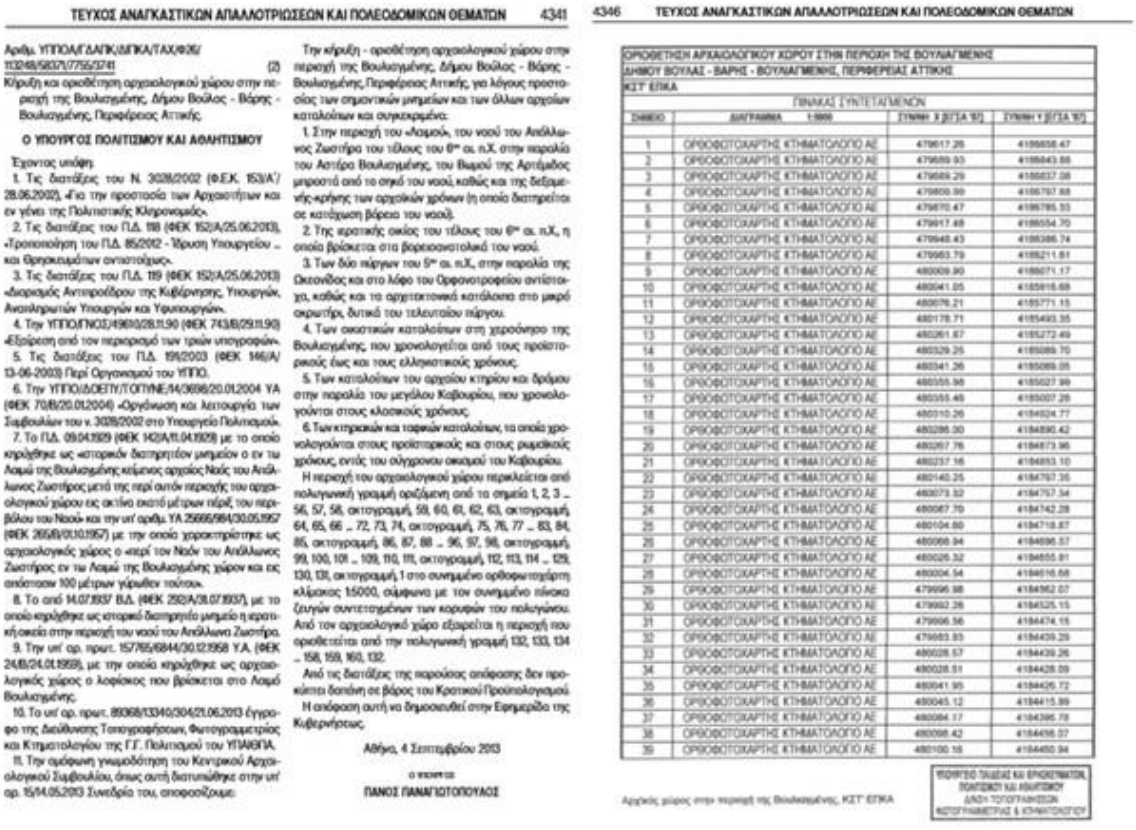
- Protection Zone B: the geographical region around or close to the Protection Zone A. Few specific activities can be allowed such as hunting and agriculture as well as the construction of public buildings assistant to the monument under specific terms. Special constraints concern the external features of the buildings. As a peripheral zone of protection, all economic activities can take place after the related permit is issued.

Below there are two examples of delimitation of archaeological sites based on the Administrative Act of Declaration conducted by the Ministry of Education, Religious Affairs, Culture and Sports. The first example describes the Declaration held for the region of Astir, Vouliagmeni in the metropolitan area of Athens. Astir lays in the peninsula of Vouliagmeni, in the position Mikro Kavouri, about 20 kilometers form the center of Athens. It covers about 120 acres, where hotels and touristic facilities lay in different positions. Astir Palace, the Vouliagmeni Marina and other touristic services operate since 1959.

Figure 24, The Region of Astir Vouliagmeni (source: https://enotitasaronikou.wordpress.com)

The Declaration describes all the ancient constructions and defines the boundaries of their protection zones. The boundaries of each protection zone are described on a topographic diagram with coordinates in the Greek Geodetic Reference System (GGRS1987). More specifically the ancient assets protected are described below:

- The ancient temple of Apollon Zostir, in the beach of Astir, dating back to 6th century BC, together with a peripheral zone of 100 meters (Protection Zone A)
- The hieratic house in the northeast of the above temple dating back to 6th century BC
- Two towers next to the beach of Oceanis, dating back to 5th century BC
- Residential indications in the peninsula of Vouliagmeni, dating from the prehistoric to the Hellenistic era
- Residues of ancient buildings and public roads in the Kavouri beach, dating back to the classical era
- Residues of properties and burial complexes in the modern settlement of Kavouri, dating from the prehistoric to Roman era



ΤΕΥΧΟΣ ΑΝΑΓΚΑΣΤΙΚΩΝ ΑΠΑΛΛΟΤΡΙΩΣΕΩΝ ΚΑΙ ΠΟΛΕΟΔΟΜΙΚΩΝ ΘΕΜΑΤΩΝ 4341

Αριθμ. ΥΠΠΟΑ/ΓΔΑΠΚ/ΔΠΚΑ/ΤΑΧ/Φ36/
103248/5837/7755/3741 (2)
Κήρυξη και οριοθέτηση αρχαιολογικού χώρου στην περιοχή της Βουλιαγμένης, Δήμου Βούλας - Βάρης - Βουλιαγμένης, Περιφέρειας Αττικής.

Ο ΥΠΟΥΡΓΟΣ ΠΟΛΙΤΙΣΜΟΥ ΚΑΙ ΑΘΛΗΤΙΣΜΟΥ

Έχοντας υπόψη:
1. Τις διατάξεις του Ν. 3028/2002 (Φ.Ε.Κ. 153/Α') «Για την προστασία των Αρχαιοτήτων και εν γένει της Πολιτιστικής Κληρονομιάς».
2. Τις διατάξεις του Π.Δ. 118 (ΦΕΚ 152/Α/25.06.2013), «Τροποποίηση του Π.Δ. 85/2012 - Ίδρυση Υπουργείου – και Θρησκευμάτων αντιστοίχως».
3. Τις διατάξεις του Π.Δ. 119 (ΦΕΚ 152/Α/25.06.2013) «Διορισμός Αντιπροέδρου της Κυβέρνησης, Υπουργών, Αναπληρωτών Υπουργών και Υφυπουργών».
4. Την ΥΠΠΟ/ΓΝΩΣ/49610/28.11.90 (ΦΕΚ 743/Β/29.11.90) «Εξαίρεση από τον περιορισμό των τριών υπογραφών».
5. Τις διατάξεις του Π.Δ. 159/2003 (ΦΕΚ 146/Α/13-06-2003) Περί Οργανισμού του ΥΠΠΟ.
6. Την ΥΠΠΟ/Δ.ΟΕΕΤΥ/Τ.ΟΙΤΥΝΕ/14/3696/20.01.2004 ΥΑ (ΦΕΚ 70/Β/20.01.2004) «Οργάνωση και λειτουργία των Συμβουλίων του ν. 3028/2002 στο Υπουργείο Πολιτισμού».
7. Το Π.Δ. 09.04.1929 (ΦΕΚ 142/Α/11.04.1929) με το οποίο κηρύχθηκε ως «ιστορικόν διατηρητέον μνημείον ο εν τω Λαμπ της Βουλιαγμένης κείμενος αρχαίος Ναός του Απόλλωνος Ζωστήρος μετά της περί αυτόν περιοχής του αρχαιολογικού χώρου εις ακτίνα εκατόμ μέτρων πέριξ του περιβόλου του Ναού» και την υπ' αριθμ. ΥΑ 25666/584/30.05.1957 (ΦΕΚ 265/Β/01.10.1957) με την οποία χαρακτηρίστηκε ως αρχαιολογικός χώρος ο «περί τον Ναόν του Απόλλωνος Ζωστήρος εν τω Λαμπ της Βουλιαγμένης χώρον και εις απόστασιν 100 μέτρων γύρωθεν τούτου».
8. Το από 14.07.1937 Β.Δ. (ΦΕΚ 292/Α/31.07.1937), με το οποίο κηρύχθηκε ως ιστορικό διατηρητέο μνημείο η αρχαιολογική στην περιοχή του ναού του Απόλλωνα Ζωστήρα.
9. Την υπ' αρ. πρωτ. 157765/6844/30.12.1958 Υ.Α. (ΦΕΚ 24/Β/24.01.1959), με την οποία κηρύχθηκε ως αρχαιολογικός χώρος ο λοφίσκος που βρίσκεται στο Λαμπ Βουλιαγμένης.
10. Το υπ' αρ. πρωτ. 89368/13340/304/21.06.2013 έγγραφο της Διεύθυνσης Τοπογραφήσεων, Φωτογραμμετρίας και Κτηματολογίου της Γ.Γ. Πολιτισμού του ΥΠΑΘΠΑ.
11. Την εμφάνιση γνωμοδότηση του Κεντρικού Αρχαιολογικού Συμβουλίου, όπως αυτή διατυπώθηκε στην υπ' αρ. 15/14.05.2013 Συνεδρία του, αποφασίζουμε:

Την κήρυξη - οριοθέτηση αρχαιολογικού χώρου στην περιοχή της Βουλιαγμένης, Δήμου Βούλας - Βάρης - Βουλιαγμένης, Περιφέρειας Αττικής, για λόγους προστασίας των σημαντικών μνημείων και των όλων αρχείων καταλοίπων και συγκεκριμένα:

1. Στην περιοχή του «ναμού», του ναού του Απόλλωνος Ζωστήρα του τέλους του 6ου αι. π.Χ. στην παραλία του Αστέρα Βουλιαγμένης, του θιμού της Αρτέμιδος μπροστά από το αηρό του ναού, καθώς και της δεξαμενής-κρήνης των αρχαίων χρόνων (η οποία διατηρείται σε κατάσταση βάρεια του ναού).
2. Της ερατικής οικίας του τέλους του 6ου αι. π.Χ., η οποία βρίσκεται στα βορειοανατολικά του ναού.
3. Των δύο πύργων του 5ου αι. π.Χ., στην παραλία της Ωκεανίδος και στο λόφο του Ορφανοτροφείου αντίστοιχα, καθώς και τα αρχιτεκτονικά κατάλοιπα στο μικρό ακρωτήρι, δυτικά του τελευταίου πύργου.
4. Των οικοτικών καταλοίπων στη χερσόνησο της Βουλιαγμένης, που χρονολογείται από τους προϊστορικούς έως και τους ελληνιστικούς χρόνους.
5. Των καταλοίπων του αρχαίου κτηρίου και δρόμου στην παραλία του μεγάλου Καβουρίου, που χρονολογούνται στους κλασικούς χρόνους.
6. Των κτηρικών και ταφικών καταλοίπων, τα οποία χρονολογούνται στους προϊστορικούς και στους ρωμαϊκούς χρόνους, εντός του ούγγρουν οικισμού του Καβουρίου.

Η περιοχή του αρχαιολογικού χώρου περικλείεται από πολυγωνική γραμμή οριζόμενη από τα σημεία 1, 2, 3 .. 56, 57, 58, ακτογραμμή, 59, 60, 61, 62, 63, ακτογραμμή, 64, 65, 66 .. 72, 73, 74, ακτογραμμή, 75, 76, 77 .. 83, 84, 85, ακτογραμμή, 86, 87, 88 .. 96, 97, 98, ακτογραμμή, 99, 100, 101 .. 109, 110, 111, ακτογραμμή, 112, 113, 114 .. 129, 130, 131, ακτογραμμή, 1 στο συνημμένο ορθοφωτοχάρτη κλίμακος 1:5000, σύμφωνα με τον συνημμένο πίνακα ζευγών συντεταγμένων των κορυφών του πολυγώνου. Από τον αρχαιολογικό χώρο εξαιρείται η περιοχή που οριοθετείται από την πολυγωνική γραμμή 132, 133, 134 .. 158, 159, 160, 132.

Από τις διατάξεις της παρούσας απόφασης δεν προκύπτει δαπάνη σε βάρος του Κρατικού Προϋπολογισμού.

Η απόφαση αυτή να δημοσιευθεί στην Εφημερίδα της Κυβερνήσεως.

Αθήνα, 4 Σεπτεμβρίου 2013

Ο ΥΠΟΥΡΓΟΣ
ΠΑΝΟΣ ΠΑΝΑΓΙΩΤΟΠΟΥΛΟΣ

4346 ΤΕΥΧΟΣ ΑΝΑΓΚΑΣΤΙΚΩΝ ΑΠΑΛΛΟΤΡΙΩΣΕΩΝ ΚΑΙ ΠΟΛΕΟΔΟΜΙΚΩΝ ΘΕΜΑΤΩΝ

ΟΡΙΟΘΕΤΗΣΗ ΑΡΧΑΙΟΛΟΓΙΚΟΥ ΧΩΡΟΥ ΣΤΗΝ ΠΕΡΙΟΧΗ ΤΗΣ ΒΟΥΛΙΑΓΜΕΝΗΣ
ΔΗΜΟΥ ΒΟΥΛΑΣ - ΒΑΡΗΣ - ΒΟΥΛΙΑΓΜΕΝΗΣ, ΠΕΡΙΦΕΡΕΙΑΣ ΑΤΤΙΚΗΣ
ΚΣΤ' ΕΠΚΑ

ΠΙΝΑΚΑΣ ΣΥΝΤΕΤΑΓΜΕΝΩΝ

ΣΗΜΕΙΟ	ΔΙΑΓΡΑΜΜΑ 1:5000	ΣΥΝΘΗΚΗ Χ [ΕΓΣΑ '87]	ΣΥΝΘΗΚΗ Υ [ΕΓΣΑ '87]
1	ΟΡΘΟΦΩΤΟΧΑΡΤΗΣ ΚΤΗΜΑΤΟΛΟΓΙΟ ΑΕ	479617.26	4186838.47
2	ΟΡΘΟΦΩΤΟΧΑΡΤΗΣ ΚΤΗΜΑΤΟΛΟΓΙΟ ΑΕ	479659.93	4186843.88
3	ΟΡΘΟΦΩΤΟΧΑΡΤΗΣ ΚΤΗΜΑΤΟΛΟΓΙΟ ΑΕ	479689.29	4186837.08
4	ΟΡΘΟΦΩΤΟΧΑΡΤΗΣ ΚΤΗΜΑΤΟΛΟΓΙΟ ΑΕ	479809.99	4186787.88
5	ΟΡΘΟΦΩΤΟΧΑΡΤΗΣ ΚΤΗΜΑΤΟΛΟΓΙΟ ΑΕ	479870.47	4186785.33
6	ΟΡΘΟΦΩΤΟΧΑΡΤΗΣ ΚΤΗΜΑΤΟΛΟΓΙΟ ΑΕ	479917.49	4186554.70
7	ΟΡΘΟΦΩΤΟΧΑΡΤΗΣ ΚΤΗΜΑΤΟΛΟΓΙΟ ΑΕ	479948.43	4186386.74
8	ΟΡΘΟΦΩΤΟΧΑΡΤΗΣ ΚΤΗΜΑΤΟΛΟΓΙΟ ΑΕ	479993.79	4186211.81
9	ΟΡΘΟΦΩΤΟΧΑΡΤΗΣ ΚΤΗΜΑΤΟΛΟΓΙΟ ΑΕ	480009.90	4186071.17
10	ΟΡΘΟΦΩΤΟΧΑΡΤΗΣ ΚΤΗΜΑΤΟΛΟΓΙΟ ΑΕ	480041.05	4185816.68
11	ΟΡΘΟΦΩΤΟΧΑΡΤΗΣ ΚΤΗΜΑΤΟΛΟΓΙΟ ΑΕ	480076.21	4185771.15
12	ΟΡΘΟΦΩΤΟΧΑΡΤΗΣ ΚΤΗΜΑΤΟΛΟΓΙΟ ΑΕ	480178.71	4185493.35
13	ΟΡΘΟΦΩΤΟΧΑΡΤΗΣ ΚΤΗΜΑΤΟΛΟΓΙΟ ΑΕ	480261.67	4185272.49
14	ΟΡΘΟΦΩΤΟΧΑΡΤΗΣ ΚΤΗΜΑΤΟΛΟΓΙΟ ΑΕ	480329.25	4185089.70
15	ΟΡΘΟΦΩΤΟΧΑΡΤΗΣ ΚΤΗΜΑΤΟΛΟΓΙΟ ΑΕ	480341.26	4185069.05
16	ΟΡΘΟΦΩΤΟΧΑΡΤΗΣ ΚΤΗΜΑΤΟΛΟΓΙΟ ΑΕ	480355.96	4185027.99
17	ΟΡΘΟΦΩΤΟΧΑΡΤΗΣ ΚΤΗΜΑΤΟΛΟΓΙΟ ΑΕ	480355.46	4185007.28
18	ΟΡΘΟΦΩΤΟΧΑΡΤΗΣ ΚΤΗΜΑΤΟΛΟΓΙΟ ΑΕ	480310.29	4184924.77
19	ΟΡΘΟΦΩΤΟΧΑΡΤΗΣ ΚΤΗΜΑΤΟΛΟΓΙΟ ΑΕ	480286.30	4184890.42
20	ΟΡΘΟΦΩΤΟΧΑΡΤΗΣ ΚΤΗΜΑΤΟΛΟΓΙΟ ΑΕ	480267.76	4184873.96
21	ΟΡΘΟΦΩΤΟΧΑΡΤΗΣ ΚΤΗΜΑΤΟΛΟΓΙΟ ΑΕ	480237.16	4184853.10
22	ΟΡΘΟΦΩΤΟΧΑΡΤΗΣ ΚΤΗΜΑΤΟΛΟΓΙΟ ΑΕ	480140.25	4184767.35
23	ΟΡΘΟΦΩΤΟΧΑΡΤΗΣ ΚΤΗΜΑΤΟΛΟΓΙΟ ΑΕ	480073.32	4184757.34
24	ΟΡΘΟΦΩΤΟΧΑΡΤΗΣ ΚΤΗΜΑΤΟΛΟΓΙΟ ΑΕ	480067.70	4184742.28
25	ΟΡΘΟΦΩΤΟΧΑΡΤΗΣ ΚΤΗΜΑΤΟΛΟΓΙΟ ΑΕ	480104.60	4184710.87
26	ΟΡΘΟΦΩΤΟΧΑΡΤΗΣ ΚΤΗΜΑΤΟΛΟΓΙΟ ΑΕ	480066.94	4184696.57
27	ΟΡΘΟΦΩΤΟΧΑΡΤΗΣ ΚΤΗΜΑΤΟΛΟΓΙΟ ΑΕ	480026.32	4184655.81
28	ΟΡΘΟΦΩΤΟΧΑΡΤΗΣ ΚΤΗΜΑΤΟΛΟΓΙΟ ΑΕ	480004.54	4184610.68
29	ΟΡΘΟΦΩΤΟΧΑΡΤΗΣ ΚΤΗΜΑΤΟΛΟΓΙΟ ΑΕ	479996.98	4184562.07
30	ΟΡΘΟΦΩΤΟΧΑΡΤΗΣ ΚΤΗΜΑΤΟΛΟΓΙΟ ΑΕ	479992.28	4184525.15
31	ΟΡΘΟΦΩΤΟΧΑΡΤΗΣ ΚΤΗΜΑΤΟΛΟΓΙΟ ΑΕ	479996.56	4184474.15
32	ΟΡΘΟΦΩΤΟΧΑΡΤΗΣ ΚΤΗΜΑΤΟΛΟΓΙΟ ΑΕ	479993.93	4184439.29
33	ΟΡΘΟΦΩΤΟΧΑΡΤΗΣ ΚΤΗΜΑΤΟΛΟΓΙΟ ΑΕ	480028.57	4184439.26
34	ΟΡΘΟΦΩΤΟΧΑΡΤΗΣ ΚΤΗΜΑΤΟΛΟΓΙΟ ΑΕ	480028.51	4184428.09
35	ΟΡΘΟΦΩΤΟΧΑΡΤΗΣ ΚΤΗΜΑΤΟΛΟΓΙΟ ΑΕ	480041.95	4184426.72
36	ΟΡΘΟΦΩΤΟΧΑΡΤΗΣ ΚΤΗΜΑΤΟΛΟΓΙΟ ΑΕ	480045.12	4184415.89
37	ΟΡΘΟΦΩΤΟΧΑΡΤΗΣ ΚΤΗΜΑΤΟΛΟΓΙΟ ΑΕ	480084.17	4184396.78
38	ΟΡΘΟΦΩΤΟΧΑΡΤΗΣ ΚΤΗΜΑΤΟΛΟΓΙΟ ΑΕ	480098.42	4184458.57
39	ΟΡΘΟΦΩΤΟΧΑΡΤΗΣ ΚΤΗΜΑΤΟΛΟΓΙΟ ΑΕ	480100.16	4184460.94

Αρχαιολ. χώρος στην περιοχή της Βουλιαγμένης, ΚΣΤ' ΕΠΚΑ

ΥΠΟΥΡΓΕΙΟ ΠΟΛΙΤΙΣΜΟΥ, ΠΑΙΔΙΚΟΥ ΚΑΙ ΑΘΛΗΤΙΣΜΟΥ
ΔΙΑΧΕΙΡΙΣΗ ΤΟΠΟΓΡΑΦΗΣΕΩΝ
ΦΩΤΟΓΡΑΜΜΕΤΡΙΑΣ & ΚΤΗΜΑΤΟΛΟΓΙΟΥ

Figure 25, Declaration for the Archaeological Site of Astir, Vouliagmeni (Law 350/2013)

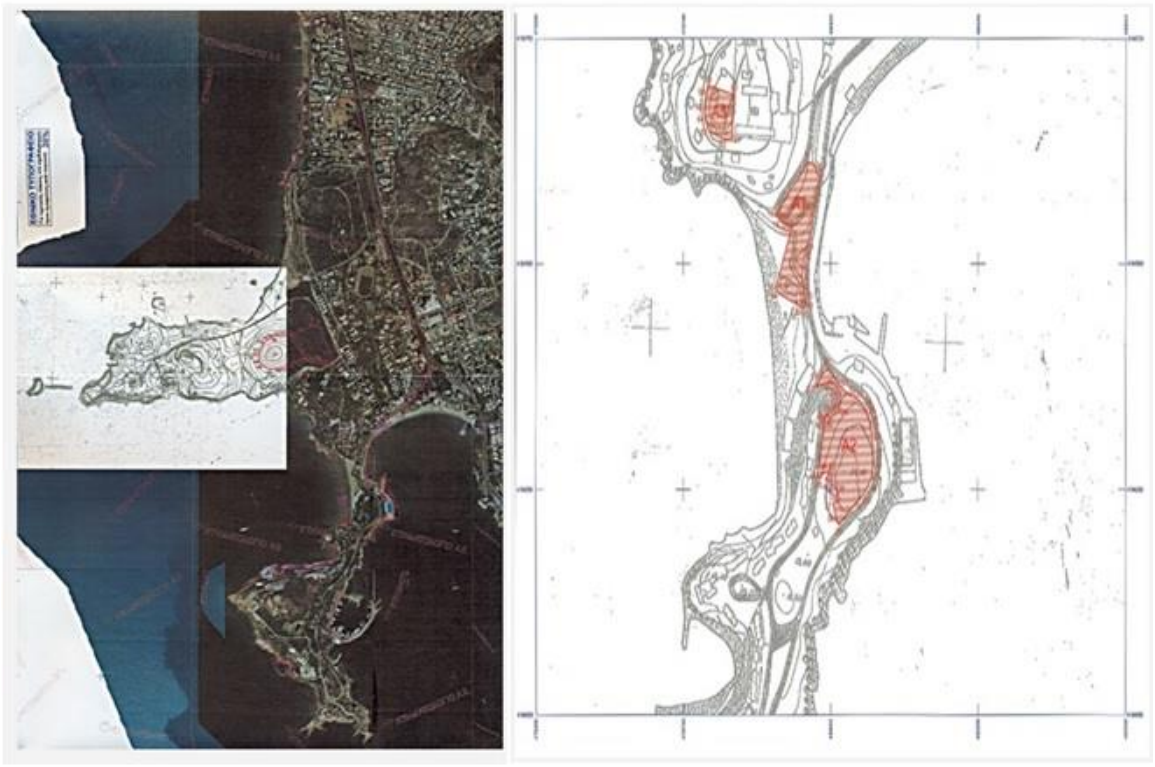


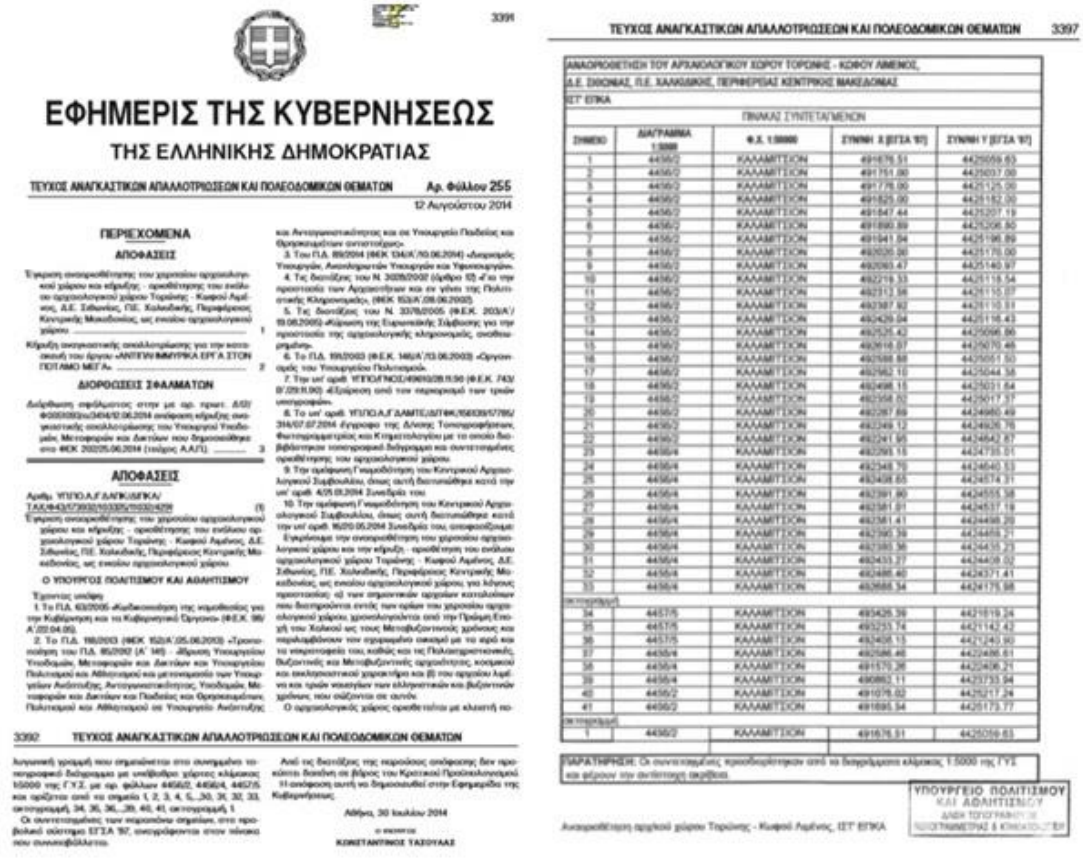
Figure 26, Topographic Map of the Declaration of Astir, Vouliagmeni (Law 402/2013)

The second example describes the Declaration held for the region of Toroni, Sithonia, Chalkidhiki and the Port of Kofos. Toroni lays in the southwest edge of the peninsula of Sithonia and holds the remains of an ancient settlement of the 8th century B.C together with the walls and the sunken port. Port of Kofos (Porto Kofos) lies in the southern region of Sithonia and was considered to be the second port utilized by the habitants of ancient Toroni.

Figure 27, The Archaeological Site of Toroni and the Port of Kofos, Chalkidiki (source: http://www.kastra.eu/)

he Declaration concerns a territorial and a marine archaeological site at the same time and it is issued for the second time, as it was considered by the Ministry that many important archaeological findings were not included in the boundaries set by the first Declaration. More specifically the ancient assets protected are described below:

- The important residential remains inside the archaeological site of Toroni, dating from the Bronze Age to the After-Byzantine Period
- The fortified settlement of ancient Toroni
- The temples and hieratic houses in the settlement of Toroni
- The graveyards
- The religious immovable antiquities dating back to the Early Christian, Byzantine and After-Byzantine Periods
- The ancient Port of Kofos
- The three shipwrecks dating back to the Hellenistic era and the Byzantine Period



ΕΦΗΜΕΡΙΣ ΤΗΣ ΚΥΒΕΡΝΗΣΕΩΣ

ΤΗΣ ΕΛΛΗΝΙΚΗΣ ΔΗΜΟΚΡΑΤΙΑΣ

ΤΕΥΧΟΣ ΑΝΑΓΚΑΣΤΙΚΩΝ ΑΠΑΛΛΟΤΡΙΩΣΕΩΝ ΚΑΙ ΠΟΛΕΟΔΟΜΙΚΩΝ ΘΕΜΑΤΩΝ Αρ. Φύλλου 255

12 Αυγούστου 2014

ΠΕΡΙΕΧΟΜΕΝΑ

ΑΠΟΦΑΣΕΙΣ

ΔΙΟΡΘΩΣΕΙΣ ΣΦΑΛΜΑΤΩΝ

ΑΠΟΦΑΣΕΙΣ

ΤΕΥΧΟΣ ΑΝΑΓΚΑΣΤΙΚΩΝ ΑΠΑΛΛΟΤΡΙΩΣΕΩΝ ΚΑΙ ΠΟΛΕΟΔΟΜΙΚΩΝ ΘΕΜΑΤΩΝ 3397

ΑΝΑΘΕΩΡΗΣΗ ΤΟΥ ΑΡΧΑΙΟΛΟΓΙΚΟΥ ΧΩΡΟΥ ΤΟΡΩΝΗΣ - ΚΩΦΟΥ ΛΙΜΕΝΟΣ,

Δ.Ε. ΣΙΘΩΝΙΑΣ, Π.Ε. ΧΑΛΚΙΔΙΚΗΣ, ΠΕΡΙΦΕΡΕΙΑΣ ΚΕΝΤΡΙΚΗΣ ΜΑΚΕΔΟΝΙΑΣ

ΙΣΤ' ΕΠΚΑ

ΠΙΝΑΚΑΣ ΣΥΝΤΕΤΑΓΜΕΝΩΝ

ΣΗΜΕΙΟ	ΔΙΑΓΡΑΜΜΑ 1:5000	Φ.Σ. 1:50000	ΣΥΝΘΗΚΗ Χ [ΕΓΣΑ '87]	ΣΥΝΘΗΚΗ Υ [ΕΓΣΑ '87]
1	44567/2	ΚΑΛΑΜΙΤΣΙΟΝ	491676.51	4425059.63
2	44567/2	ΚΑΛΑΜΙΤΣΙΟΝ	491751.00	4425037.00
3	44567/2	ΚΑΛΑΜΙΤΣΙΟΝ	491776.00	4425125.00
4	44567/2	ΚΑΛΑΜΙΤΣΙΟΝ	491825.00	4425182.00
5	44567/2	ΚΑΛΑΜΙΤΣΙΟΝ	491847.44	4425207.19
6	44567/2	ΚΑΛΑΜΙΤΣΙΟΝ	491890.89	4425206.80
7	44567/2	ΚΑΛΑΜΙΤΣΙΟΝ	491941.04	4425196.89
8	44567/2	ΚΑΛΑΜΙΤΣΙΟΝ	492020.00	4425170.00
9	44567/2	ΚΑΛΑΜΙΤΣΙΟΝ	492093.47	4425140.97
10	44567/2	ΚΑΛΑΜΙΤΣΙΟΝ	492219.33	4425118.54
11	44567/2	ΚΑΛΑΜΙΤΣΙΟΝ	492313.56	4425110.07
12	44567/2	ΚΑΛΑΜΙΤΣΙΟΝ	492387.92	4425110.51
13	44567/2	ΚΑΛΑΜΙΤΣΙΟΝ	492429.04	4425116.43
14	44567/2	ΚΑΛΑΜΙΤΣΙΟΝ	492525.42	4425098.86
15	44567/2	ΚΑΛΑΜΙΤΣΙΟΝ	492616.07	4425070.46
16	44567/2	ΚΑΛΑΜΙΤΣΙΟΝ	492688.88	4425051.53
17	44567/2	ΚΑΛΑΜΙΤΣΙΟΝ	492762.15	4425044.38
18	44567/2	ΚΑΛΑΜΙΤΣΙΟΝ	492498.15	4425031.64
19	44567/2	ΚΑΛΑΜΙΤΣΙΟΝ	492358.02	4425017.37
20	44567/2	ΚΑΛΑΜΙΤΣΙΟΝ	492287.89	4424980.49
21	44567/2	ΚΑΛΑΜΙΤΣΙΟΝ	492349.12	4424926.76
22	44567/2	ΚΑΛΑΜΙΤΣΙΟΝ	492241.95	4424842.87
23	44567/4	ΚΑΛΑΜΙΤΣΙΟΝ	492293.15	4424793.01
24	44567/4	ΚΑΛΑΜΙΤΣΙΟΝ	492348.70	4424840.53
25	44567/4	ΚΑΛΑΜΙΤΣΙΟΝ	492408.65	4424874.31
26	44567/4	ΚΑΛΑΜΙΤΣΙΟΝ	492391.90	4424555.38
27	44567/4	ΚΑΛΑΜΙΤΣΙΟΝ	492581.01	4424537.19
28	44567/4	ΚΑΛΑΜΙΤΣΙΟΝ	492581.41	4424498.20
29	44567/4	ΚΑΛΑΜΙΤΣΙΟΝ	492590.39	4424469.21
30	44567/4	ΚΑΛΑΜΙΤΣΙΟΝ	492583.36	4424435.23
31	44567/4	ΚΑΛΑΜΙΤΣΙΟΝ	492433.27	4424408.02
32	44567/4	ΚΑΛΑΜΙΤΣΙΟΝ	492488.40	4424371.41
33	44567/4	ΚΑΛΑΜΙΤΣΙΟΝ	492686.34	4424175.88
[illegible]				
34	44577/5	ΚΑΛΑΜΙΤΣΙΟΝ	493426.39	4421619.24
35	44577/5	ΚΑΛΑΜΙΤΣΙΟΝ	493253.74	4421142.42
36	44577/5	ΚΑΛΑΜΙΤΣΙΟΝ	493436.15	4421240.90
37	44567/4	ΚΑΛΑΜΙΤΣΙΟΝ	492586.46	4423486.51
38	44567/4	ΚΑΛΑΜΙΤΣΙΟΝ	491170.36	4423436.21
39	44567/4	ΚΑΛΑΜΙΤΣΙΟΝ	490863.11	4423733.94
40	44567/2	ΚΑΛΑΜΙΤΣΙΟΝ	491076.02	4425217.24
41	44567/2	ΚΑΛΑΜΙΤΣΙΟΝ	491685.34	4425173.77
[illegible]				
1	44567/2	ΚΑΛΑΜΙΤΣΙΟΝ	491676.51	4425059.63

ΠΑΡΑΤΗΡΗΣΗ: Οι συντεταγμένες προσδιορίστηκαν από τα διαγράμματα κλίμακας 1:5000 της ΥΤΥ και φέρουν την αντίστοιχη ακρίβεια.

Αναθεώρηση αρχικού χώρου Τορώνης - Κωφού Λιμένος, ΙΣΤ' ΕΠΚΑ

ΥΠΟΥΡΓΕΙΟ ΠΟΛΙΤΙΣΜΟΥ ΚΑΙ ΑΘΛΗΤΙΣΜΟΥ

3392 ΤΕΥΧΟΣ ΑΝΑΓΚΑΣΤΙΚΩΝ ΑΠΑΛΛΟΤΡΙΩΣΕΩΝ ΚΑΙ ΠΟΛΕΟΔΟΜΙΚΩΝ ΘΕΜΑΤΩΝ

Αθήνα, 30 Ιουλίου 2014

ΚΩΝΣΤΑΝΤΙΝΟΣ ΤΑΣΟΥΛΑΣ

Figure 28, Declaration for the Unified Archaeological Site of Toroni and Port of Kofos (source: Law 255/2014)

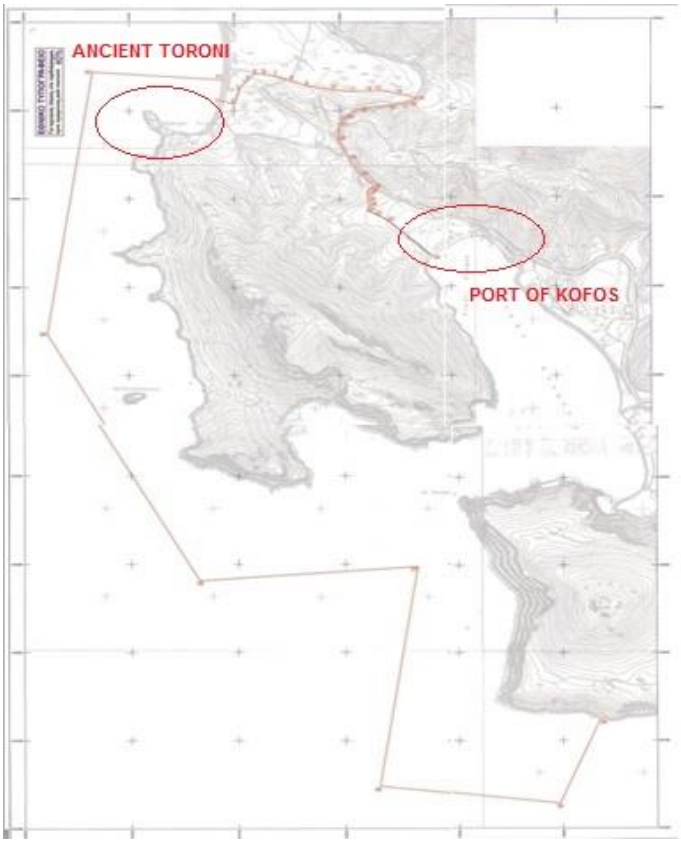


Figure 29, Topographic Map of the Declaration of the Unified Archaeological Site of Toroni and Port of Kofos (source: Law 255/2014)

4.5.2 The Archaeological Cadastre

The Hellenic Archaeological Cadastre (HAC) is an ongoing project implemented by the Hellenic Ministry of Education, Religious Affairs, Culture and Sports and specifically by the Department of Expropriations and Real Property. According to the Ministry, the Archaeological Cadastre is defined as a complete and systematic survey, codification and recordation o data and metadata for properties that belong to the Ministry, mainly for archaeological purposes and which are part of the public or private property of the Public Sector, with the final goal of the implementation of a formal registry for the cultural reserve of the country.

The HAC holds as a useful administrative tool that could lead to higher levels state services by saving human resources and public costs, therefore simplifying the administrative procedures needed and reducing bureaucracy. At the same time an important scientific tool is implemented, which provides clear scientific data concerning the cultural heritage of Greece. The registration of immovable antiquities in terms of cadastral information happens for the first time in Greece, a country that counts three millennia of civilization. Such a management tool for the protection of the Cultural

Heritage (CH) will provide explicit qualitative and quantitative features and will result to faster transactions between the citizens and the State. The cadastral registration of real estate with archaeological interest is also important for another reason. As official archaeological sites, historic places and regions of cultural environment are defined as the 8% of the Greek territory, it is of high importance that we develop a special system of land administration that will cover all the people-to-land relationships and will provide valuable descriptive and geospatial information concerning property with immovable monuments.

4.5.3 The Database System

The cadastral system formed for the implementation of the Archaeological Cadastre will incorporate descriptive and spatial information concerning the ownership status of properties with archaeological interest that belongs to the State and to private owners and needs to be clarified due to archaeological interest. The properties included lay in and out of urban centers and have a certain expropriation status. Furthermore, maritime antiquities and sites of underground placed antiquities are included. More analytically as Dimopoulou and Gogolou (2013) refer, the properties are divided as below:

- Immovable monuments of the Prehistoric, Classical, Byzantine, After- byzantine and Modern Period
- Immovable property of the Public Sector, such as parcels with historic architectural buildings and
- Areas of cultural environment under protection, such as archaeological sites, Protection Zones, monuments and historic places.

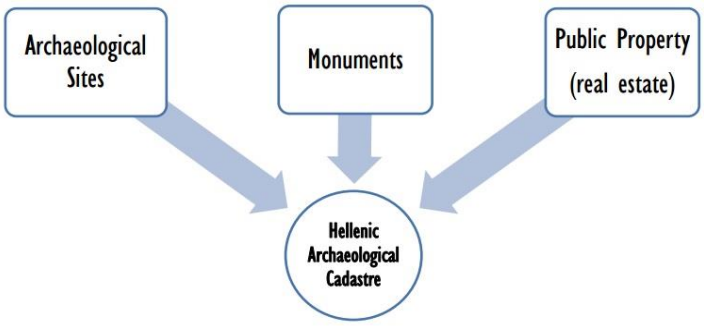


Figure 30, Basic Components of the Hellenic Archaeological Cadastre Project (source: Vradis C. & Syllaiou S., 2011)

4.5.4 The Database Operation

The HAC Project is being implemented in three stages. The first stage has already been completed and included the initial collection of data, indexing and preparation procedures by a labor working team specialized in archaeology. The second stage involves the development of an intermediate management system. The system will

include the collection of archive material, the cataloguing of monuments, sites and real property and the quantification of the above data. It also includes procedures of digitalization of archives and survey maps, introduction of topologies, spatial positioning and field surveying if necessary. The intermediate management system has already been completed and functions as the basis for the final Integrated Information System. The final Integrated Information System will be completed until early 2016 and will be formed as two databases. The general database will be at the service of the Ministry of Education, Religious Affairs, Culture and Sports. The second internet database gate called ‘’GAIA’’ (gaia; γαία= land) will be at the service of citizens. This means that the Ministries involved to the protection of the cultural assets will be able to know exact features of the protected areas, such as the position, the area, the legal status of protection and the property rights and restrictions associated with them. There are already 7500 public properties with archaeological interest and over 25000 archaeological sites formally recorded information which will constantly be enriched.

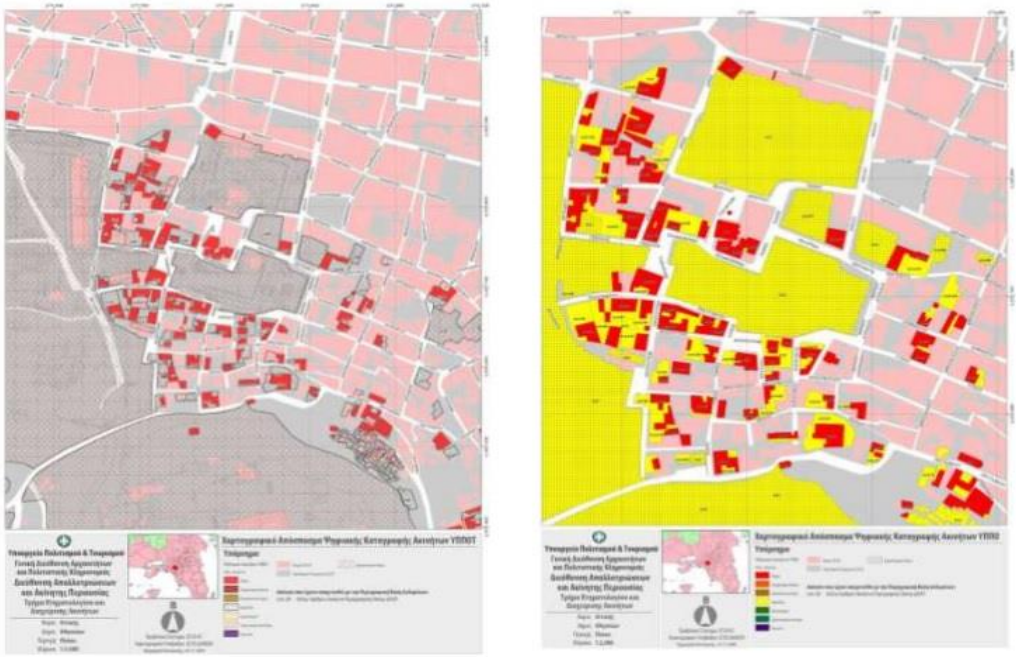


Figure 31, Intermediate collection of archaeological cadastral data sites and boundaries in Plaka, Athens (source: Vradis C. & Syllaiou S., 2011)

5. A 3D Hellenic Archaeological Cadastre based on LADM

5.1 Possibilities for Implementation

As mentioned above, the cadastral registration is a dynamic process with constant flow of data which are in need of spatial representation. Therefore, the utilization of internationally recognized standards for a cadastral system is critical. The LADM, as an ISO since 2012 can serve as a basis for the detailed legal and spatial representation of properties with archaeological interest as it provides a conceptual model with a range of representation possibilities. The implementation of a Hellenic Archaeological Cadastre (HAC) is important as the lack of a National Cadastre means that there is an unclear ownership status for properties with immovable antiquities. Interoperability between the two systems can raise the quality of cadastral data of the general Hellenic Cadastre. Furthermore, the structural normalization of data that concern the ownership status, the allowed jurisdictions and all the related legal activities that concern submarine immovable antiquities could also give a new dimension of possibilities for the Spatial Data Infrastructure of the fragile marine environment of Greece. Until now, there is no provision for the implementation of a Marine Cadastre in Greece. A conceptual schema as the one described below could give a perspective for the cadastral registration of marine archaeological sites.

As the conceptual model provided by the LADM suggests, the third dimension can be included with detailed information (see also LA_SpatialPackage). The class LA_BoundaryFace is appropriate for the spatial representation of the vertical boundary of a parcel. LA_BoundaryFace is useful when the boundary face strings are not sufficient for the description of three-dimensional spatial units. For example if a parcel contains underground immovable antiquities a vertical boundary face is necessary to describe the volume and the depth. There is an actual need for use of boundary faces in describing properties with archaeological interest. In Greece, there is a plethora of underground antiquities lying under modern cities, inside or near urban constructions. These sites together with monuments, protection zones and traditional architectural ensembles create a complex environment, which is affected by human activities. The registration of the third dimension would lead to a complete multipurpose registry that would serve the challenges of protection and restoration of antiquities as well as the quantification of the archaeological space, leading to better land use policies and decisions by the State.

As the HAC is on the verge of its implementation, its harmonization with international good practices could be achieved by incorporating land administration standards. The international state of the art is on the direction to innovative models that reach effectiveness and interoperability between different systems. Standards can lead to the formation of effective systems by offering sufficiency of administrative and spatial representation of people-to-land relationships and parcel design in two or three dimensions. The interoperability of systems can be achieved indirectly through the adaptation of standards in the conceptual schema of a cadastral system.

5.2 Formation of the Conceptual Model

The aim of the proposed model is the implementation of a land administration system for properties with archaeological and architectural interest based on the international good practice of standardization, in order to achieve clear administrative information of the rights, restrictions and responsibilities of the private owners and the State and their detailed spatial representation on two or three dimensions. A legal profile of the Hellenic Archaeological Cadastre based on the LADM core model is described in this chapter. The core model of the LADM is chosen due to its possibilities of producing detailed administrative and spatial information through a wide range of simplified procedures for entities and semantics. LADM can provide clear records of people-to-land relationships and special features related to properties and ownership status. This means that the cadastral registrations are specific and not generic, as they refer to specific parties that take part in every transaction, administrative sources, parcels and property rights, that clearly represent the ownership status of properties with archaeological interest and spatial units that clarify the boundaries of the archaeological or cultural space in relation with other public or private spaces.

Furthermore, a provision for the integration of attributes of a Marine Cadastre is included, in order to create a unified cadastral system for terrestrial and marine immovable antiquities. The research in the field of marine administration internationally focuses on the legal, jurisdictional and structural requirements needed for the development of land-based systems for cadastral registration. Both land and marine administration systems involve dynamic data flows which are in need of strong assessment and accurate qualitative documentation (administrative and spatial). A successful integration of marine cadastral data on a management system such as the Archaeological Cadastre, as it is proposed in this Thesis, seems to be a real challenge. In Greece, the problem of the management of terrestrial archaeological space lays to several deficiencies, such as the confusing legal framework for the protection, the fuzziness of responsibilities, the weak collaboration of institutions and the insufficient cadastral registration. Different and multidimensional constraints appear in the property registration of marine territories, a fact that would make the cadastral registration of submarine archaeological sites hard to implement. Greece is a country with extensive coastline and many island complexes. It has the 13th largest coastline worldwide, which counts as 17245 km. 73% of this coastline belongs to the islands. Maritime territories are far larger than the land itself. Therefore there is an ultimate need for its special management. Constraints that should be overcome are the uncertainty of maritime boundaries, the definition of the necessary 3D marine parcel, the application of the legal framework (both national and international) for the marine management and the protection of marine archaeological space and the clear definition of the maritime Rights, Restrictions and Responsibilities included on a cadastral registration.

As internationally recognized standards are promoted for better Land Administration, the implementation of a national Archaeological Cadastre with the LADM Standard will

enable the registration of important cultural property information by following the global good practices. The management of archaeological data with the proposed system will provide a useful tool to the protection services as it integrates a commonly shared vocabulary with possibilities of exchange and interoperability with related registries or infrastructure (e.g. National Cadastre, INSPIRE, etc.). Therefore, geospatial infrastructure could be implemented for the best management of the cultural space of Greece, combining not just classic GIS platforms, but also descriptive administrative information for the complex ownership relationships in heritage assets on a standardized structure. The incorporation of the third dimension is absolutely necessary. It enables the possibility of registering detailed boundaries of parcels with archaeological interest. Detailed administrative and spatial description of boundaries is essential for an Archaeological Cadastre, as it clarifies the boundaries of private ownership and introduces special constraints to it, by giving accurate information, not only as lines or points in a map, but also by representing the vertical plane (in volumes).

The model proposed is a property-centered model for the cadastral registration of the archaeological space. For this reason all the identifiers of classes and types begin with the prefix *"Arch_".* As the figure shows below, a basic property unit (Arch_BAUnit in the administrative level) has a spatial reference (Arch_SpatialUnit in the spatial level) and is related with a unique property right (Arch_RRR). The transactions always happen between the involved parties (Arch_Party).

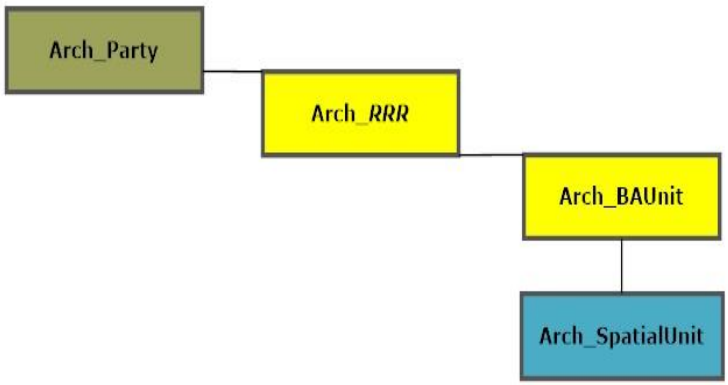


Figure 32, The Proposed Model

More specifically, a basic property unit (Arch_BAUnit) that consists of zero or more spatial units (Arch_SpatialUnit) and belongs to one party (Arch_Party), is related to one property right (Arch_RRR) in order to form a unique combination of instances of the above classes. The property right (Arch_RRR) is explained at Right (Arch_Right), Restriction (Arch_Restriction) and Responsibility (Arch_Responsibility). A Restriction can be a Servitude (Arch_Servitude). One or more RRRs are described in the Administrative Source (Arch_AdministrativeSource) and their acquisition type arises from the Way of Ownership, an external class to the Administrative Source (extArch_WayOwn). The Administrative Source describes zero or more acquisition types of RRRs. The Spatial Unit may contain zero or more building units (Arch_SpatialBuildingUnit). At last a Spatial Unit is represented in one or more Levels (Arch_Level).

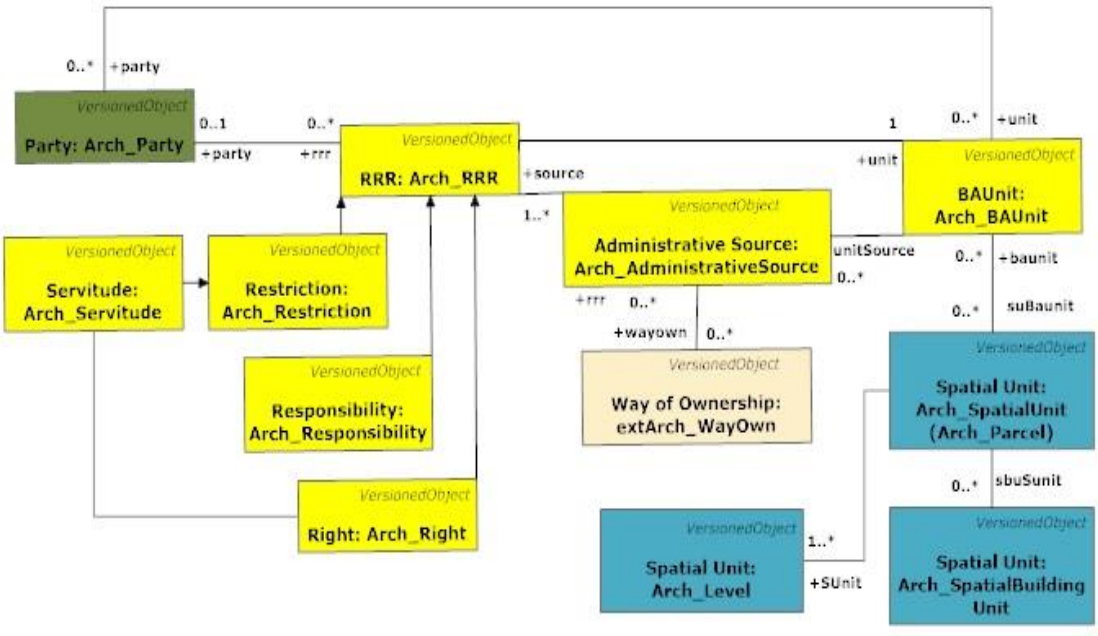


Figure 33, Classes of the Proposed Conceptual Model

Data has been adapted to the core model with changes and external classes in the system in order to serve the implementation of a 3D Hellenic Archaeological Cadastre based on the LADM. There is a connection of cadastral data between registrations of the Archaeological Cadastre and the National Cadastre. The LADM provides a conceptual schema for the common representation of both registries. As the figure shows below, there is a matching of the basic classes of the three models, which consists the premise for their common expression with shared vocabulary (Dimopoulou and Gogolou, 2013). The schema shows how the basic entities of the National Cadastre and the Hellenic Archaeological Cadastre can be described based on the entities the LADM provides. The basic entities of the National Cadastre of Greece are existing classes as described in the Hellenic Cadastre Standards, which are implemented by the National Cadastre & Mapping Agency S.A .(NCMA S.A.). The entities of the Hellenic Archaeological Cadastre are the classes based on the LADM, as defined in Dimopoulou and Gogolou (2013). The convergence of schemas serves the request for flexibility of both cadastral systems by incorporating international prototypes and adopting standardized models.

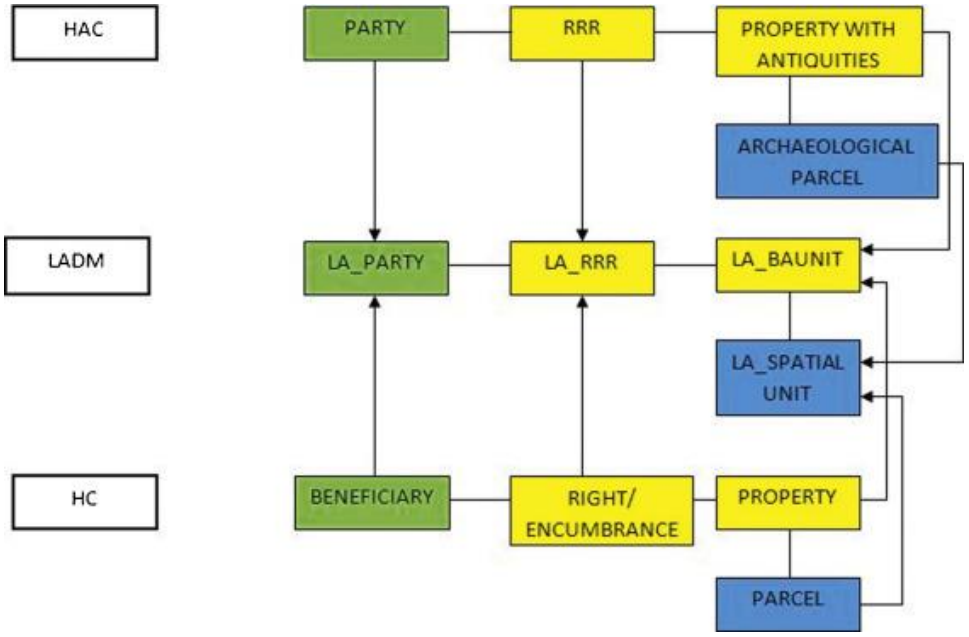


Figure 34, Classes of the HC and the HAC Interacting with LADM Classes (Gogolou C. & Dimopoulou E., 2015)

It is of high importance to mention that the codification of classes follows the principles and standards of the Hellenic National Cadastre and the types of RRRs have incorporated the Greek Archaeological Legislation. The historical status, the legal framework of protection and the archaeological and architectural details of the monuments are also included. Features that concern the expropriation status of properties are integrated in order to quantify properties with existing expropriation status and provide information for a financial rationalization.

The final model consists of the legal and spatial profile as described below. Types and roles are features explained in the code lists. The legal profile, as in LADM, includes the classes for the party, the Basic Administrative Unit and the Rights, Restrictions and Responsibilities (RRRs). It consists of three packages:

5.2.1 Party Package

The Party Package includes the class Arch_Party and the external classes extArch_PartyRepresentative and extArc_PartyAddress. In this class are registered legal persons that represent the State, for example the Ministry of Education, Religions, Culture and Sports, the Ministry of Environment and Climate Change, the Touristic and Real Estate Company and physical persons who are owners of properties with immovable antiquities. The Party Package also refers to physical persons or organizations involved in transactions registered by the HAC, such as lawyers, notaries, engineers, banks, tax authorities and all the natural persons or legal institutions that take part in the administrative process.

Figure 35, Arch_Party and Codelists

Two external classes have been added to the Party Package. The class extArch_PartyRepresentative indicates the representative person that takes part in a transaction instead of the involved party. The class extArch_PartyAddress is related to the address of the party and its attributes.

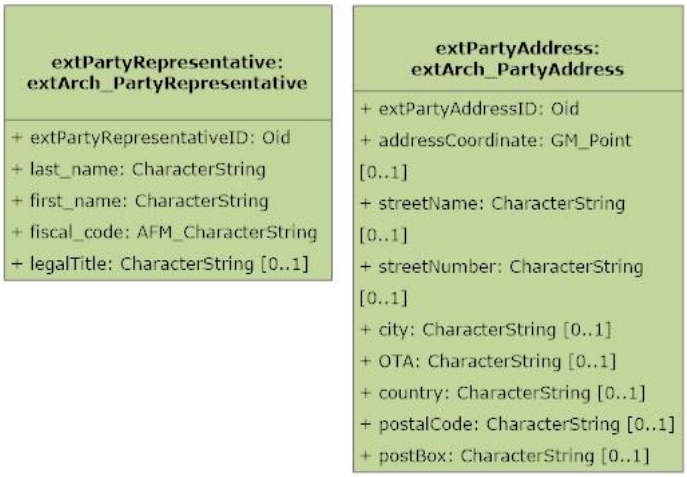


Figure 36, External Classes of the Party Package

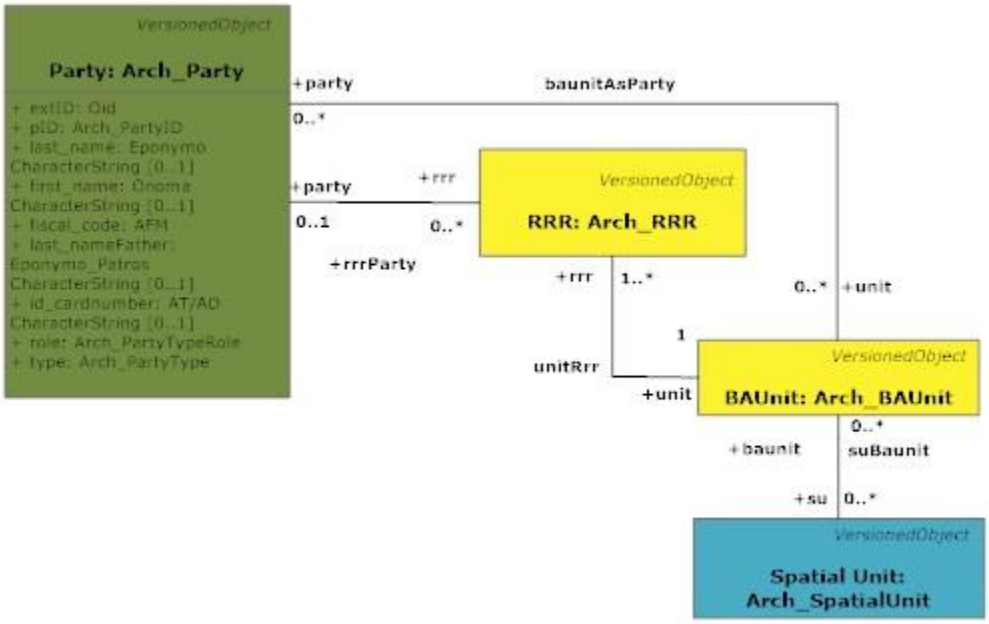


Figure 37, Class Arch_Party Interacting with Classes of the Proposed Model

5.2.2 Basic Administrative Unit Package

Basic Administrative Unit Package includes three classes, Arch_BAUnit, Arch_AdministrativeSource and the external class extArch_WayOwn. For the complete registration, the Hellenic Cadastre Standards have been utilized. Furthermore specific laws and guidelines related to the protection of archaeological space have been incorporated in order to describe the types of properties, administrative sources and ways of acquisition of ownership.

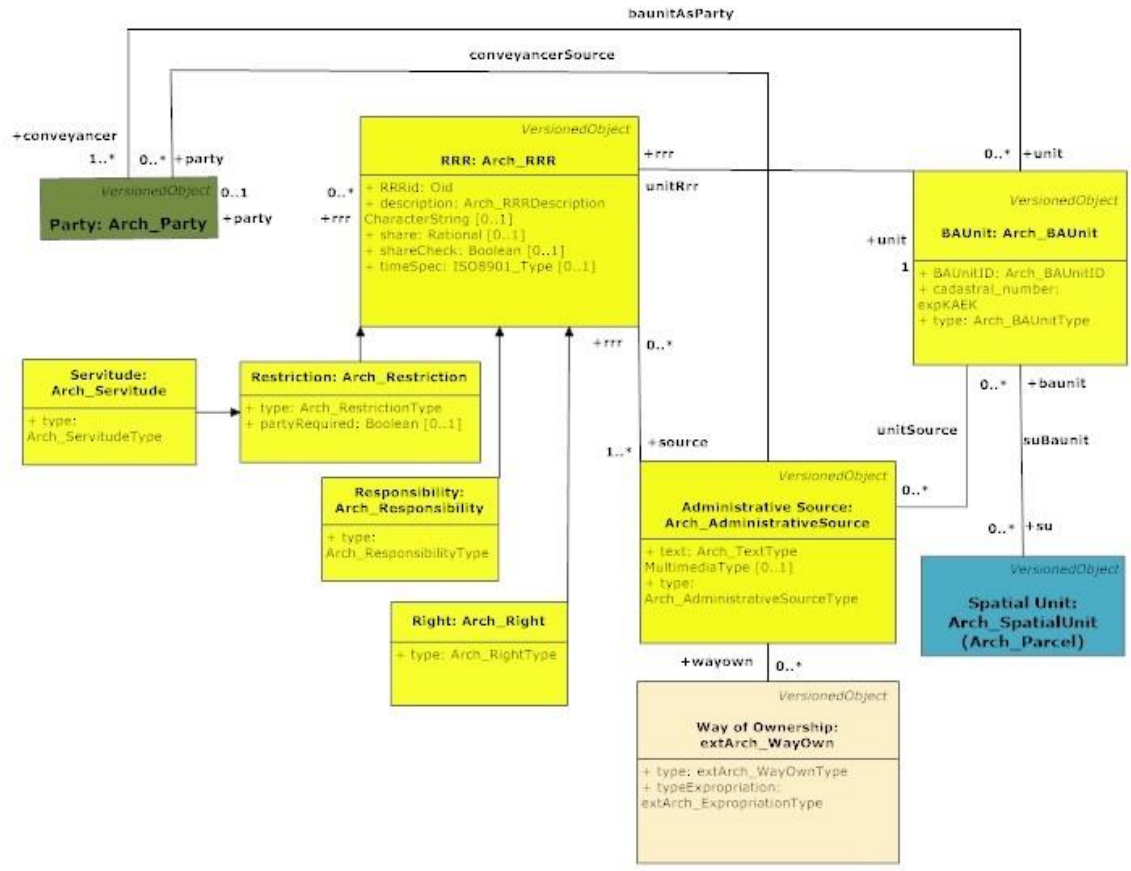


Figure 38, Classes of the Administrative Package Interacting with Classes of the Proposed Model

Class Arch_BAUnit is an administrative class that is objective to the current legal framework, concerning the types of properties and how they are associated with land rights. The legal framework is a combination of the existing Cadastral Law (N.2308/1995) and the Archaeological Law (N.3028/2002). The Arch_BAUnit consists of zero or more spatial units in which one or more Rights, Restrictions and Responsibilities are exercised. A unique cadastral record is created if one Party exercises a Right, Restriction or Responsibility in the BAUnit. The Arc_BAUnit includes the descriptive information regarding the types of properties met in Greece. For the identification of each property the Hellenic Cadastral Code Number (KAEK) is introduced to the system. KAEK consists of 12 digits. Each of the KAEK 12 digits indicates codificated administrative information concerning the parcel's location, as Kalogianni (2015) refers: The first 2 digits correspond to the Prefecture where the land parcel is located, the next 3 digits correspond to the sector of each Municipality, Municipal District or Community, the next 2 digits correspond to the cadastral sector of each municipality, the next 2 digits correspond to the cadastral section and the last 3 digits correspond to the serial number of the land parcel within the section. The utilization of KAEK is also necessary for the classification and thus the recognition as unique of the horizontally or vertically fragmented administrative units. Therefore, the expKAEK is the unique identifier for the Arch_BAUnit that lies on land (expanded KAEK contains 16 digits and gives information

about the unique number of the horizontal, vertical or mixed property). The unique identifier could not take the value “expKAEK” only in case the Arch_BAUnit is a Marine Parcel. Property is an autonomous object of transactions and it is classified as in the code list for Arch_BAUnitType. The types Coastal Zone and Marine Parcel belong to the State and refer to coastal or underwater immovable antiquities, which mean that they cannot take part in any financial transactions. As a result a variety of property restrictions is associated with them, which are in need of registration.

Figure 39, Class Arch_BAUnit and Codelist

Class Arch_AdministrativeSource incorporates all the types of archives and formal or informal documents related to the properties (Arch_BAUnit). Such sources can be deeds, laws, administrative acts and sources that describe the special historical, archaeological or architectural features of the Arch_BAUnit. Administrative sources incorporated in this class are used for the classification of property rights in properties with archaeological interest, a fact that brings in surface all the contradictory attributes of the ownership status of the archaeological space. For the completeness of records of the Administrative Source the LADM provides three additional attributes related to their legality and to the facilitation of their portrayal in any historical moment. The attribute recordation describes the issuing date of the administrative source. The attribute submission describes the date of the submission of the administrative source in the cadastral database. The attribute lifespanStamp reflects a time stamp in the system.

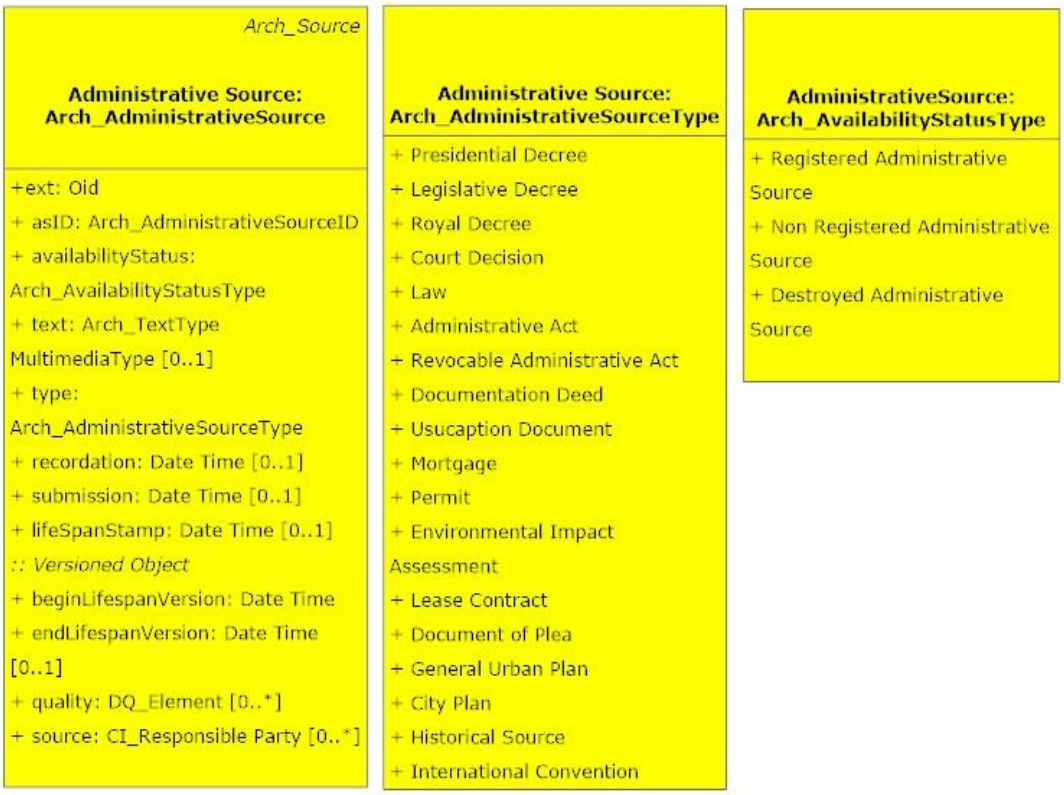


Figure 40, Class Arch_AdministrativeSource and Codelists

Class extArch_WayOwn is an external class that is primarily connected with the Arch_AdministrativeSource and through them with the Arc_BAUnit. As Dimopoulou and Gogolou (2013) refer, the implementation of the HAC aims to the delimitation of the archaeological space of Greece in order to spatially clarify the protection zones and the public or private spaces with archaeological interest. Therefore, the acquisition of ownership is of high importance. The external class extArch_WayOwn includes all the formal types of property ownership which are proven with legal deeds as they are described in the HC Standards. The class is defined as an external class firstly connected to the Arch_AdministrativeSource and secondly to the Arch_RRR. The information that provides gives extra information for the RRRs exercised and arises from the administrative source, therefore it justifies the way of acquisition of RRRs with the administrative source being the intermediate link.

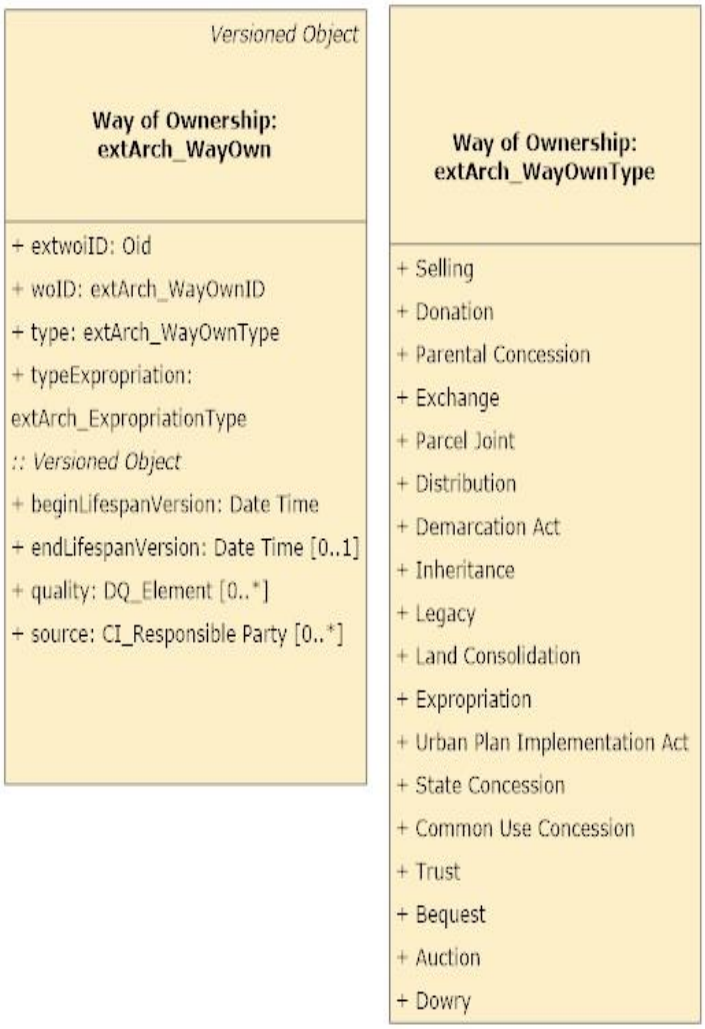


Figure 41, Class extArch_Way_Own and Codelist

5.2.3 RRR Package

RRR Package includes three basic classes, Arch_Right, Arch_Restriction and Arch_Responsibility which are specializations of the abstract class Arch_ RRR as described in the LADM Text. The class Arch_Restriction also has its specialization, the class Arch_Servitude.

Class Arch_RRR is an abstract class for the Rights, Restrictions and Responsibilities. It is further described in classes Arch_Right, Arch_Restriction and Arch_Responsibility.

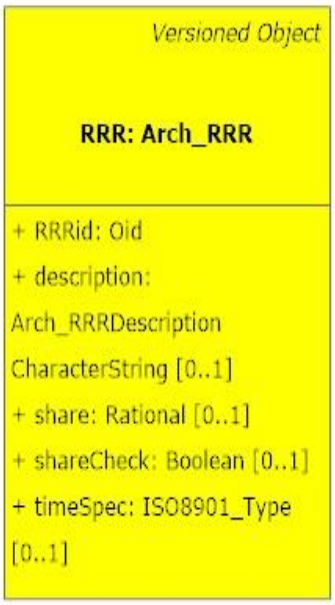


Figure 42, Abstract Class Arch_RRR

Class Arch_Right represents all the registrable rights that can be declared for a property (Arch_BAUnit). By the term registrable rights it is implied that all RRRs should be administratively demonstrated, which means that the information arises from the administrative source. The codelist for the rights follows the HC Standards and includes all the types of rights met in the Greek territory. Full Ownership, Limited Ownership and Usufruct should be expressed on shares. It is obligatory to have Limited Ownership and Usufruct at the same property. Air Right, Water Right and Building Coefficient Factor Transfer can be associated with a property (Arch_BAUnit) which is spatially represented as a 3D property object. Jurisdiction is the right of the coastal state associated with a marine parcel, which can also be three-dimensional.

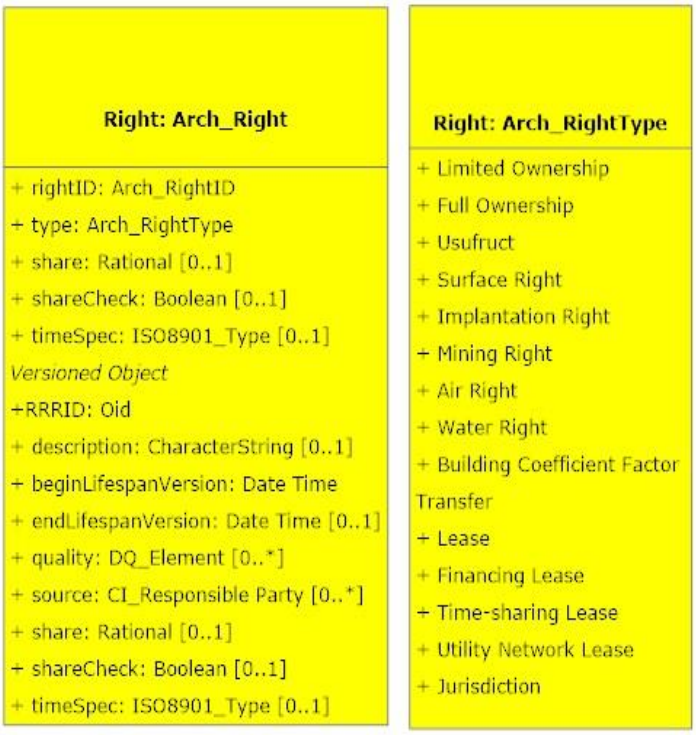


Figure 43, Class Arch_Right and Codelist

Class Arch_Restriction describes the constraints associated to properties with archaeological assets (Arch_BAUnit). These constraints mainly refer to economic activities such as agriculture or farming and to specific building or urban planning rules that may affect the land uses of the property. There are also restrictions in economic activities exercised on properties that lay on protection zones of archaeological sites. The restriction types Aquaculture and Anchorage refer to marine parcels with antiquities and they are strictly forbidden within the limits of a marine archaeological site, according to the Archaeological Law (N. 3028/2002). The restriction type Marine Works can be raised only after the Service for the Protection of Submarine Antiquities gives the permission to.

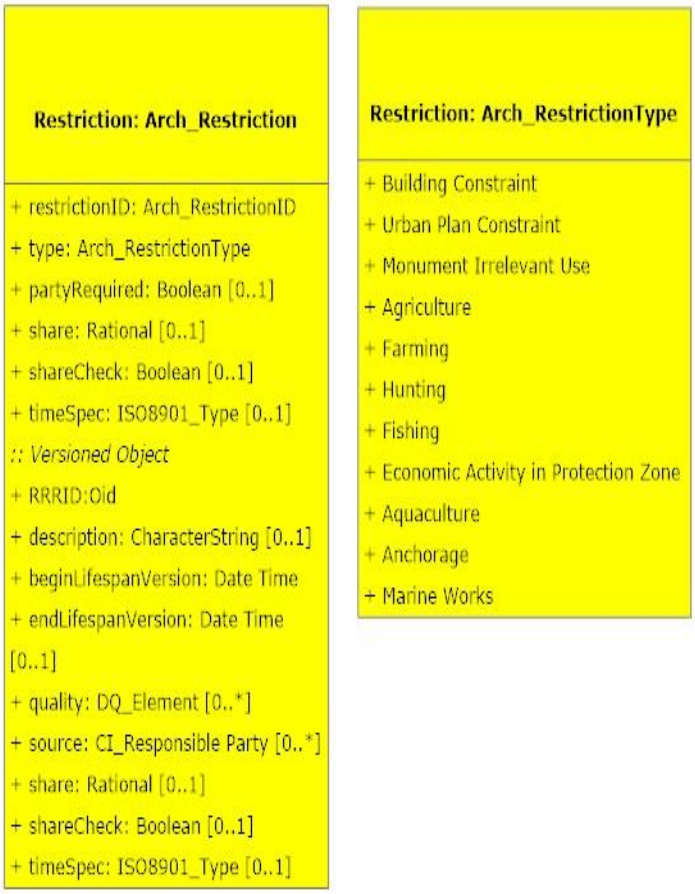


Figure 44, Class Arch_Restriction and Codelist

Class Arch_Servitude incorporates the special restrictions associated with the rights of the Arch_BAUnits.

Figure 45, Class Arch_Servitude and Codelist

Class Arch_Responsibility refers to the responsibilities that arise from the legal framework for the protection of properties with archaeological interest (Law 3028/2002). Responsibilities may refer to owners of rights in the property (Arch_BAUnit), such as the private owners, but also to the State that does not have any right in the property. Parties such as the Greek State or a Public Institution are obliged to preserve cultural assets even in private properties.

Figure 46, Class Arch_Responsibility and Codelist

5.2.4 Spatial Package

Spatial Package also includes three basic classes, Arch_SpatialUnit, Arch_Level and Arch_BuildingUnit.

Class Arch_SpatialUnit is the basic class for the spatial representation of Archaeological Parcels. The term Archaeological Parcel means a unique property expressed in spatial level, in which there is one or more immovable antiquities. In Greece, property is highly fragmented. This fact creates a big number of relatively small areas of public or private parcels. A large public parcel such as a declared archaeological site can be considered as one Archaeological Parcel. A homogeneous area of archaeological or cultural interest could be considered as one Archaeological Parcel or could consist of many Archaeological Parcels. These Archaeological Parcels are recorded as separate land parcels due to different owners and complex RRRs that arise from deeds or due to problems in the expropriation process. However, there are different cases where the separate representation is not feasible. The Archaeological Cadastre is being implemented in order to facilitate the successful development of the Hellenic Cadastre. On this direction, the Archaeological Parcel can be expressed with the conventional

cadastral parcel of the Hellenic Cadastre, which will be enriched with information about the constraints of the archaeological space. Separate registration based on the existing cadastral parcels could also facilitate the spatial representation of the third dimension, as an already defined jurisdictional polygon integrates the legal background for the delimitation of 3D property units. In this way, an Archaeological Cadastre can quantify and provide valid information about the physical extent of archaeological spaces. In other cases the Archaeological Parcel is not needed to coincide with the cadastral parcel of the Hellenic Cadastre. Such cases can include large regions of special protection or Archaeological Site Declarations. Overlapping RRRs associated will also be accurately recorded. The identifier of the Arch_SpatialUnit is the expKAEK if the type of parcel lies on land and different only in case the parcel is a Marine Archaeological Site. The codelist Arch_SpatialUnitType refers to the categories of parcels. The first four types are defined by the Ministry of Education, Religious Affairs, Culture and Sports that is responsible for the implementation of the HAC. The last type (Marine Archaeological Site) enables the future registration of submarine archaeological sites. The attribute zone is a special and important attribute for the Archaeological Parcel. It refers to the existence of protection zones of archaeological sites (according to the Greek Archaeological Law there is Protection Zone A and Protection Zone B). The coastal state has the immediate right to protect the submarine antiquities in both Territorial Sea and Contiguous Zone, according to the United Nations Convention on the Law of the Sea (UNCLOS, 1982). In other marine zones defined by the UNCLOS (1982), such as the continental shelf or the exclusive economic zone there is not any jurisdiction of the coastal state described concerning the protection of submarine antiquities. The attributes area, mapPosition, topo_exist and forestArea, as well as their codelists have been added according to the HC Standards. The attribute dimension gives information gives information for the dimension of the Archaeological Parcel. The attribute surfaceRelation shows where an Archaeological Parcel lies based on the elevation. The case of mixed surface means that a parcel may lie below or above and on surface at the same time. Accordingly a surface below, above or mixed implies the registration of volumes (delimitation of a 3D parcel). At last, the attribute volume refers to a three-dimensional level of registration and describes the 3D boundaries and volumes or depths. Data acquisition for the implementation of initial cadastral maps is highly dependent on public institutions for geospatial data, such as the NCMA S.A, the Ministry of Education, Religions, Culture and Sports, the Hellenic Military Geographic Service (HMGS) and the Hellenic Navy Hydrographic Service (HNHS).

Figure 47, Class Arch_SpatialUnit and Codelists

Class Arch_Level refers to the Archaeological Parcel (Arch_SpatialUnit) and the level of its spatial representation. A 2D and a 3D level are added as types of levels in order to include all the cases of parcels where immovable archaeological findings appear. For example, a parcel that lies in a rural area and carries the remains of an ancient residence is not in need for a three-dimensional registration. In the opposite, a parcel that includes immovable archaeological findings in the basement of a modern building has to be represented in three dimensions. Furthermore, a level for the representation of marine parcels has been provisioned. In this case a submarine archaeological site, such as a shipwreck or an ancient sunken settlement is in need of cadastral registration. At last levels of urban planning and utility networks are added to the model. Level of urban planning is necessary, as it is important to imprint the ownership status of every region. Planning zones and administrative acts that concern cities are useful data expressed on the related level. Utility networks level is also important, especially in cases of underground utility networks that can affect ancient immovable monuments.

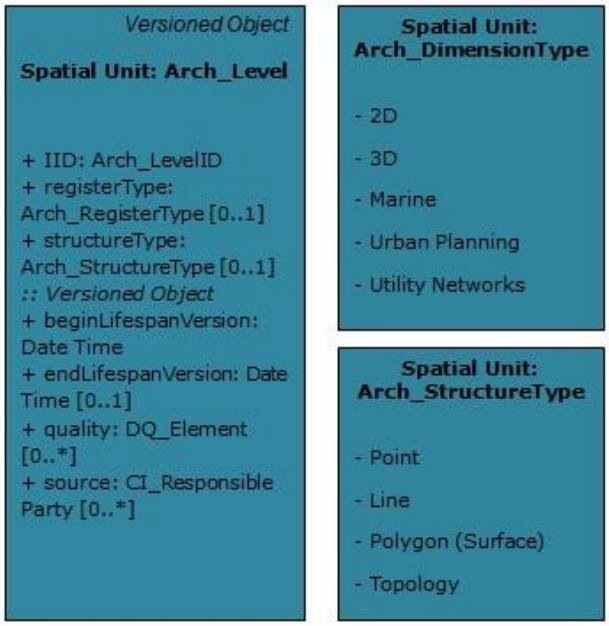


Figure 48, Class Arch_Level and Codelists

Class Arch_BuildingUnit refers to the ancient buildings or other constructions of the Archaeological Parcel. The spatial representation of the HAC includes parcels and building units with special features, such as archaeological interest and protection frameworks. For this reason the model that is described should integrate a descriptive management tool for the cultural objects inside the parcels and the clarification of their ownership status. The descriptive information for the types and the number of the antiquities is the core of the HAC. The attribute building_number is added in order to quantify the constructions to and represent their exact position in the Archaeological Parcel. The attribute admSource_Number refers to the number of construction described in the given administrative source. The Hellenic Cadastre Standards imply that the first building described in the deeds shall take the building number 1, the second building shall take the building_number 2 and so on. The building_number is not always the same as the admSource_Number. The type of archaeological construction is described in the code list of the Arch_BuildingUnitType. The type Shipwreck (sui generis) refers to shipwrecks that are characterized as marine archaeological sites with shipwrecks.

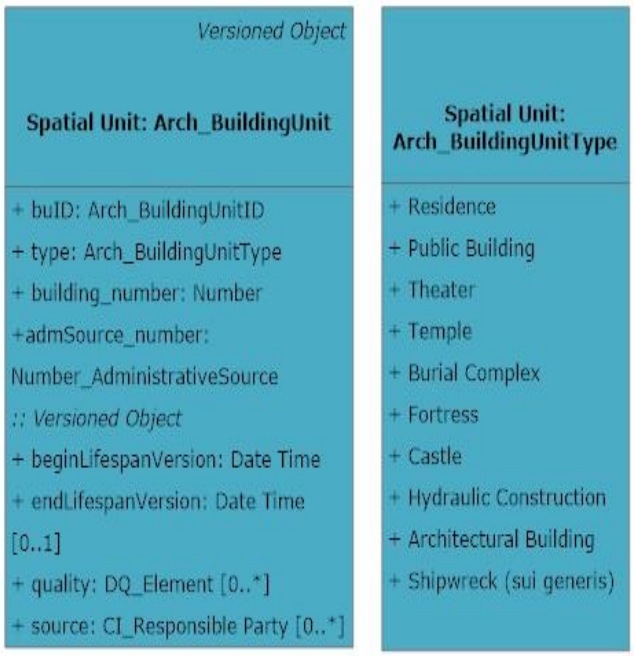


Figure 49, Class Arch_Building and Codelist

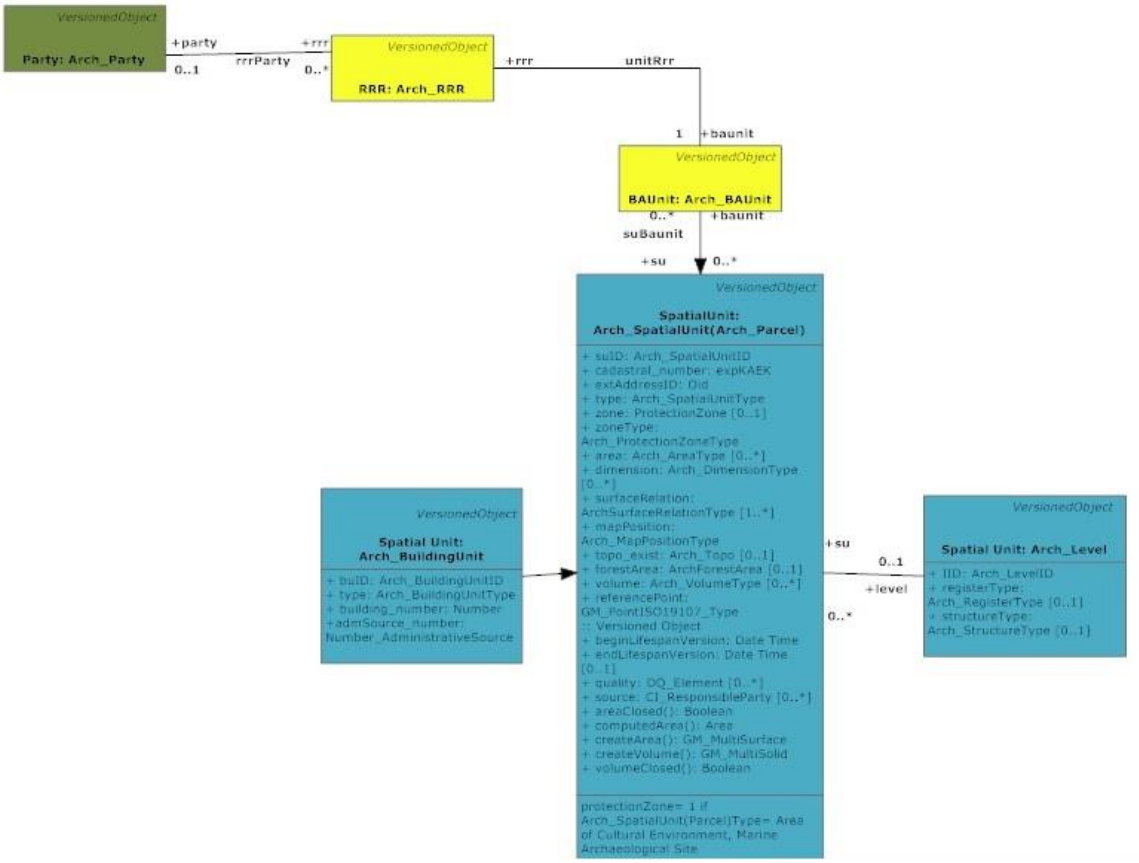


Figure 50, Classes of the Spatial Package Interacting with the Classes of the Proposed Model

5.2.5 Subpackage of Surveying and Representation

Subpackage of Surveying and Representation includes four classes, Arch_Point, Arch_SpatialSource, Arch_BoundaryFaceString and Arch_BoundaryFace.

Class Arch_Point refers to the types of points used for the positioning of spatial units. Types of points are analyzed with the attribute Arch_PointType and they can be check points surveyed by the institution of trigonometric points that are provided by national surveying organizations.

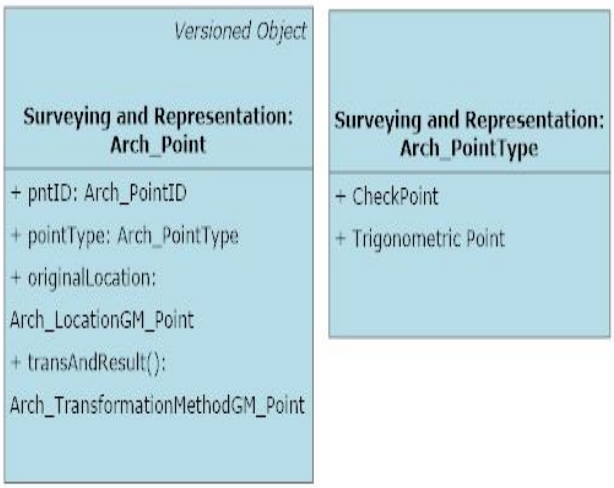


Figure 51, Class Arch_Point and Codelist

Class Arch_SpatialSource classifies the spatial archives utilized for the tracking and spatial design of the Archaeological Parcel, such as topographic plans or aerial photographs. The methods and processes of measurement are defined, as in the LADM, by ISOs and are also included.

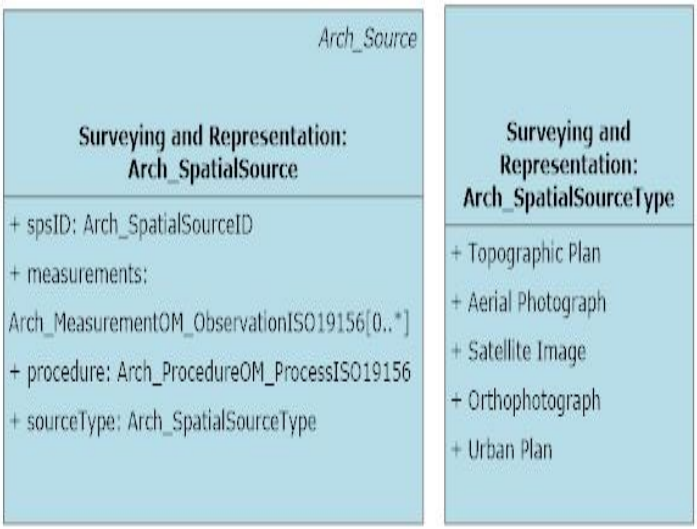


Figure 52, Class Arch_SpatialSource and Codelist

Class Arch_BoundaryFaceString is used for the two-dimensional description of the boundaries of the Archaeological Parcel. The geometry of the boundaries is implemented with the integrated ISO (ISO 19107) and their textual description is integrated with the attribute locationByText, which includes a short description based in the administrative sources. The attribute Arch_BoundaryFaceStringType is not described in the LADM conceptual model and offers additional information to the system. It is necessary in order to give detailed information regarding the boundaries of the registered parcel with archaeological interest. Boundaries can be public bordering on public or public bordering on private or private bordering on private, for example a declared archaeological site bordering on the public road, a public historical building bordering with a private block of apartments, a private neoclassical building bordering on a private block of apartments.

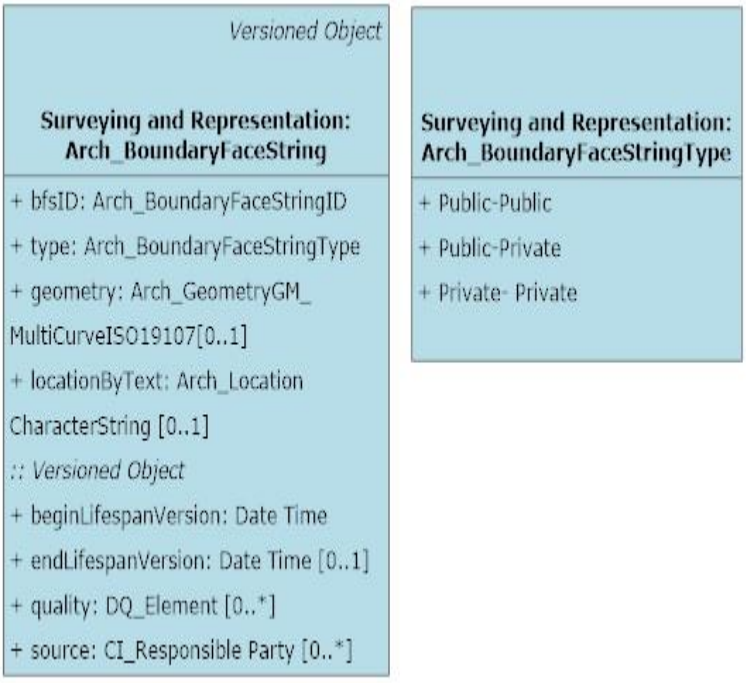


Figure 53, Class Arch_BoundaryFaceString and Codelist

Class Arch_BoundaryFace is used for the three-dimensional description of the boundaries of the Archaeological Parcel. As in Arch_BoundaryFaceString the geometry of the boundaries is implemented with the integrated ISO (ISO 19107) and their textual description is integrated with the attribute locationByText, which includes a short description based in the administrative sources. The attribute Arch_BoundaryFaceType offers the same important information as the above described Arch_BoundaryFaceStringType.

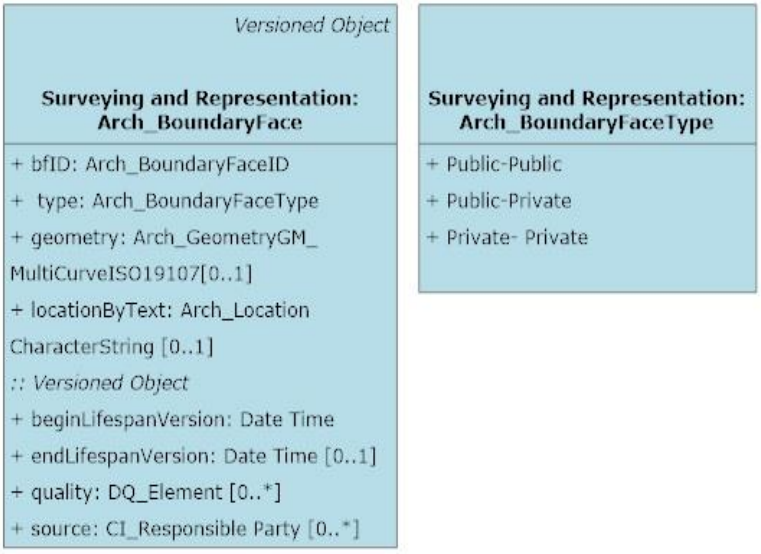


Figure 54, Class Arch_BoudaryFace and Codelist

5.2.6 Versioned Objects

For the formation of versioned objects every class has additional attributes that can be utilized for the portrayal of a complete cadastral record at a specific moment on the past. The necessity of those attributes reflects the fact that a cadastral database should be able to be reconstructed with the exact historical data in different times in the past and that the institution should have the possibility of recovering the initial information of the database. This way it is ensured that the cadastral database is a reliable dynamic system. The possibility for reconstruction of the database is of high importance for an Archaeological Cadastre, as there is a constant flow of information that concerns the legal, jurisdictional, taxation, delimitation and ownership changes of properties with archaeological interest. As described in the LADM (Text for ISO/FDIS 19152 GI-LADM, Annex N), the class Versioned Object serves a state based modeling; every object is assigned (at least (two dates/times which indicate the time interval during which the object is recorded in the system as an actual version.. through the comparison of two successive states it is possible to reconstruct what has happened, as a result of one specific event. It is straightforward to obtain the state at a given moment in time, by selecting the object based on a time interval (tmin-tmax). The temporal aspect is inherited from the class Versioned Object with the attributes beginLifespanVersion and endLifespanVersion, which respectively represent the date of inception and end of the cadastral record in the database. The attribute quality refers to the quality of cadastral records. The attribute source describes the responsible institution for the creation of cadastral records based on ISOs. Most objects inherit their temporal attributes via the Arch_Party, Arch_RRR, Arch_BAUnit, and Arch_SpatialUnit or directly via the class Versioned Object. In the last case classes Arch_Party, Arch_RRR, Arch_BAUnit, Arch_SpatialUnit, Arch_Level, Arch_Point, Arch_BoundaryFaceString, Arch_BoudaryFace Arch_RequiredRelationshipBAUnit and

Arch_RequiredRelationshipSpatialUnit are all subclasses of the class Versioned Object. Classes Arch_Right, Arch_Restriction, Arch_Servitude and Arch_Responsibility inherit VersionedObject through the above classes.

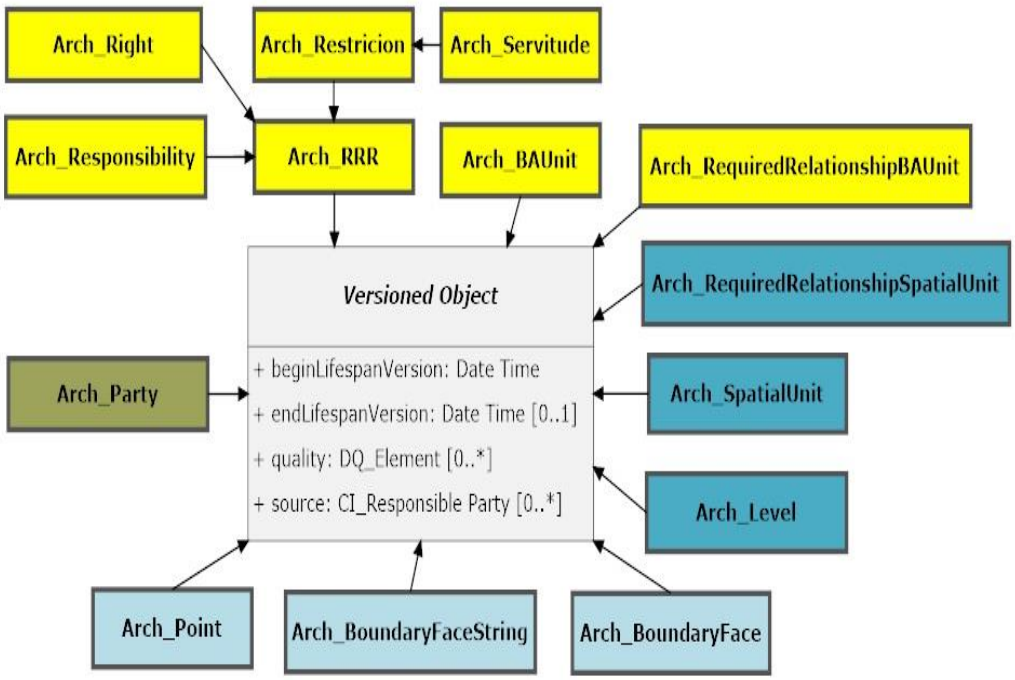


Figure 55, Versioned Object in the Proposed Model

5.3. Applications

Three pilot applications of typical situations of properties with archaeological features are described below. The complexity of the archaeological space and the multiplicity of property rights associated with it are presented in detail. The functional possibilities and requirements set by the author to the proposed model are examined through the applications in order to acquire better knowledge about the conceptual design of the model.

5.3.1 Case Study 1: Way Servitude in Archaeological Parcel

Party 1 owns full ownership of a private Archaeological Parcel in non-serviced land. The parcel holds the remains of an ancient burial complex. Party 2 owns full ownership of a bordering blind parcel. Both owners have agreed by contract that the blind parcel holds way servitude through the Archaeological Parcel. The passage does not affect the archaeological remains described above. As the figure shows below there are three RRRs associated with the Archaeological Parcel; the right of Full Ownership and the responsibility of Monument Conservation are exercised by the owner of the parcel (Party

1). At the same time Party 1 has a restriction, which is translated as a Way Servitude for Party 2.

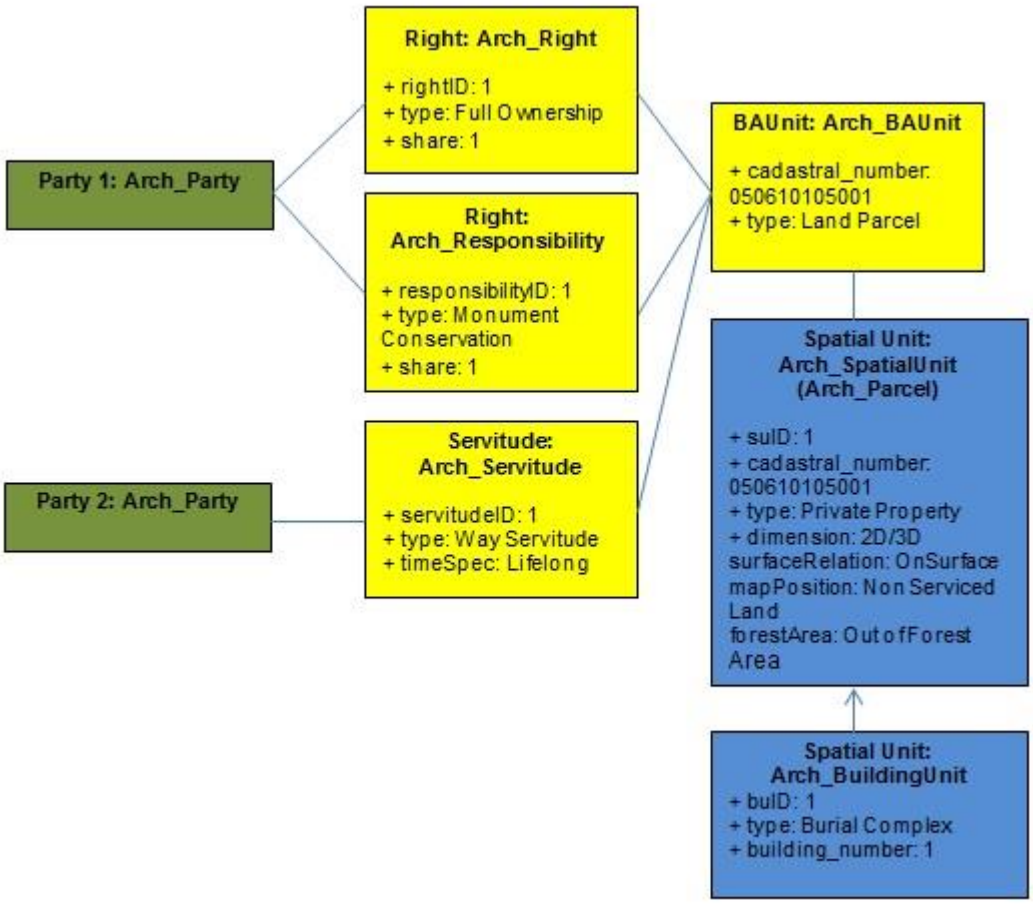


Figure 56, Way Servitude in Archaeological Parcel

5.3.2 Case Study 2: Antiquities in the Basement of Horizontal Property

In a land parcel of an urban area a horizontal fragmentation has resulted to the formation of three horizontal properties, described in the related contract. The first horizontal property has a partition (or else a share of co-ownership) in the parcel of 334/1000; it lies in the basement and belongs to Party 1 and Party 2 with a share of ½ each. The second horizontal property has a partition of 333/1000 in the parcel; it lies in the ground floor and belongs to Party 1. The third horizontal property has a partition of 333/1000 in the parcel; it lies in the first floor and belongs to Party 2. During the excavation for the construction of the building a part of an ancient fortress was revealed. The responsible protection service (Ministry of Education, Religious Affairs, Culture and Sports) decided that the building could be constructed but the fortress should be protected in a special area of the basement. This fact means that co-owners of the horizontal property of the basement will share the responsibility of protecting the ancient monument. A separate

three-dimensional representation of spatial units for the three horizontal properties is also needed, in order to clarify the spaces of special protection in the building.

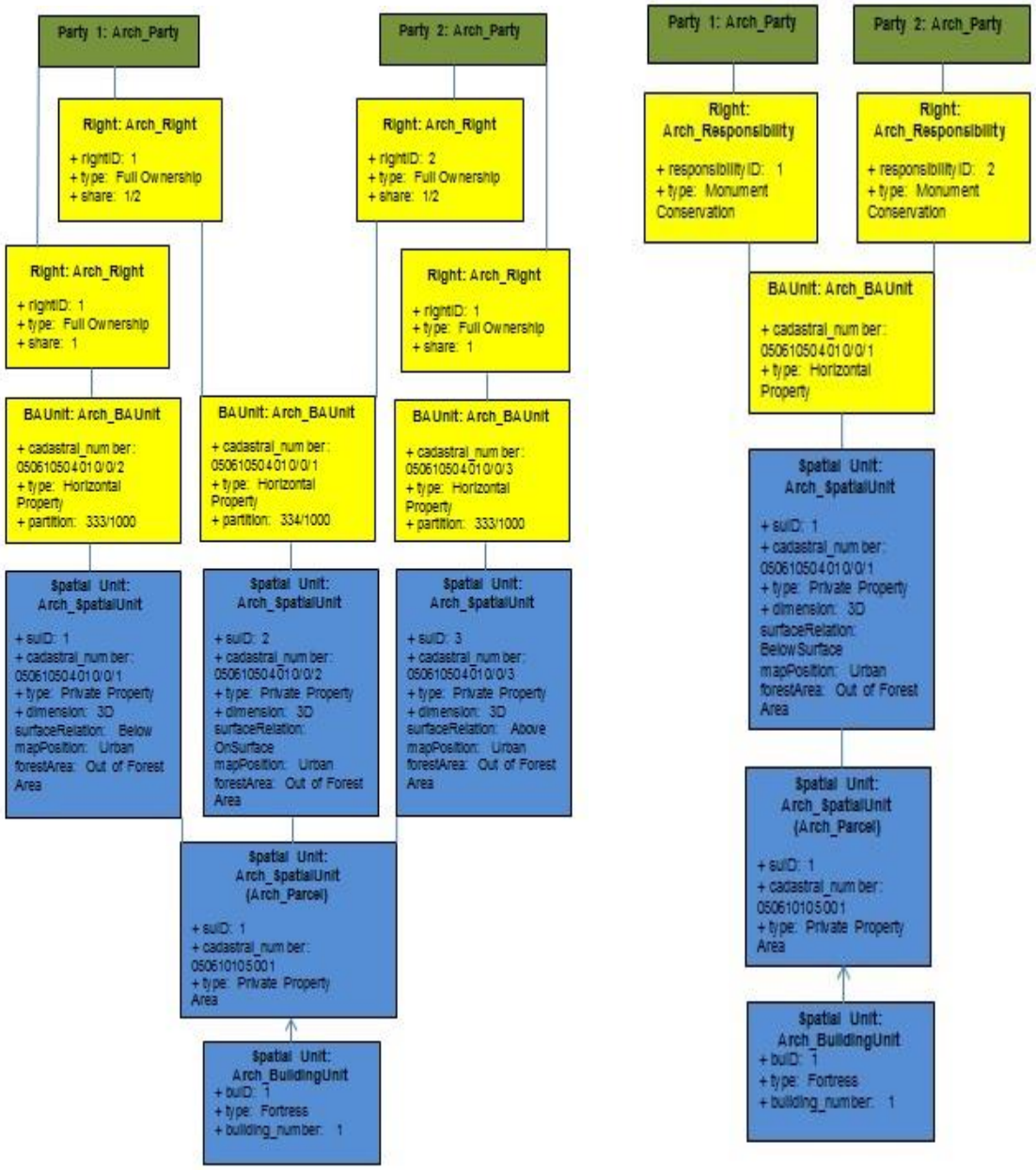


Figure 57, Horizontal Partition with Underground Antiquities

5.3.3 Case Study 3: Land and Marine Archaeological Site Declaration

Excavation process in a large region has brought in the light important ancient findings. The Greek Ministry of Education, Religious Affairs, Culture and Sports is about to issue an Administrative Act for the declaration and delimitation of the archaeological site in the region. The Archaeological Site Declaration will describe at the same time terrestrial and submarine antiquities that need to be preserved such as a fortress, a public building and a shipwreck. Protection zones are also set depending on the position of immovable antiquities (land antiquities belong to Protection Zone A and marine antiquities refer to the Territorial Sea). A variety of property rights is associated with the archaeological site. Full ownership belongs to the State (expressed by the Ministry of Education, Religious Affairs, Culture and Sports) who also has the responsibility of Declaration of the Archaeological Site. Restrictions are set from the experts of the Ministry and express the constraints of the Archaeological Law, which are the Monument Irrelevant Use for terrestrial antiquities and the restrictions of Anchorage, Aquaculture and Fishing for the submarine antiquities. As the figure shows below, two property units are created, extensively two parcels, for land and marine territories. The parcels are spatially represented on three dimensions in order to describe on detail the archaeological space.

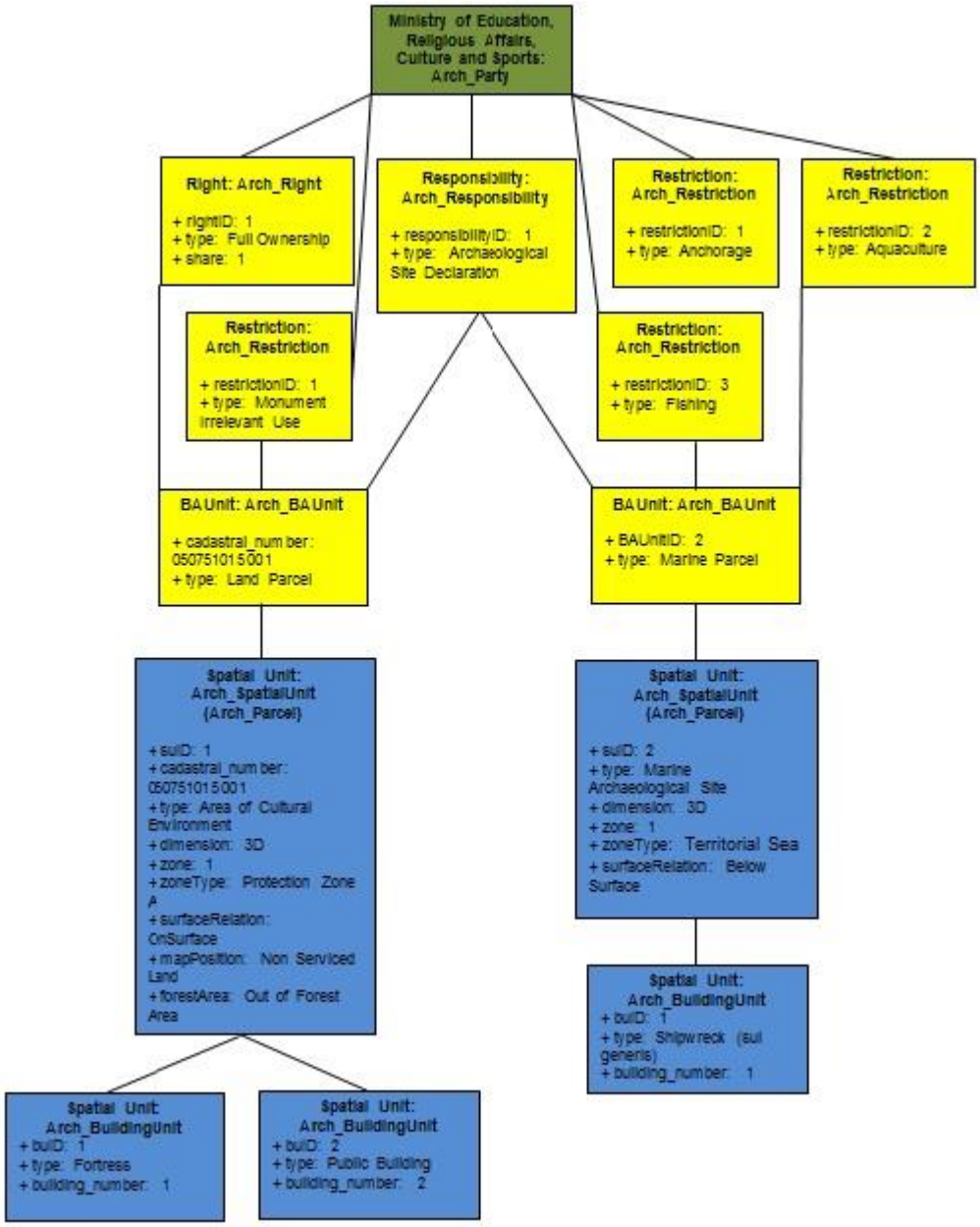


Figure 58, Land and Marine Archaeological Site Declaration

5.4 Requirements for the Adjustment of the Third Dimension to Archaeological Cadastral Data

The archaeological space of Greece (land and overseas) is an environment with a variety of complexities, being under the protection of the State with a strict legal framework. The management of the property rights associated with properties inside the archaeological space reflects an approach of cadastral registration. Requirements and development of a 3D Cadastre are dependent on the type of Cadastre (Archaeological, Marine Archaeological), as well as the historical and juridical background of the country.

In order to identify the legal obstacles for the incorporation of the third dimension to archaeological cadastral registrations, it is necessary to explore apart from the legal framework, the existing situation on jurisdictional and technical level. This means that the current legislative and cadastral framework ought to be adapted to the modern needs of 3D registration.

5.3.1 Legal Framework

Greek Legislation on real properties consists of a variety of laws including the Constitution, the Civil Law, the Urban Plan Law, the Agricultural Law and the Greek Civil Code (article 1010 that concerns building parties in outland properties and articles 1118-1141, that concern land interests, such as servitudes, benefits of holding or using a part of foreign property –rights of way or sewers-). Customary Law also exists and defines in many regions the social life including property transactions.
Archaeological Legislation also includes many laws for the cultural assets. The basic Archaeological Law N.3028/2002 describes the responsibilities of the State in the protection of cultural assets and defines the special features of properties with archaeological interest. It also defines the protection zones of land and marine archaeological sites. Although none of the above legislations supports the definition of 3D property objects, yet many statutes connote the vertical limits of properties, such as the Law N.3741/1929 which clearly defines the boundaries and the volume of each fragmented horizontal property of a building.

Greek legislation involves contradictory laws on property rights, which is rather confusing. There are many deficiencies in the field of legislation related to the description of RRRs in two dimensions; consequently there is no provision of their three-dimensional approach. Special legal and technical guidelines for the spatial measurement of properties in topographic plans have not yet been issued by the qualified institutions. The need for radical reforms and adjustments is obvious in order to register the third dimension. The development of national 3D property legislation could be achieved by reforming specific law of the existing legal framework. As Tsiliakou and Dimopoulou (2011) refer: *"A primary arrangement would be to repeal old laws such as (superficies solo credit) Article 954 of the Civil Code, while reviewing and redefine those applied to comprise the description of three-dimensional objects".* The definition of 3D property objects should be clearly described on the national Civil Code. It also involves better recognition and classification of the legal status of the overlapping property rights associated. Such special property rights appear in objects considered to be (or include) cultural assets, which are also in need of three-dimensional registration. A predefined 3D cadastral object clearly supported by the national legislation offers possibilities of recordation of special features of the space; parcels with immovable antiquities can be spatially represented on detail, concerning the elevation or the volume. On the descriptive level as well, a 3D cadastral object can assist to defining the multiple RRRs of the parcel, the share of RRRs and particularly of the Responsibilities related to the conservation of a monument that owners have, the legal status of condominium in cases

of the existence of modern constructions above the monument, the degree of intervention of the protection services to private properties with immovable antiquities and the provision in the planning of new projects without affecting underground cultural assets.

5.3.2 Jurisdictional Framework

Requirements on the jurisdictional level refer to the degree of development of 3D cadastral databases. In Greece the Hellenic Cadastre is an ongoing project that operates under the Hellenic Cadastre Standards. The Standards are set by the National Cadastral and Mapping Agency (NCMA SA) which is the responsible public organization for the development and maintenance of the cadastral database and there is no provision for the incorporation of the third dimension in the system. Properties with conflicts due to rights that are exercised on potential 3D property objects (eg multilevel ownership, customary rights) appear as overlapping registrations in the cadastral database. Furthermore marine cadastral data are not incorporated. The institutional framework also combines several laws from 1995 until 2013, which are all evolutions of the initial Cadastral Law N.2308/1995. The HAC Project is also an ongoing initiative with the Ministry of Education, Religious Affairs, Culture and Sports being the responsible institution for its implementation. The project is not implemented based on the general framework for cadastral registration described above. It is a scientific effort of managing the archaeological space with the approach and benefits of a cadastral system. No special information is yet given to the public concerning its conceptual schema, its final products and the existence or not of the vertical plane in the records. Yet, its technological principles of implementation follow some international good practices, such as free software principles, free data (WMS, WFS, GML), the Dublin Core Standard for metadata, web ontologies with OWL (Web Ontology Language), cloud computing (G-Cloud), electronic governance (e-GIF) and the possibility for harmonization with the INSPIRE Directive.

Institutional changes or introduction of new information have to be conducted in order to achieve meliorated cadastral registrations for a successful Archaeological Cadastre. A modern and feasible Archaeological Cadastre should function under a clear legislative framework and follow the national guidelines or international standardization practices. It is also important that a cadastral system for the management of the land and marine archaeological space should take under consideration the international research and practices as the ones developed in Australia, USA and Canada, in order to define the basic characteristics of a Marine Cadastre and how a system can be adapted to the Greek reality of managing the special component of the marine cultural heritage. One of the most important issues that should be addressed is the uncertainty of marine boundaries. Data for the limits of every marine territory should be based on accurate tidal plans, coastal boundaries and defined geodetic boundaries of marine zones. Of course the legal and jurisdictional framework should describe those boundaries on a theoretical level. On this direction, data that arise from the Archaeological Site

Declarations could serve as a basis for the delimitation of marine archaeological parcels. The reduction of the uncertainty of archaeological sites' marine boundaries can show the way to the definition of a 3D marine property object, which will not also serve an Archaeological Cadastre, but will provide a holistic approach in the management of the marine environment. As Fraser et al (2003) conclude*: "To avoid ambiguity or uncertainty, the technical solutions offered by a marine cadastre for visualizing and realizing the spatial extent of a legal definition must correctly reference the spatial entities according to their original legal description."*

Furthermore, the existing situation shows a lack of collaboration between the responsible institutions for the maintenance of cadastral data. It is obvious that properties with archaeological interest create overlapping cadastral registrations in the Hellenic and the Archaeological Cadastre. Registrations in the first system have less detail related to the restrictions of the owners, the responsibilities of the State, the boundaries and the land uses permitted. Exchange of data between the two organizations would lead to better management of properties and to the exploration of possible methods of registering volumes. Changes in the general cadastral database system are also required. The registrations of the Hellenic Archaeological Cadastre Project are a subset of them in the Hellenic Cadastre. Also marine cadastral registrations can be considered as a separate dataset, but marine archaeological cadastral registrations can be incorporated on a national scale Archaeological Cadastre. Issues of connectivity of the two database systems should be discussed over the next years between the responsible institutions. A possible implementation of a separate Marine Administration System, such as a Marine Cadastre should also be discussed. This requires strong communication between institutions and is not considered to be an easy task. Important changes and constraints may occur concerning the architectural structure of the systems, for example will terrestrial and marine archaeological cadastral data be presented as a separate level of registration or will they follow the same principles as common cadastral data (Hellenic Standards). In any case, interpretation of topological relationships of RRRs associated with classical cadastral properties and properties with archaeological interest could lead institutions to the development of formulas for the classification of 3D information and their 3D spatial representation. Of course this requires a high level of quality of spatial and cadastral data, so that infrastructure consists of databases and registries that can be linked and combined in order to produce real property objects in the third dimension.

5.3.3 Technical Framework

As in many other countries, cadastral registrations are based on an initial entity; the parcel. This principle of cadastral registration reflects the juridical boundaries of ownership of land. Information about land ownership is described in the formal or informal deeds and is delimited within the described boundaries, which are measured on the surface of the earth. Therefore, spatial information for their vertical plane is not available. In Greece, there are few cases where projects have been completed including

boundary faces of properties with archaeological interest. Those projects are related to the 3D representation of major cultural heritage assets (eg the Parthenon, the Ancient Athens, the Amphipolis), implemented by the national services or by private initiatives for touristic or educational purposes.

Figure 59, 3D Modeling of the Acropolis and the Temple of Sounio (source: http://www.ancientathens3d.com/)

However administrative information that indicates archaeological assets' location below or above the surface of the earth (or underwater) arises from the sources of the National Monuments Archive (NMA). The NMA is the responsible service for the documentation of the Greek monuments in general. In the process of documentation, basic features of the identity of a monument are being recorded, such as the exact location, the material, the dimensions and in some cases the elevation or depth. This initial data allows scientists proceed to the geometrical documentation of the monument with modern geodetic, photogrammetric and scanning methods. The initial data are important as they can lead to the production of 3D models for the precious cultural assets. As the monuments documentation is a regulatory process that is followed by the state services for the protection of immovable antiquities, special data of the existing documents can be added to archaeological cadastral registrations in order to incorporate the third dimension of boundaries. As information is an expensive digital resource, accessibility, exploration and reuse of the already collected, could reduce the need for investment in extra spatial information for the three-dimensional representation of archaeological assets. This means that already existing information stored in databases or other related registries for different purposes, such as elevation, coordinates and dimensions used for volumetric measurements could be utilized to form 3D objects and thus reduce the cost and time needed for a 3D spatial cadastral registration. At this point it is worth mentioning that interoperability of the public protection services is required. The NMA and the implementation service of the HAC Project (Department of Expropriations and Real Property of the General Directorate of Antiquities and Cultural Heritage) both belong to the Ministry of Education, Religious Affairs, Culture and Sports, which makes access to data feasible.

6. Conclusions

Over the last decades many examples of Spatial Data Infrastructure (SDI) have been developed with the aid of internationally recognized standards. LADM has proven to be an important representative of ISOs of Geographic Information that enables the normalization of Land Administration and its expressed aspects, e.g cadastral systems, regional and national profiles, registries and supportive to land management software tools. Possibilities for interoperability, compatibility of national systems with international initiatives and guidelines as well as the utilization of common terminology for similar spatial problems are some of the benefits of incorporating the LADM in National Spatial Data Infrastructure. National cadastral systems can also benefit from the adoption of the LADM, as recognized by the various country profiles developed around the world, such as the Netherlands, Japan, the Russian Federation, Portugal and the Republic of Korea.

The incorporation of the core model of the LADM on an initiative such as the Hellenic Archaeological Cadastre (HAC) Project provides the basis for its international description and its adaptation to a commonly shared vocabulary for cadastral systems. The management of the property Rights, Restriction and Responsibilities (RRRs) related to the archaeological space is a very demanding and complex task, but also a necessary one, as the future development related to many economic activities imposes the full knowledge of the various aspects of the archaeological space. Such a system must be completed with caution and with tools that will clarify the ownership status and the conflicts in properties with archaeological assets and that will ensure that their protection is on the right direction.

6.1 Feasibility of the Proposed Model

The proposed conceptual model in this Thesis provides a description of a cadastral model that incorporates the logic of the LADM in the structural schema for the database architecture of the Hellenic Archaeological Cadastre. LADM, as an internationally recognized standard, provides the basic model for standardization through the utilization of common terminology and compatibility with the modern global good practices in the field of Land Administration. This structure can offer a full support of a property-centered system, which focuses on the clarification of the ownership status of properties with archaeological interest. It is of high importance to mention that there is a plethora of administrative sources in Greece for the properties with archaeological features; existing data can be easily extracted and incorporated in the proposed model. Archaeological sites and monuments that belong to the State are strictly defined by laws, declarations and administrative acts, a fact that produces a variety of data that may lead to fuzziness and need of classification. However, data are imprinted to the administrative sources, setting their normalization feasible. Conventional contracts that refer to private transactions also carry valuable information, as there is at least a verbal description of

the existence of immovable antiquities on private properties. This information can also set the basis for the recordation of archaeological cadastral data. Another benefit from the adoption of the LADM in the HAC is the possibility for historical representation of the database with the formation of versioned objects. At first, it should be noticed that such an extension can ensure the accuracy of the initial data. This fact can provide the responsible services qualitative and quantitative information regarding important issues such as:

- The extent of the archaeological space, which can lead to better knowledge about the areas of protection, the conservation methods and the avoidance of infringements from private owners
- The stages of the expropriation process, which can assist to the clarification of which property has or doesn't have important archaeological assets and how this affects the economic exploitation by the owner
- The number of compensated or non-compensated properties and how this affects the public expenses at any time.

The model proposed consists of two levels of information, the administrative and the spatial level. In the administrative level, property units and RRRs described are a conceptual effort of incorporating the legal framework for the protection of archaeological heritage and the national Cadastral Law of Greece. The legal framework for cadastral registration does not clearly set the types of properties and rights exercised on a marine environment (there is not yet a provision for the implementation of a Marine Cadastre in Greece), however, the Archaeological Law makes reference for their existence. As a result, the properties and RRRs of marine archaeological assets described in the proposed model, for example the Marine Parcel and the Jurisdiction, are added as a combination of the incorporation of the Archaeological Law and the international research on Marine Cadastres. LADM gives the opportunity for clear description of property types and rights that arise from the above legal framework, as all the possible registrable rights are classified in different tables regarding their content. The LADM also enables the descriptive representation of more than one RRR type for every property unit at the same time, describing this way the multiple party roles that co-exist in a property unit. As property units with archaeological features are a special component, it is important that the way of acquisition of RRRs is represented. This fact is generally recognized and imprinted in the HC Standards, as there are various reasons for ownership acquisition in Greece. In the proposed model the external class Way of Ownership gives this information to the three types of RRRs through the administrative source. In other words formal titles and deeds must prove the current ownership status of properties, which in case of properties with archaeological features is of high importance.

The spatial level includes the classes that are necessary for the spatial representation of properties with archaeological interest. The Spatial Unit defines the spatial dimension of the administrative property unit. Attributes of the Spatial Unit have incorporated many recommendations of the HC Standards, for example the existence or not of a

topographic diagram or the position of the Spatial Unit related to urban plans or forest lands. The author considers that the Archaeological Parcel, which represents the Spatial Unit, is possible to have the same jurisdictional polygon as the cadastral parcel of the Hellenic Cadastre. This consideration occurs for reasons of convenience and interoperability between the two systems. The registration of the Archaeological Parcel could be aided by utilizing ready cadastral data provided by the Hellenic Cadastre and vice-versa. The registration of marine parcels can also produce initial data for a future implementation of a Marine Cadastre, which will take under consideration the restrictions of the existing marine archaeological sites. This fact can create perspectives of interoperability with the Archaeological Cadastre. However cases of different spatial representation should be examined, as the archaeological space cannot be registered only with the above conformance.

6.2 Interoperability of Archaeological Cadastral Data

The unique representation of a cadastral parcel, no matter the cadastral database on a national scale, could also serve the harmonization of Greek cadastral data with the INSPIRE Directive for the formation of National and consequently European Spatial Data Infrastructure. A clear and continuous flow of data between the HC and the HAC demands their common background in terms of database architecture, conceptualization and terminology. Sharing the same principles and harmonizing the two cadastral databases could lead to the contribution of Greece to the implementation of European Spatial Data Infrastructure (ESDI). The figure below can be explained as the necessary step for the common expression of HC, HAC and ESDI. The INSPIRE Directive can offer the European framework for the representation of a common cadastral parcel in Greece, meaning through the Hellenic Cadastre and the Hellenic Archaeological Cadastre. Reversely, both systems can serve as the basis for the development of ESDI in Greece. Such a development should also incorporate the appropriate techniques for the three-dimensional spatial representation of cadastral registrations.

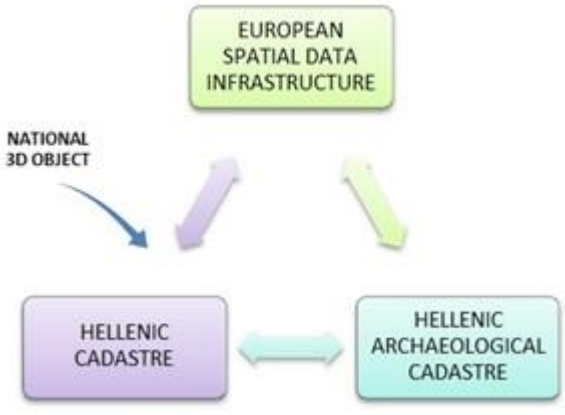


Figure 60, Interaction of HC and HAC with the INSPIRE Directive

The delimitation of the Archaeological Parcel could coincide with the registered national cadastral parcel for another purpose. Expropriation should be based on formal documents that describe the boundaries of parcels. Documents that describe cadastral parcels can serve this formality and be used as a basis for quantitative features that concern economic transactions between the State and the citizens, in other words the public services responsible for the excavation and expropriation process will be able to know at every moment which part of the land will be excavated or expropriated for archaeological reasons, together with features such as the exact area, the boundaries of the parcel and the jurisdictional framework of the region (e.g urban or non-urban areas, in or out of forest lands). At the same time they will be able to know who is going to be compensated and how this will affect the public expenses.

Another extensively important reason for the adoption of the national cadastral parcel's boundaries in registrations for archaeological data is the definition and spatial representation of a common 3D property object. In a general context, as cadastral systems evolve including the third dimension, many benefits for the systems themselves and the transactions result. At first, there is a better description of the land rights related to the spatial objects. That means that in complex situations, such as constructions in the urban environment, there is a clear representation of which property object belongs to who, how many rights, restrictions and responsibilities appear in limited space and how all the above affect the real-estate values, the taxation and the future urban planning. Furthermore, there is a better understanding of the property status in the area, which means that the stakeholders are aware of the boundaries of ownership. The clear property status also leads to better transactions between the citizens and the State.

Reforms in the legal and jurisdictional framework for the addition of the third dimension in archaeological cadastral registrations, as described in this Thesis, are very difficult to implement. As the modern needs demand the identification of 3D property objects, their legislative recognition should follow international experience and good practices; thus a national definition should take under consideration all types of spatial components that are in need of a three-dimensional registration. This includes not only archaeological and marine data, but also other features of territories, such as environmental, mining, geological or hydrological characteristics. The preparation of a complete definition for a 3D property object can offer extensibility and feasibility for future cadastral evolution. A 3D property object development definitely comes as a necessity for the spatial representation of properties with immovable antiquities. As described in this Thesis, the nature of the archaeological space of Greece embodies a variety of underground, underwater, coastal and of high elevation archaeological assets, which in many cases are overlapping with modern constructions. A 3D complex ownership status in need of special registration is encrypted on them.

6.3 Future Development

As the ICT advances, it is obvious that systems for cadastral registration should adopt good practices, such as standards (LADM) and guidelines (INSPIRE). A completion of an archaeological cadastral system such as the HAC Project should follow the international experience in order to provide an interoperable evolved registry for archaeological spatial information. Interoperability and services for the three-dimensional projection of immovable antiquities, as well as the inclusion of the constraints for the cadastral recordation of submarine antiquities can be achieved with the adjustment of the Land Administration Domain Model to the Hellenic Archaeological Cadastre, as suggested in this Thesis. Further development could endorse the utilization of GIS and spatial database systems (such as PostGIS) as helpful tools for the technical implementation of the proposed model, as well as the complete spatial representation of the archaeological space in three dimensions.

References

Aalders, H. J., & Moellering, H. (2001). Spatial Data Infrastructure. 20th International Cartographic Conference, August 6-10, 2001, Beijing, China.

Ali, A. I. E. N., Rajabifard, A., Kalantari, M., Williamson, I. (2011). Aspects of 3D Cadastre-A Case Study in Victoria. FIG Working Week – Bridging the Gap between Cultures, 18-22 May 2011, Marrakech, Morocco

Caine, A. (2009). Spatial Rights Legislation in Israel - A 3D Approach, FIG Working Week, Surveyors Key Role in Accelerated Development, 3-8 May 2009, Eliat, Israel.

Binns, A. (2004). Defining a Marine Cadastre: Legal and Institutional Aspects. Master Thesis. Department of Geomatics, Faculty of Engineering, The University of Melbourne, February 2004, Melbourne, Australia

Collier, P. A., Leahy, F. J., & Williamson, I. P. (2001). Defining a Marine Cadastre for Australia. 42nd Australian Surveyors Congress, Brisbane, Australia, 2001

Dimopoulou, E. & Elia, E. (2012). Legal Aspects of 3D Property Rights, Restrictions and Responsibilities in Greece and Cyprus, 3rd International Workshop on 3D Cadastres: Development and Practices, 25- 26 October 2012, Shenzhen, China.

Dimopoulou, E. & Gogolou, C. (2013). LADM as a Basis for the Hellenic Archaeological Cadastre. 5th Land Administration Domain Model Workshop, 24- 25 September 2013, Kuala Lumpur, Malaysia.

Dimopoulou, E., Kitsakis, D., & Tsiliakou, E. (2015). Investigating Correlation Between Legal and Physical Property: Possibilities and Constraints. Third International Conference on Remote Sensing and Geoinformation of the Environment (pp. 95350A-95350A), International Society for Optics and Photonics.

Elizarova, G., Sapelnikov, S., Vandysheva, N., Pakhomov, S., Van Oosterom, P., De Vries, M., Stoter, J., Ploeger, H., Spiering, B., Wouters, R., Hooveveen, A., Pemkov, V. (2012). Russian - Dutch Project "Design of a 3D Cadastre Model in the Russian Federation", 3rd International Workshop on 3D Cadastres: Development and Practices, 25- 26 October 2012, Shenzhen, China.

Erba, D.A.& Piumetto, M.A.(2012). 3D Cadastre in the Federal Countries of Latin America, International Institution of Surveyors, Article of the Month, July 2012.

Fraser, R., Todd, P. J., & Collier, P. A. (2003, October). Issues in the Development of a Marine Cadastre. In Addressing Difficult Issues in UNCLOS: 2003 ABLOS Conference (pp. 28-30).

Fowler, C., Smith, B., & Stein, D. (2010). Building a Marine Spatial Data Infrastructure to Support Marine Spatial Planning in US Waters. GISLANDS at: http:// www.gislands.org.

Gogolou, C. & Dimopoulou, E. (2015). Land Administration Standardization for the Integration of Cultural Heritage in Land Use Policies, Land Use Policy Journal, Vol. 49, p. 617 - 625, December, 2015.

Gourmelon, F., Georis-Creuseveau, J., Le Tixerant, M., Rouan, M., & Maris, T. (2012). Towards a Coastal Spatial Data Infrastructure (CSDI) Responsive to the Needs of Integrated Coastal Zone Management: The GeoBretagne Experience (France). Global Geospatial Conference: Spatially Enabling Government, Industry and Citizen (pp. 1-16).

Ho, S., Rajabifard, A., Stoter, J., & Kalantari, M. (2013). Legal barriers to 3D Cadastre Implementation: What is the Issue?. Land Use Policy, 35, 379-387.

Kalogianni, E. (2015). Design of a 3D Multipurpose Land Administrative System for Greece, in the Context of LADM. Master Diploma Thesis, Inter-Departmental Postgraduate Course Geomatics, National Technical University of Athens, Athens, Greece

Kitsakis, D., Dimopoulou, E. (2013). Contribution of Existing Documentation in 3D Cadastres. 4th International Workshop on 3D Cadastres, 9-11 November, Dubai, United Arab Emirates.

Kitsakis, D., & Dimopoulou, E. (2014). 3D Cadastres: Legal Approaches and Necessary Reforms. Survey Review, 46(338), 322-332.

Kokalj, Z., Pehani, P., Hvala, S.T., Ostir, K. (2006). Application of Internet GIS Tools for Heritage Management. ARKAS Case Study, caENTI 1st International Conference of Territorial Intelligence, September 206, Alba Iulia, Romania.

Ioannides, M., Georgopoulos, A., & Scherer, M. (2005). Standards in Cultural Heritage: the missing grammar for the digital documentation of the past. XX CIPA Symposium, September, 2005.

Lemmen, C. H. J. (2012). A Domain Model for Land Administration. Delft University of Technology, Delft, the Netherlands.

Paasch, J. & Paulsson, J. (2014). Legal Framework 3D Cadastres - Position Paper 1, Working Group 1 - Chair - Jesper Paasch, 4th International Workshop on 3D Cadastres, 9-11 November 2014, Dubai, United Arab Emirates.

Papaefthymioy, M., Labropoulos, T., Zentelis, P. (2004). 3-D Cadastre in Greece- Legal, Physical and Practical Issues, Application on Santorini Island, FIG Working Group, 22-27 May, Athens, Greece.

Serlorenzi, M. & De Tommasi, A. (2010). S.I.T.A.R - Sistema Informativo Territoriale Archeologico di Roma. A Repository for Archaeological Data for Conservation of Cultural

Heritage and Town Planning, 15th International Conference on Cultural Heritage and New Technologies, 15- 17 November 2010, Vienna, Austria.

Stoter, J.E. (2004). 3D Cadastre. PhD Thesis. Delft University of Technology, Delft, the Netherlands.

Strain, L., Rajabifard, A., & Williamson, I. (2004). Spatial Data Infrastructure to Facilitate Coastal Zone Management. Coastal Zone Asia Pacific Conference(pp. 1-6).

Text for ISO 19152 Geographic Information-Land Administration Domain Model (LADM) as sent to ISO Central Secretariat for issuing as FDIS.

Tsiliakou, E. & Dimopoulou, E. (2011). Adjusting the 2D Hellenic Cadastre to the Complex 3D World - Possibilities and Constraints, 2nd International Workshop on 3D Cadastres, 16-18 November 2011, Delft, the Netherlands.

Tsiliakou, E., Labropoulos, T., & Dimopoulou, E. (2013). Transforming 2D Cadastral Data Into a Dynamic Smart 3D Model. International Archives of Photogrammetry, Remote Sensing and Spatial Infrastructure Sciences, ISPRS 8th 3DGeoInfo conference and WG II/2 workshop, 27-29 November, Istanbul, Turkey

Van Oosterom, P., Vandysheva, N., Ivanov, A., Pakhomov, S., Spiering, B., Stoter, J., Zlatanova, S. (2012). Design of a 3D Cadastre Model in the Russian Federation, Article, 4 April 2012, Technical University of Delft, the Netherlands.

Vradis, C., Sylaiou, S. (2011), Hellenic Archaeological Cadastre. Information Day on European Funding Opportunities for Research Infrastructure, ARTOS Foundation, 15 September 2011, Nicosia, Cyprus

Williamson, I., Enemark, S., Wallace, J., & Rajabifard, A. (2010). Land administration for sustainable development. FIG Congress-Facing the Challenges-Building the Capacity, 11-16 April 2010, Sydney, Australia.

Αθανασίου, Α., (2014). Σχεδιασμός μοντέλου για τη διαχείριση του Ελληνικού Θαλάσιου Χώρου με Διεθνή Πρότυπα". Διπλωματική Εργασία, ΣΑΤΜ, ΕΜΠ, Αθήνα, 2014.

Ζεντέλης, Π., (2011b). Περί Κτημάτων λόγος και Κτηματολόγιο, Τόμος Β, Εκδόσεις Παπασωτηρίου, Αθήνα 2011.

Καλογιάννη, Ε. (2012). Σχεδιασμός μοντέλου για τη Διαχείριση της Δημόσιας Περιουσίας στην Ελλάδα. Διπλωματική Εργασία, ΣΑΤΜ, ΕΜΠ, Αθήνα, 2012.

Ψωμαδάκη, Σ. (2014). Διερεύνηση των δυνατοτήτων εναρμόνισης του Εθνικού Κτηματολογίου με Διεθνή Πρότυπα. Διπλωματική Εργασία, ΣΑΤΜ, ΕΜΠ, Αθήνα, 2014.

Electronic Sources

http://archaeocadastre.culture.gr

http://www.cidoc-crm.org

http://www.dailymail.co.uk

https://enotitasaronikou.wordpress.com

http://www.fig.net/resources/publications/figpub/pub11/figpub11.asp

http://www.gsdidocs.org/GSDIWiki/index.php/Main_Page"

http://nam.culture.gr

http://www.kastra.eu

http://www.ktimatologio.gr

http://library.oceanteacher.org

http://www.opengeospatial.org

http://www.visitgreece.gr