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"Coastal erosion – Evaluation of the need for action"
Directorate General Environment
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Living with coastal erosion in Europe: Sediment and Space for Sustainability

Guidelines for implementing local information systems dedicated to coastal erosion management

Data architecture modelling and spatial data representation

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DATA ARCHITECTURE MODELLING

Scope

The purpose of this section is to establish common requirements for modelling and documenting the architecture of data meant to be integrated into an “exemplary” local information system dedicated to decision-making in the fields of coastline management. These requirements are intended for system architects, database designers, and software developers who will implement these requirements in different GIS applications. Benefits of these requirements are to facilitate: (i) interchange of data among data providers and users, (ii) maintenance operations to the information system, and (iii) further improvements to the information system.

To avoid any confusion, these requirements do not impose or prescribe any particular architecture of the data themselves. Instead, it is meant to codify and formalise the various elements and steps – including for example terminology, modelling language, and documentation - which are needed to develop and implement a data architecture.

Finally, the elements which are part of these requirements should be implemented for each Reference Topic meant to become part of the coastal information system. Reference Topics for coastal information system are fully described in the section *Data content requirements*. Once implemented for each Reference Topic, these elements form a standard hereafter referred as a “Reference Topic Standard”. This means that in line with the rest of the documents, 26 reference topic standards should be developed in order to build an “ideal” coastal information system.

Reference model

Data modelling and documentation requirements are based upon ISO/TC211 standards, and are described in accordance to the reference model ISO 19101:2002. In the rest of this section, the terminology used complies with the requirements of ISO 19101:2002 and, in particular with the standard ISO 19104 - Terminology.

Application schema

Each of the Reference topic standards described in the section 5.6. Coastal data content specifications shall include an integrated application schema expressed in the Unified Modeling Language (UML) according to ISO 19109, Rules for application schema and its normative references. The application schema will specify, as appropriate, the feature types, attribute types, attribute domain, feature relationships, spatial representation, data organization, and metadata that define the information content of a data set.

UML is not a database model; rather, it describes the common content and structures that could be exchanged between members of the geospatial community. The use of UML and abstract modelling concepts allows the standard to be technology independent but permits current and future implementation cases to be derived from the UML model.

UML notations

The UML notations prescribed by the ISO19000 series are described in the Figure 1 below.

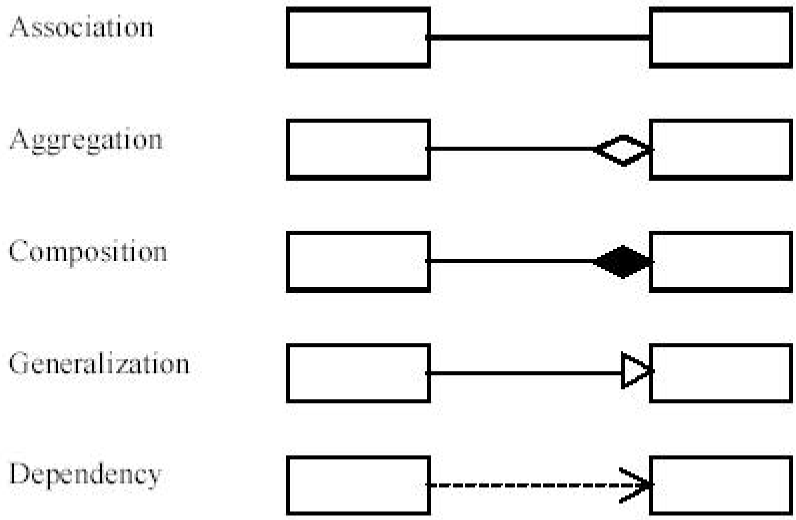


Figure 1 — UML notation

UML model relationships

Associations:

An association is used to describe a relationship between two or more classes. UML defines three different types of relationships, called association, aggregation and composition. The three types have different semantics. An ordinary association shall be used to represent a general relationship between two classes. The aggregation and composition associations shall be used to create part-whole relationships between two classes. The direction of an association must be specified. If the direction is not specified, it is assumed to be a two-way association. If one-way associations are intended, the direction of the association can be marked by an arrow at the end of the line.

An aggregation association is a relationship between two classes in which one of the classes plays the role of container and the other plays the role of a containee.

A composition association is a strong aggregation. In a composition association, if a container object is deleted, then all of its containee objects are deleted as well. The composition association shall be used when the objects representing the parts of a container object cannot exist without the container object.

Generalization:

A generalization is a relationship between a superclass and the subclasses that may be substituted for it. The super-class is the generalized class, while the subclasses are specified classes.

Instantiation / Dependency:

A dependency relationship shows that the client class depends on the supplier class/interface to provide certain services, such as:

- Client class accesses a value (constant or variable) defined in the supplier class/interface
- Operations of the client class invoke operations of the supplier class/interface
- Operations of the client class have signatures whose return class or arguments are instances of the supplier class/interface

An instantiated relationship represents the act of substituting actual values for the parameters of a parameterised class or parameterised class utility to create a specialized version of the more general item.

Roles

If an association is navigable in a particular direction, the model shall supply a “role name” that is appropriate for the role of the target object in relation to the source object. Thus in a two-way association, two role names will be supplied.

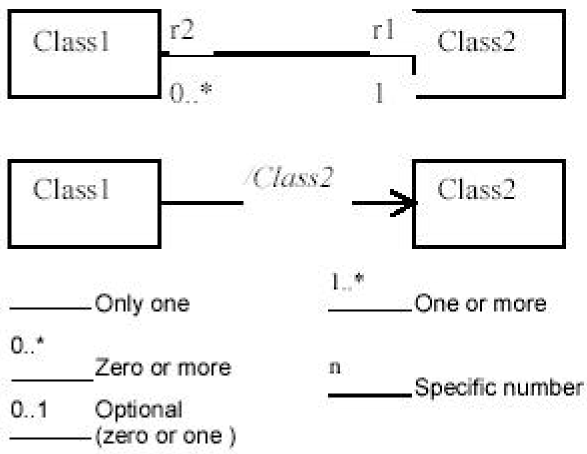


Figure 2 — UML roles

Figure 2 represents how role names and cardinalities are expressed in UML diagrams. The role name “r1”' is Class1’s relationship to Class2. The role name “r2” is Class2’s relationship to Class1. The cardinalities show that “zero or many” Class1s are related to “exactly one” Class2.

Figure 2 also shows how derived classes will be expressed. The diagram indicates that Class1 is a derived class of Class2. Any attributes and aggregates of Class1 are also derived from Class2.

Stereotypes

A UML stereotype is an extension mechanism for existing UML concepts. It is a model element that is used to classify (or mark) other UML elements so that they in some respect behave as if they were instances of new virtual or pseudo metamodel classes whose form is based on existing base metamodel classes. Stereotypes augment the classification mechanisms on the basis of the built-in UML metamodel class hierarchy. Below are brief descriptions of the stereotypes used in this International Standard, for more detailed descriptions consult ISO 19103.

In this International Standard the following stereotypes are used:

a) <<Type>> class used for specification of a domain of instances (objects), together with the operations applicable to the objects. A type may have attributes and associations.

b) <<Enumeration>> data type whose instances form a list of named literal values. Both the enumeration name and its literal values are declared. Enumeration means a short list of well-understood potential values within a class.

c) <<DataType>> descriptor of a set of values that lack identity (independent existence and the possibility of side effects). Data types include primitive predefined types and user-definable types. A DataType is thus a class with few or no operations whose primary purpose is to hold the abstract state of another class.

d) <<CodeList>> used to describe a more open enumeration. <<CodeList>> is a flexible enumeration. Code lists are useful for expressing a long list of potential values. If the elements of the list are completely known, an enumeration should be used; if the only likely values of the elements are known, a code list should be used.

e) <<Union>> describes a selection of one of the specified types. This is useful to specify a set of alternative classes/types that can be used, without the need to create a common super-type/class.

f) <<Abstract>> class (or other classifier) that cannot be directly instantiated. UML notation for this to show the name in italics.

g) <<Metaclass> class whose instances are classes. Metaclasses are typically used in the construction of metamodels. A metaclass is an object class whose primary purpose is to hold metadata about another class.

h) <<Interface>> named set of operations that characterize the behaviour of an element.

i) <<Package>> cluster of logically related components, containing sub-packages.

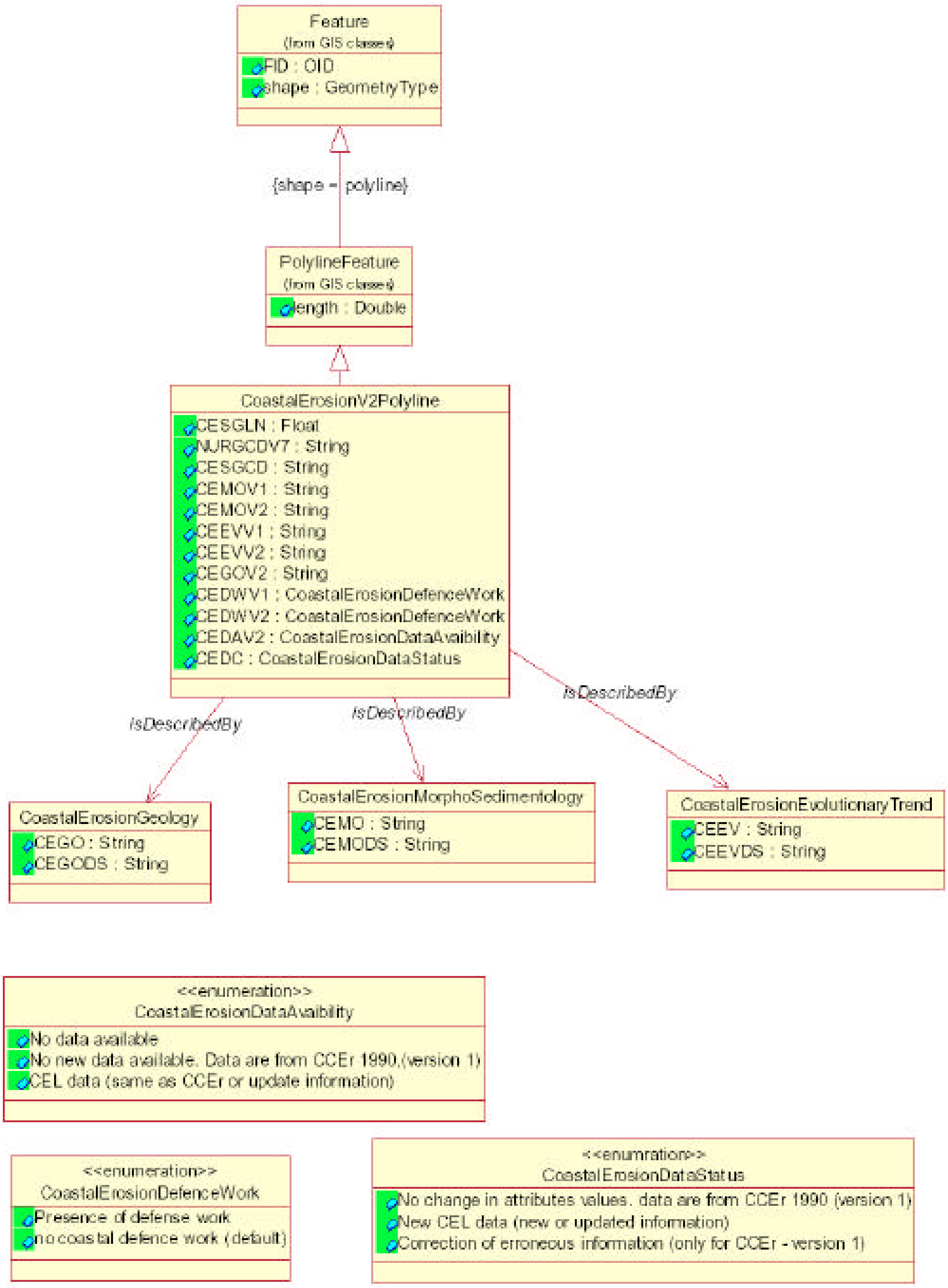
j) <<Leaf>> package that contains definitions, without any sub-packages.

Two examples

Example 1 – Coastline geomorphology, geology, erosion trends and coastal defence status

Example 1 illustrates how UML schema has been used in the framework of EUROSION to model data on coastline geomorphology, geology, erosion trends and coastal defence status.

UML-based schema for the coastline geomorphology, geology, erosion trends, and coastal defence status



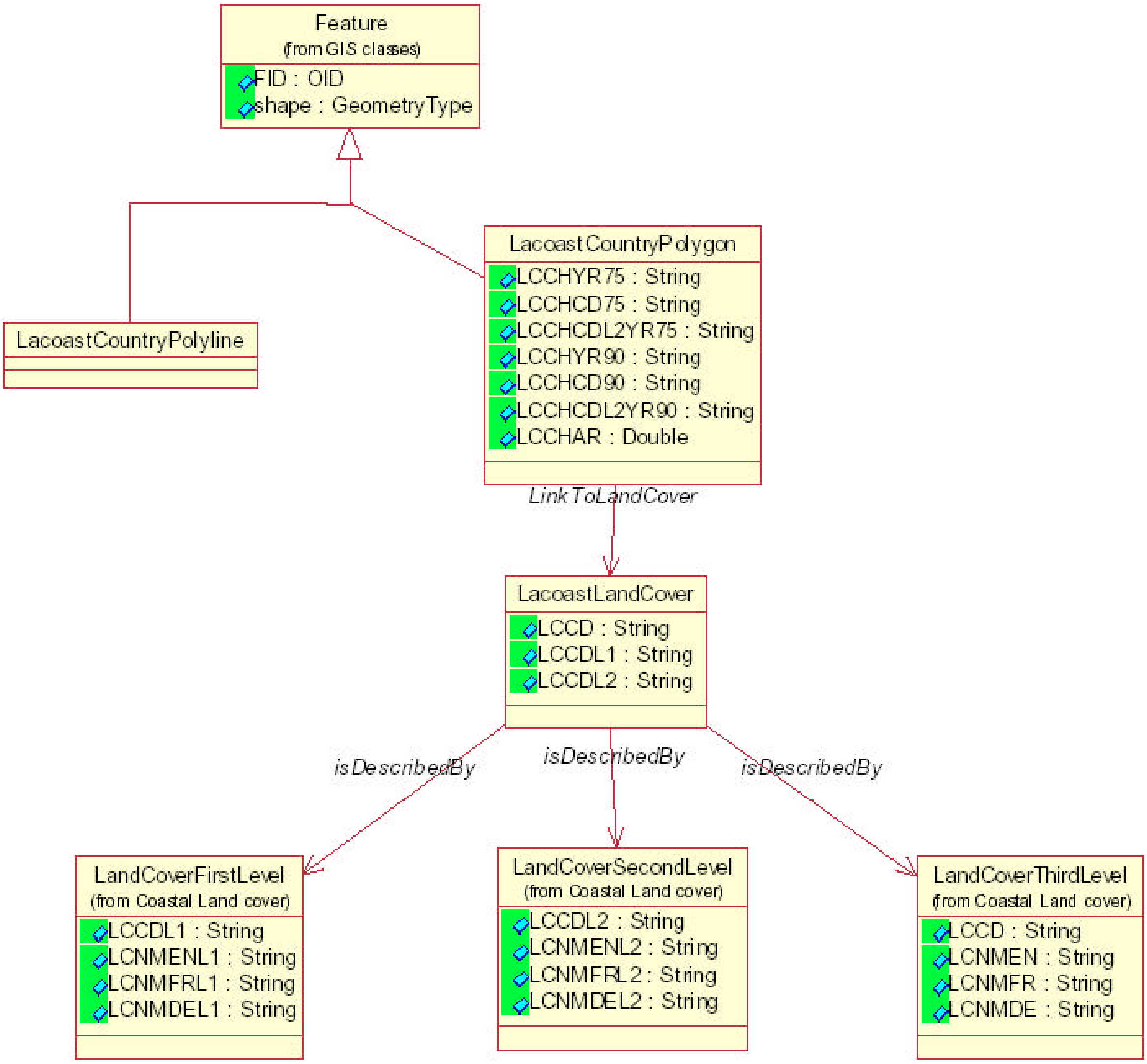
The diagram must be understood as follows: "the coastline is made of different polylines. Each polyline has a number of attributes including for example its length (CESGLN), its morphological code in 1986 (CEMOV1), its morphological code in 2001 (CEMOV2), its erosion trends in 1986 (CEEVV1), its erosion trends in 2001 (CEEVV2), its geological code in 2001 (CEGOV2), its defence works status in

1986 (CEDWV1), its defence works status in 2001 (CEDWV1). In turn, each of these codes follows a standard definition. for example the coastal defence works status (CoastalErosionDefenceWorks type) can only take 2 values: Presence of defence works or no coastal defence works (default)"

Example 2 – Land cover changes

Example 2 illustrates how UML schema has been used in the framework of EUROSION to model data on land cover changes.

UML-based schema for the land cover changes



The diagram must be understood as follows: "Data on land cover changes are depicted as attributes of polygons. Each polygon features different attributes including for example its land cover code in 1975 of level 3 (LCCHCD75) and level 2 (LCCHCDL2YR75), its land cover code in 1990 of level 3 (LCCHCD90) and level 2 (LCCHCDL2YR90). Each land cover code has to be documented conform to CORINE Land Cover nomenclature (LaCoastLandCover) which is defined at three levels: LandCoverFirstLevel (5 classes), LandCoverSecondLevel (15 classes) and LandCoverThirdLevel (44 classes)."

Data dictionary

Each of the Reference topic standards described in the section 5.6. Coastal data content specifications, as appropriate, documentation of all features, attributes, and relationships and their definitions. A data dictionary table shall be used to describe the characteristics of the UML model diagrams.

The data dictionary (see Table 1) is formatted as follows:

- Each UML model class equates to a data dictionary entity.
- Each UML model class attribute equates to a data dictionary element.
- Each UML model association equates to a data dictionary element.
- The shaded rows define entities.
- The entities and elements within the data dictionary are defined by six attributes (those attributes are listed below and are based on those specified in ISO/IEC 11179-3 for the description of data element concepts, i.e. data elements without representation).

	Name / Role name	Definition	Restrictions	Maximum occurrence	Data type	Domain
1.						
2.						
3.						
4.						

Table 1. Example Data Dictionary

Name/role name

The name/role name is a label assigned to a data dictionary entity or to a data dictionary element.

Entity names begin with a three letter abbreviations that denotes the UML package containing a class, followed by an underscore ("_"), and followed by the class name. The class name begins with an upper case letter. Spaces do not appear in an entity name: instead, multiple words are concatenated, with each word starting with a capital letter (example: XnnnYmmm). Entity names are unique within the entire data dictionary of this Standard.

Element names start with a lower case letter. Spaces do not appear in an element name: instead, multiple words are concatenated, with subsequent words starting with a capital letter (example: xnnnYmmm). Element names are unique within an entity by the combination of the entity and element names (example: GUB_Dataset.Name).

Role names are used to identify abstract model associations and are preceded by "Role name:" to distinguish them from other elements.

Definition

The definition is the data or metadata entity description.

Restrictions

Restrictions is a descriptor indicating whether an entity or element shall always be documented (i.e. contains value(s)) or sometimes is documented. This descriptor may have the following values: M (mandatory), C (conditional), or O (optional).

Mandatory (M): Mandatory (M) indicates that the entity or element shall be documented.
Conditional (C): Conditional (C) specifies an electronically manageable condition under which at least one entity or element is mandatory. 'Conditional' is used for one of the three following possibilities:

- Expressing a choice between two or more options. At least one option is mandatory and must be documented.
- Documenting an entity or element if another element has been documented.
- Documenting an element if a specific value for another element has been documented. To facilitate reading by humans, the specific value is used in plain text (ex. "C/not defined by encoding?”). However, the code shall be used to verify the condition in an electronic user interface.

If the answer to the condition is positive, then the entity or the element shall be mandatory.

Optional (O): The entity or the element may be documented or may not be documented. Optional entities and optional elements have been defined to provide a guide to those looking to fully document their data. (Use of this common set of defined elements will help promote interoperability among U.S. geographic data users and producers). Optional entities may have mandatory elements: if the optional entity is used, the mandatory elements shall be used. If an optional entity is not used, the elements contained within that entity (including mandatory elements) will also not be used.

Maximum occurrence

Maximum occurrence specifies the maximum number of instances the entity or the element may have. Single occurrences are shown by “1”; repeating occurrences are represented by “N”. Fixed number occurrences other than one are allowed, and will be represented by the corresponding number (i.e. “2”, “3”…etc).

Data type

Specifies a set of distinct values for representing the elements, for example, integer, real, string, DateTime, and Boolean. The data type attribute is also used to define entities, stereotypes, and associations.

Domain

For an entity, the domain indicates the line numbers covered by that entity.
For an element, the domain specifies the values allowed or the use of free text. “Free text” indicates that no restrictions are placed on the content of the field. Integer-based codes shall be used to represent values for domains containing code lists.

Example

Attribute	FieldName	Definition	Type	Length	Restrictions
Shape	SHAPE	Geometry (polygons)	Geometry		Mandatory
EuropeanCode	EU_CD	Unique code for a waterbody at EU level	String	24	Mandatory. As per coding guidelines
Name	NAME	Locally used name	String	100	Mandatory
MSCode	MS_CD	Unique code for a waterbody within MS	String	22	As per coding guidelines
EcoRegionCode	REGION_CD	Ecoregion to which a waterbody belongs	String	2	Mandatory. Foreign Key to REGION_CD in EcoRegion
System	SYSTEM	Type of characterization of a waterbody	String	1	Mandatory {A, B}
InsertedWhen	INS_WHEN	Moment of insertion in the database	Date	YYYYMMDD	Mandatory
InsertedBy	INS_BY	Acronym of operator	String	15	Mandatory
RiverBasinCode	BASIN_CD	The code of the parent river basin (see coding system)	String		Mandatory. Foreign Key to EU_CD in RiverBasin
StatusYear	STATUS_YR	Year of reporting of waterbody characterisation	String	4	Possibly can be dropped if duplicates INS_WHEN
HeavilyModified	MODIFIED	Whether the waterbody is heavily modified	String	1	Mandatory {Y, N}
Artificial	ARTIFICIAL	Whether the waterbody is artificial	String	1	Mandatory {Y,N}
SalinityTypology	SALINITY	Salinity category according to Annex II	String	1	Mandatory {F = Freshwater O = Oligohaline M = Mesohaline P = Polyhaline E = Euhaline}
DepthTypology	DEPTH_CAT	Depth category based on mean depth	String	1	Mandatory {S = Shallow <30m I = Intermediate 30-200m D = Deep >200m}
Latitude	LAT	Definition not given in WFD. Assume Latitude (in ETRS89) of mathematical centre of waterbody	Number	8,5	Mandatory if Type = B. Can be calculated from supplied geometry
Longitude	LON	Definition not given in WFD. Assume Longitude (in ETRS89) of mathematical centre of waterbody	Number	8,5	Mandatory if Type = B. Can be calculated from supplied geometry
TidalTypology	TIDAL	Not defined – assume same as Transitional Tidal range category according to Annex II	String	5	Mandatory if Type = B {MICRO, MESO,MACRO}
CurrentVelocity	VELOCITY	Not defined			Optional
WaveExposure	WAVE_EXPO	Not defined			Optional
MeanWaterTemp	AV_W_TEMP	Not defined			Optional
MixingCharac	MIXING	Not defined			Optional
Turbidity	TURBIDITY	Not defined			Optional
MeanSubstratComp	SUBSTRATUM	Not defined			Optional
RetentionTime	RET_TIME	Not defined			Optional
WaterTempRange	W_TEMP_RGE	Not defined			Optional

Example of a data dictionary for the entity *Coastal Waters* developed in the scope of the Water Framework Directive (source: Guidance Document on Implementing the GIS Elements of the WFD)

Metadata

Metadata is the information and documentation, which makes data understandable and shareable for users over time (ISO 11179, Annex B). We can distinguish different types of Metadata of increasing detail: Metadata for Inventory (i.e. internal to an organisation), Metadata for Discovery (i.e. that is necessary for external users to know who has what data, where to find it, and how to access it), and Metadata for Use (i.e. a fuller description of an information resource that enables users to make a judgement about the relevance and fitness-for-purpose of the resource before accessing it).

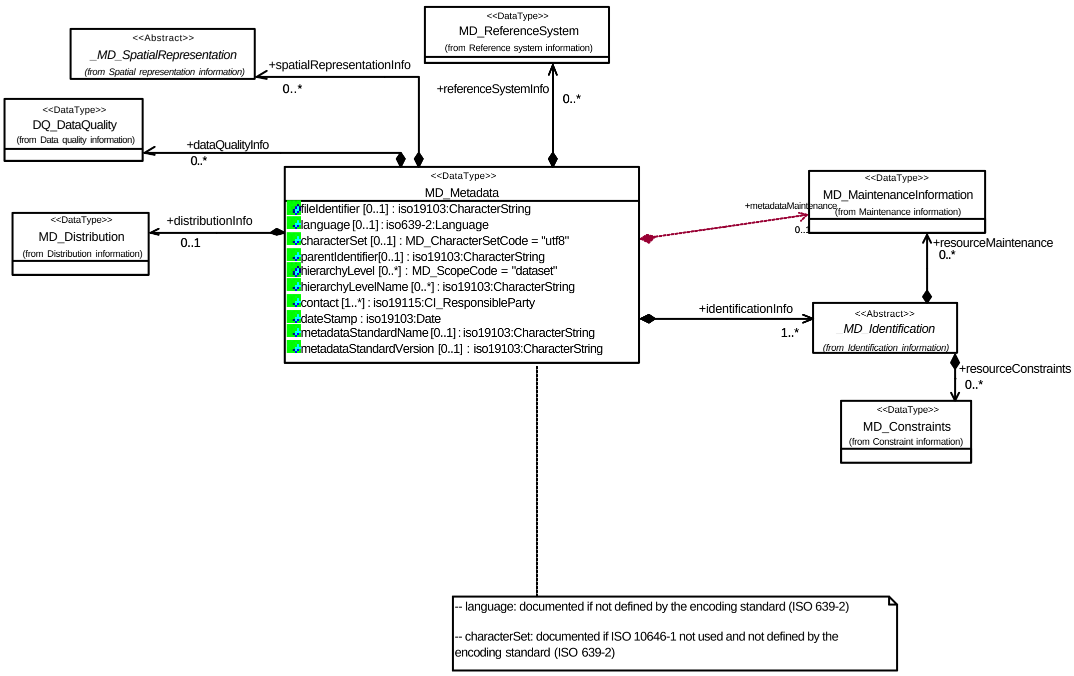
The metadata standard ISO 19115 being developed by ISO Technical Committee 211 tends to supersede other standards such as CEN/TC287, or the GISCO data dictionary. It is therefore desirable that appropriate migration mechanisms are set-out that allow to convert existing metadata into ISO 19115. Existing conversion, also called "mapping", exists between CEN/TC287 metadata elements and ISO 19115.

<u>Metadata profile</u>

The ISO 19115 for metadata comprises about 300 elements that exhaustively describe an information resource. Most of these elements are defined as being optional, i.e. they are not needed for compliance with the international standard but are defined for helping users to understand exactly the described data. Individual organisations may develop a profile of the standard according to their needs. A profile consists of the core metadata elements, an additional set of optional elements that are then declared as mandatory part of the profile. Additionally a profile may add elements, i.e. extensions that are not part of the international standard.

The ISO 19115 describes rules for defining community profiles and extensions. A profile must not change names, the definition or data types of metadata elements. A profile must include all core metadata elements of a digital geographic data set, all mandatory elements in mandatory sections as well as in conditional sections, if the data set meets the condition required by the metadata element. Relationships between the elements have to be identified. Finally, the profile has to be made available to any user of the metadata. A profile has to follow the rules for defining extensions, too. Metadata extensions are used to impose more stringent obligations on existing metadata elements. In addition, an extension can limit or extend the use of domain values for describing metadata elements.

The diagram below is an extract of the UML schemas defining ISO19115 metadata entities. In this diagram, one can see the type of information which is mandatory (1..* relations), and which information is optional (0..*).



Core elements of ISO 19115

Based on the UML schema above, it is possible to define the minimum set of metadata required. They constitute the core elements. ISO 19115 consists of 22 core elements of which 12 are mandatory. The elements are described in Table 2. The mandatory elements focus on the discovery aspect of the metadata (catalogue purposes). Despite on information on the metadata itself, they provide information on the title, the category, the reference date, the geographic location, and a short description of the data and the data provider. The core set expands the mandatory elements with additional information on the type, the scale, the format, the reference system and the data lineage. These elements give rough information on the potential usage of the data.

Table 2: Core metadata elements for geographic datasets (ISO/DIS 19115)

Information about the Metadata

1. Metadata language (C)	(MD_Metadata.language)
2. Metadata character set (C)	(MD_Metadata.characterSet)
3. Metadata file identifier (O)	(MD_Metadata.fileIdentifier)
4. Metadata standard name (O)	(MD_Metadata.metadataStandardName)
5. Metadata standard version (O)	(MD_Metadata.metadataStandardVersion)
6. Metadata point of contact (M)	(MD_Metadata.contact > CI_ResponsibleParty)
7. Metadata date stamp (M)	(MD_Metadata.dateStamp)

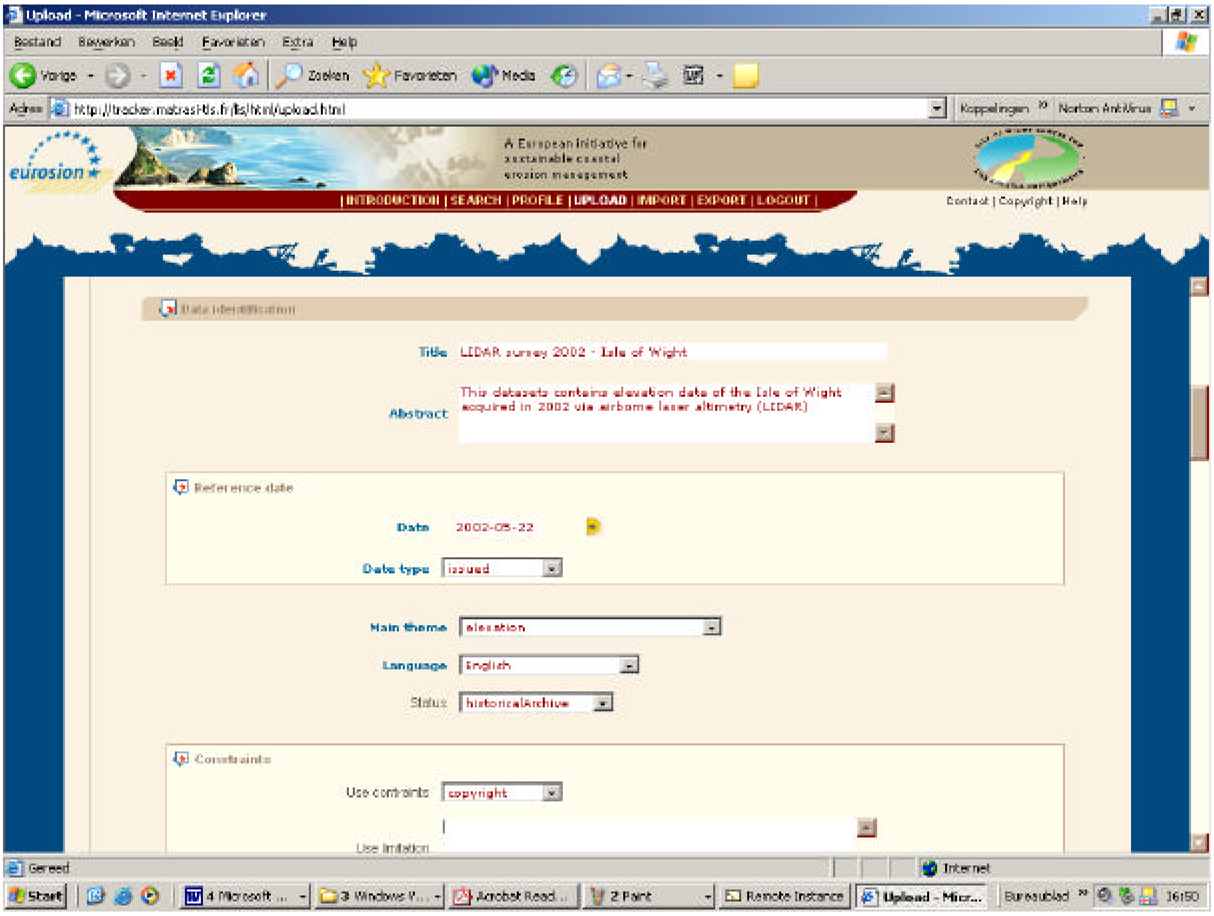
Information about the Dataset

8. Dataset title (M)	(MD_Metadata > MD_Identification.citation > CI_Citation.title)
9. **Dataset reference date (M)**	(MD_Metadata > MD_Identification.citation > CI_Citation > CI_Date.date and CI_Date.dateType)
10. Dataset responsible party (O)	(MD_Metadata > MD_Identification.pointOfContact > CI_ResponsibleParty)
11. Geographic location of the dataset (by four coordinates or by geographic identifier) (C)	(MD_Metadata > MD_DataIdentification.geographicBox or MD_DataIdentification.geographicIdentifier)
12. Dataset language (M)	(MD_Metadata > MD_DataIdentification.lauguage)
13. Dataset character set (C)	(MD_Metadata > MD_DataIdentification.characterSet)
14. Dataset topic category (M)	(MD_Metadata > MD_DataIdentification.topicCategory)
15. Spatial resolution of the dataset (O)	(MD_Metadata > MD_DataIdentification.spatialResolution > MD_Resolution.equivalentScale or MD_Resolution.distance)
16. Abstract describing the dataset (M)	(MD_Metadata > MD_Identification.abstract)
17. Distribution format (O)	(MD_Metadata > MD_Distribution > MD_Distributor > MD_Format.name and MD_Format.version)
18. Additional extent information for the dataset (vertical and temporal) (O)	(MD_Metadata > MD_DataIdentification.extent > EX_Extent)
19. Spatial representation type (O)	(MD_Metadata > MD_DataIdentification.spatialRepresentationType)
20. Reference system (O)	(MD_Metadata > MD_ReferenceSystem)
21. Lineage statement (O)	(MD_Metadata > DQ_DataQuality > LI_Lineage.statement)
22. On-line resource (O)	(MD_Metadata > MD_Distribution > MD_DigitalTransferOption.onLine > CI_OnlineResource)

- An “M” indicates that the element is mandatory.
- An “O” indicates that the element is optional.
- A “C” indicates that the element is mandatory under certain conditions.

Example

In the framework of EUROSION, a web interface enabling data providers and users to document metadata has been developed. The structure of metadata used for this interface is compliant with ISO19115 core metadata elements. Below is a screenshot of this metadata functionality (source: Isle of Wight / EUROSION Local Information System)



Establishment of permanent identifiers

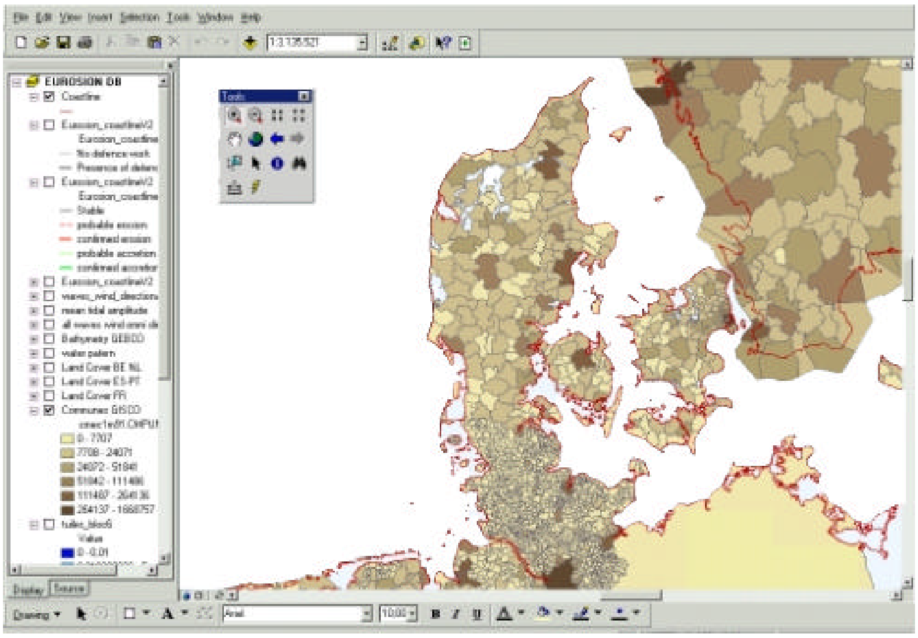
Several national systems have proposed the use of a common or permanent feature identifier to be associated with the object in the real world so that different representations and attributes of that object on maps can be cross-referenced. This is particularly the case for features like roads, hydrography, administrative units, etc. which are common to different GIS applications (not just coastal). Having well-known identitiers of features established with a coding system within a community greatly assists in the association of attribute information to real-world objects where such attributes may not reside in a GIS or spatially-enabled data base. Also, multiple representations of real world objects may be linked to the identity code, to provide views of an object that is changed over time or that has different degrees of spatial resolution at different scales of data collection or representation.

It is of the utmost importance that during the design of the coastal information system, the data modeller is knowledgeable of these features which have a permanent identifiers established by national authoritative standards. The management of a common or "permanent" feature identity needs to be undertaken within the community with permission granted to certain participant organisations to create or adjudicate these identities.

There are several examples of permanent identifiers. Quite illustrative among them is the examples of NUTS codes.

Example: NUTS code

The Nomenclature of Territorial Units for Statistics (NUTS) is a geocode for referencing the administrative division of European Union countries for statistical purposes. The purpose of NUTS is to provide an unique identifier to any administrative entity in Europe – from the national state boundaries (NUTS0) to the municipal boundaries (NUTS5) – making it possible to cross-reference data relating to administrative data and coming from different sources (e.g. population, employment, market, etc.).



This screenshot of the EUROSION database depicts the NUTS5 administrative boundaries of Denmark cross-referenced with population data. The possibility to combine spatial data with population is made possible because NUTS code is used as permanent identifier.

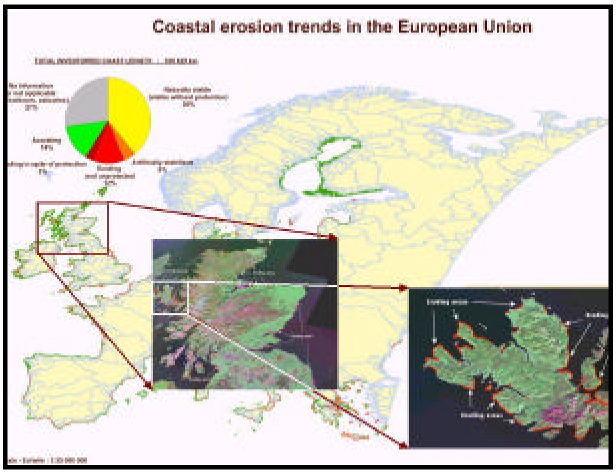
Other examples

In the framework of coastal information system, database architects should pay a particular attention to permanent identifiers possibly used for the following object classes:

- census or enumeration units (sub-municipal boundaries, e.g. IRIS identifiers in France)
- cadastral parcels
- Rivers
- water catchments
- roads
- railway
- ferry lines
- harbours
- tide-gauges

Up-scaling and down-scaling capabilities

Besides the importance of proper access to information another relevant component is the possibility to aggregate information from local level to European scale and reverse. Three main reasons for this were identified, firstly validation and representation purposes of European scale geographical information 'at the ground'. Secondly the potential European semantic network at the local, benefiting from the INSPIRE initiative and principles supports the growing of an operational Europe covering distributed network. This network aims at feeding the information updating and feedback processes. Thirdly co-operation and commitment between authorities actuating at different levels is enhanced when concretising the information sharing and fluxes through such network. A summary is given and an attempt to come to determination of the benefits of such network.



EUROSION identified 20 data groups layers and examined the up and down scaling potential. These layers are divided in four main groups.
For each of the data group layers the potential for upscaling from the local level towards European scale and the reverse downscaling process is described.
The physical environment includes: Shoreline, Wave regime, Wind regime, Sea level, Bathymetry, Foreshore Characteristics, Sediment transport, Terrestrial elevation, Geology and Geomorphology and historical events.
Legal and policy data groups consist of: Land use, Protected areas, Remarkable boundaries and land ownership.
Socio Economical layers: Population, Land cover, Infrastructure, Economic activities and Market value.
Technical measures: Coastal management operations

Benefit 1: Low-cost update of the EUROSION database and exposure assessment.
Experience has shown that the production of Europe-wide database – such as EUROSION - often results from one-time investments, little attention being given afterwards to updating mechanisms. Yet, it is highly predictable that the long-term cost of continuous data updating is far below the cost of replacing the whole database with a new one once it is completely obsolete. In that sense, Local Information Systems offer major opportunity to update these Europe-wide database at low cost since each local partner would be in charge of updating the small part of the database corresponding to its own region and would send its contribution back to the institution in charge of maintaining the Europe-wide database. One may argue that the Europe-wide database would then be updated in a piecemeal way; however we estimate that the negative effects of this piecemeal updating process could be attenuated by the implementation of "updating" standards to be respected by each LIS and a adequate documentation of the final product. In particular, such a process would make it possible to update some of EUROSION database layers which cannot benefit from economies of scale. These layers include notably:
- the coastline geomorphology
- the coastline geology
- the coastline evolutionary trends
- the presence of defence works
- the budget spent on coastal defences

Further details are provided in table 3.

Benefit 2: Provision of baseline data to regional authorities
If some regions already benefit from a huge amount of data, the situation can be quite different from one region to another. In particular, the experience of EUROSION has shown that some of the EUROSION database layers may be of relevance for regional authorities even if at a 1:100,000 scale. This is the case in particular for data on land cover (CORINE Land Cover), which combined with population data known at the municipal level, can provide a finer estimation of municipal population at risk along the risk (see for example the methodology developed by EUROSION for indicator 11 – population within the radius of influence of coastal erosion). Another example is given by the provision of data on offshore wave and wind regime (provided by EUROSION) which in turn can be transformed into near-shore wave and wind regime after combination with bathymetry and wave transformation

models. These are clear illustrations that the availability of Europe-wide data may turn quite useful for certain local or regional applications.

Benefit 3: Ensure interoperability and comparability of local data

A number of applications require that data – though local – have a consistent structure and format Europe-wide. The conclusions of EUROSION, which recommend the establishment of a European map of coastal sediment cells, illustrate this requirement. The delineation of coastal sediment cell indeed requires that a consistent methodology based on same-structure data is adopted. Failure to do so will inevitably result in coastal sediment cell overlapping or coverage gaps, which in turn may biaise coastal sediment management planning process and related responsibilities. By "forcing" the local data to fit within a specific Europe-wide structure, the opportunities offered by the cross-combination of local data increase (as illustrated in the case of coastal sediment cell) and exchange of experience and methodologies become more efficient.

Relevance of up-scaling and down-scaling capabilities : example of coastal sediment cells delineation

In line with the recommendations on assessment of hazards, environmental impacts and cost benefit analysis coastal sediment cells are deemed to constitute the units for managing coastal erosion. However, experience in Europe has shown that the delineation of coastal sediment cells is a far from trivial task and suffers from a lack of consistency Europe-wide. Efforts should be undertaken to increase the consistency of coastal sediment cell delineation throughout Europe notably by standardizing the production of key input datasets for such delineation.

The INSPIRE initiative distinguished priority common basic data, needed to be harmonized and shared. These include the first three EUROSION key data sets, while the two other recommended data sets are included in the second level of priority INSPIRE data sets. These datasets are:

EUROSION recommended key data sets		INSPIRE data
1.	The coastline.	Elevation including terrestrial elevation, bathymetry and coastline (Annex I)
2.	Coastal elevation and bathymetry.	
3.	Hydrography.	Hydrography/water catchments (Annex I)
4.	Nearshore wave regime.	Meteorological spatial features (Annex II)
5.	Astronomical tides.	Oceanic spatial features (Annex II)

Future development

Further efforts need to be undertaken to:

A) Demonstrate the mutual benefits at the various administrative levels.
B) Develop a Europe-wide methodology for delineating coastal sediment cell boundaries on the basis of the key datasets.

Specific attention shall be given to the identification of sediment sources, sinks and circulation patterns. Characteristics and differences between the European Regional Seas need to be taken into account in this process. Both combining of existing and developing technologies and operational services (e.g. through GMES projects) should contribute to this process.

The challenge to meet such European standardisation benefiting at all administrative levels needs to be demonstrated through practical experience within a coastal sediment cell.

Table 3. Potential for up-scaling and downscaling

DATA GROUP	DATA	POTENTIAL FOR UPSCALING	POTENTIAL FOR DOWNSCALING
PHYSICAL ENVIRONMENT			
Shoreline	• Current position of the shoreline • Historic position of the shoreline	YES When shoreline a high resolution shoreline is not available at the local level, the possibility to use European scale sources (e.g. EUROSION shoreline) is possible ("something is better than nothing). However, this shoreline must be super-imposed with other local sources (e.g. orthophotos) to readjust the shoreline geometry where discrepancies between the European scale source and local scale are too big.	YES The possibility to progressively upgrade European scale shoreline with higher resolution data is undeniably relevant.
Wave regime	• Near-shore wave heights • Near-shore wave periods • Near-shore wave directions	YES Wave regime near-shore may be derived from off-shore wave regime using model of wave transformation (e.g. SWAN). In practive, even if accurate data on near-shore wave (efor example collected via marine buoys) are not available, it is possible to find acceptable estimate of such local wave regime using Europe-wide wave regime data provided by in the EUROSION database.	YES Data on near-shore wave regime collected I situ makes it possible to calibrate wave transformation model, resulting in Europe-wide wave regime (offshore) of higher precision.
Wind regime	• Off-shore wind speed (10 meters above sea surface) • Off-shore wind direction • Near-shore wind speed • Near-shore wind direction	NO	NO
Sea level	• Tidal range • Relative sea level rise		
Bathymetry	• Off-shore bathymetry • Near-shore bathymetry	NO Unlike wave regime, no direct link exist between offshore bathymetry and near-shore bathymetry	YES Near-shore bathymetric data may be aggregated in a few classes (recommended -5 meters, - 10 meters, - 20 meters) which constitute valuable information Europe-wide to monitor the sea bed response to coastal erosion and also medium-scale wave modeling
Foreshore characteristics	• Sediment grain size • Foreshore slope	NO No European scale information on sediment grain size and foreshore slope exist	YES Foreshore slope may be added as a new attribute to the EUROSION "shoreline" layer
Sediment transport	• Net sediment transport • Rip currents • Long-shore drift • Ebb and flood currents	NO	YES Direction and net volume of sediment transport at an aggregated level (1:100,000) is key to delineate coastal sediment cells which should be the basis for Shoreline Management Plans proposed in EUROSION recommendations
Terrestrial elevation	• Terrestrial elevation • Contour lines (alternatively)	NO	YES Local topography may be downgraded to provided relevant information on terrestrial elevation (e.g. 1

DATA GROUP	DATA	POTENTIAL FOR UPSCALING	POTENTIAL FOR DOWNSCALING
			meter, 5 meters, 10 meters and 20 meters contour lines), which in turn is key to delineation flood prone areas as a result of dune erosion
Geology and geomorphology	• Geo-morphological patterns • Geological patterns	NO	YES Aggregation of geological and geomorphological data may on a medium term perspective become the baseline procedure to update the EUROSION database.
Historical events	• Storm records • Landslide (in the case of cliff)	NO	NO
LEGAL AND POLICY FRAMEWORK			
Land use	• Land use zoning	YES In some cases, CORINE Land cover (at scale 1:100,000) may be used at a higher scale (1:25,000) and as a proxy of land use if such an information does not exist. However, quality may be optimal.	NO
Protected areas	• Protected areas	NO	NO
Remarkable boundaries	• Remarkable boundaries	NO	NO
Land ownership	• Land ownership zoning	NO	NO
SOCIO-ECONOMIC PROFILE			
Population	• Population of coastal municipalities • Population living within 100 meters from the shoreline • Population living within 1 kilometer from the shoreline	YES JRC developed in the mid 1990's a methodology meant to disaggregate demographic data (population census) using CORINE Land cover data (at scale 1:100,000), by reallocating the population density according to the land cover units. The assumption made is that population is more likely to be found in urban areas than in other areas. This technique made it possible to estimate population density at a sub-municipal level and therefore to make simulation on for example population living in a certain buffer from the coastline. This technique is being used within EUROSION to estimate the population living within the RICE. Note however that this technique might not work for population living within 100 meter from the shoreline.	NO
Land cover	• Land cover	YES In some cases, CORINE Land cover (at scale 1:100,000) may be used at a higher scale (1:25,000) if such an information does not exist. However, quality may be optimal.	YES Possible applications include the quality control of CORINE Land Cover and also the detection of land cover changes in the future using CORINE Land Cover as a reference situation.
Infrastructure	• Roads	NO	YES

DATA GROUP	DATA	POTENTIAL FOR UPSCALING	POTENTIAL FOR DOWNSCALING
	• Railways • High voltage lines • Energy plants (nuclear, windfarms, hydro) • Harbours • Jetties	Available data on infrastructure (GISCO, 1:1,000,000) are too coarse to be used at the local level (see IGN comments on using the Infrastructure layer of GISCO for EUROSION)	Note that aggregation of local infrastructure (at scale 1:25,000) at a higher scale (1:100,000 and 1:250,000) is being done by EuroGeographics via the product EuroRegionalMap.
Economic activities	• Dredging license boundaries and volume dredged • Fishery license boundaries, annual fish captures, and employment • Aquaculture and agriculture farm boundaries, annual production, and employment • Seasonal population (tourists) • Hotel nights within 1 km of the coastline	NO Such data do not exist with a sufficient level of details to be relevant at the local level.	YES At a European scale (1:100,000), the boundaries and type of activities could be kept.
Market value	• Market value of built residential m2 within 1 km from the coastline • Market value of built commercial/industrial m2 within 1 km from the coastline • Market value of non built m2 within 1 km from the coastline	NO Such data does not exist at the European level	YES Average values may be derived at the level of Regions then combined with CORINE Land Cover to derive capital at risk. This would make it possible to finetune the methodology for assessing the exposure of European regions to Coastal erosion (e.g indicator no.12, “economic assets within RICE)
TECHNICAL MEASURES			
Coastal erosion management operations	• Geographical extent of coastal erosion works • Date of operations • Expected lifetime • Cost in Euros (investments) • Cost in Euros (maintenance) • Technical description • Known effects	NO	YES Statistics per region could be derived. Such statistics could reflect the intensity of the response to coastal erosion problems in a specific regions which have then to be compared with the erosion trends (->efficiency of measures). To be connected with the layer “budget on coastal defence”.

Use of standard geographical reference system for data representation

The Earth is a very complex shape. Its surface is disturbed by mountain ranges and deep oceans. In order to map its geography, a reference system or model is needed which will allow such topographic irregularities to be recorded and any single point on the Earth to be located unambiguously. The problem is that a variety of reference systems exist, particularly in Europe, with the consequence that when combining or integrating data from different providers into a GIS, the various themes (inputs) are not in accurate alignment. To overcome these shortcomings, which may considerably undermine the overall quality of coastal applications, it is recommended that a number of standards are adopted by the various authorities willing to implement such coastal information systems. This section explains in detail the need for adopting common reference systems.

Coordinate reference system

A coordinate system is usually defined by a an ellipsoid of reference and a geodetic datum. It makes it possible to locate any single on the earth unambiguously via three variables traditionally taken as the latitude, longitude, and the height above the ellipsoid of reference.

An ellipsoid is a mathematical model of the earth formed by rotating and ellipse around its minor axis. For ellipsoids which model the earth, the minor axis is the polar axis, and the major axis is the equatorial axis. An ellipsoid is completely defined by specifying the lengths of both axes, or by specifying the length of the major axis and the flattening. Because of the Earth's irregularities, there is no ellipsoid which fits perfectly with the earth's shape. Some ellipsoids have been modelled to fit perfectly the earth's shape at specific locations (e.g. for local applications), however the same ellipsoids do not fit at all the earth's shape at other locations. Other ellipsoids have been designed to approximately fits with the earth's surface everywhere, but these ellipsoids generally fit nowhere perfectly with the earth's surface.

As for the geodetic datum, it defines the relationship between the ellipsoid of reference and the geoid (the physical earth's surface). In practice, the distinction between local geodetic datums and global geodetic datum. A local geodetic datum is defined as a point on the topographic surface where the normal to the ellipsoid (the imaginary line perpendicular to the ellipsoid's surface) coincides with the geoid's vertical (the "direction of the plumb line"). A global geodetic datum is typically defined as the location of the centre of the ellipsoid with respect to the centre of the earth.

GPS users are familiar with the global coordinate system WGS84 which was designed for navigation applications. However, there is a problem with trying to use a global coordinate system for land surveying in a particular country or region. The problem is that the continents are constantly in motion with respect to each other, at rates of up to 12 centimetres per year. There are in reality no fixed points on Earth. By way of illustration, in common with the rest of Europe, Great Britain is in motion with respect to the WGS84 coordinate system at a rate of about 2.5 centimetres per year. Over a decade, the WGS84 coordinates of any survey station in Britain change by a quarter of a metre due to this effect, which is unacceptable for precise survey purposes required for many coastal applications. This is also true for other regions in Europe.

For this reason, the European Terrestrial Reference System 1989 (ETRS89) has been developed and endorsed by many European users – including most of national mapping agencies and the European Commission – as the standard coordinate system for positioning and surveying purposes throughout Europe. ETRS89 is based on the global ellipsoid IAG-GRS80. Its datum is tied to the European continent, and hence it is steadily moving away from the WGS84 coordinate system.

In line with the resolutions of European mapping agencies and the European Commission, EUROSION recommends the adoption of ETRS89 for producing and archiving spatial data on European coastal zones. In that respect, it is worth mentioning that some institutions, such as the International Association of Geodesy (IAG) or Eurogeographics (www.eurogeographics.org) which federates the national mapping agencies in the European Union, provide the methodology and the parameters needed (7 parameters) to convert coordinates from any coordinate systems into the system ETRS89.

Map projection

It is quite common that coordinate reference systems includes, beside the ellipsoid of reference and the datum, a map projection as well. A map projection is a mathematical model that transforms the locations of features on the Earth's surface to locations on a two-dimensional surface - typical a map - which is more convenient to visualize and handle than a three-dimensional surface. In that case, any single point of the earth's surface is located with two planimetric coordinates (x, z) instead of three as described above. Some projections preserve shape; others preserve accuracy of area, distance, or direction. None of existing projections can preserve all these features simultaneously.

When combining and integrating data coming from different providers, it is quite frequent to realize that data providers have used different ellipsoids, datums and map projections, to locate their data. However contrary to 3-D coordinate reference system, the process of converting coordinated expressed in one map projection into another map projection is time consuming and subject to uncertainties. EUROSION therefore recommends to adopt a map projection for visualization purposes only (on computer screen or printed maps) and not for archiving purposes.

Vertical Reference System

A vertical reference system makes it possible to characterise the altitude of any point on the earth's surface. Contrary to what one may think, the altitude is a "physical" value or "gravity related heights" connected to the gravity forces and not a height in its geometrical meaning (e.g. height above the ellipsoid of reference). At the very local level however the altitude and the height may be taken as identical. A vertical reference system is defined by a vertical datum, the kind of gravity related heights.

The vertical datum is in most cases related to the mean sea level which is estimated at one or more tide gauge stations. The tide gauge stations of the national height systems in Europe are located at various oceans and inland seas: Baltic Sea, North Sea, Mediterranean Sea, Black Sea, Atlantic Ocean. The differences between these sea levels can amount to several decimeters. They are caused by the various separations between the sea surface and the geoid.

In Europe three different kinds of heights are being used: normal heights, orthometric heights and normal-orthometric heights. Examples for the use of orthometric heights are Belgium, Denmark, Finland, Italy and Switzerland. Today normal heights are being used in France, Germany, Sweden and in most countries of Eastern Europe.

Within the framework of IAG Subcommission for Europe (EUREF) since 1994 various projects for realizing a European height reference system are worked on. As a result of these efforts, a United European Levelling Network (UELN) and a European Vertical Reference Network (EUVN) combining results from GPS, levelling and tide gauge observations, have been established. These points have set the basis for the edification of the European Vertical Reference Framework 2000 (EVRF2000) endorsed by the International Association of Geodesy (IAG). EVRF 2000 is characterised by :

- the datum of "Normaal Amsterdams Peil" (NAP)
- gravity potential differences with respect to NAP or equivalent normal heights,

In line with the resolution of IAG and the European Commission, EUROSION recommends the adoption of EVRF 2000 as the vertical reference system for altitude related to spatial data in the European coastal zones.

However it must be mentioned that, even though EVRF2000 is undeniably the most advanced effort to build a consistent vertical reference system, the construction of seamless coastline representation may lead to small errors. This is due to the fact that the mean sea level (i.e. the "0" level) measured by one tide-gauge (notably the reference tide-gauge of Amsterdam) differs from the "0" level measured by other tide gauges. For instance, experience has shown that a difference of about 10 centimetres between the "0" level measured along the Mediterranean coast and the "0" level measured along the North Sea can be reached. The process of converting elevation data from one local vertical reference system into EVRF2000 should take this error into account by estimating the error made.