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# Research on Integrated Mapping Mystem of Mand and Mea Basic Spatial Element Data Based on ArcGIS

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***Abstract:*** *Adhering to land and sea overall planning is the basic principle and important content of China's construction of Marine power, the basic geographic information of land and sea integration can provide data support and service guarantee for "land and sea overall planning" work. Aiming at the current land and ocean surveying and mapping system in China, an integrated data system of land and sea basic spatial elements is designed and implemented. The system uses C/S architecture and vector data integration technology to integrate and manage the data of land and sea basic spatial elements effectively. Based on ArcGIS secondary development method, this paper completed the establishment of land and sea basic spatial element data, designed the technical process and function of the integrated mapping system, and implemented the system by using.NET and ArcGIS Engine technologies. It has realized the functions of multi-field retrieval of massive surveying and mapping data, integrated spatial display, security storage and so on. Practice has proved that the data integration and management system designed and developed in this paper is feasible and effective, which can realize the efficient reuse of surveying and mapping data, provide convenient and fast data services for surveying and mapping workers, greatly improve their work efficiency, and promote the development of land and sea integration.*

***Keywords:*** *Land and sea mapping; Basic spatial elements; ArcGIS Engine; Integrated mapping system*

## 1. Introduction

Basic geographic information is an important basic and strategic information resource in national informatization construction, and can be used as the basis for unified spatial positioning and spatial analysis of all industries related to geographic information [1]. With the parallel development of basic geographic information on land and sea, a series of basic geographic information resources covering the whole land area, including topographic elements database, topographic map cartographic database, orthophoto database, digital elevation model database and other basic geographic information resources covering the sea area of China, have been formed.

With the continuous progress of surveying and mapping technology and the increasing number of surveying and mapping projects, the industry's dependence on surveying and mapping results is increasing, so more effective data integration and management systems are needed to promote the surveying and mapping work. Strong ocean surveying and mapping is a survey and chart compilation of Marine water bodies and seabed topography[2],which is the forerunner and foundation for Marine development management, rights and interests protection, disaster prevention and scientific research [3-4]. At present, the development of Marine surveying and mapping in China has been centered on Marine surveying and mapping data, resulting in separate collection of basic land-sea surveying and mapping data, sub-database storage, data accuracy and data model inconsistency [5], resulting in redundant data storage and inconvenient sharing of land-sea surveying and mapping results. Therefore, there is an urgent need for effective integration of land and sea basic spatial data to achieve the integration and unified expression of land and sea basic spatial data, so as to solve the waste of resources caused by data duplication and redundancy and expand its application prospects. In this paper, based on the existing vector data integration technology, the method and process of land and sea basic spatial elements data integration management are discussed, and the integration system of land and sea basic spatial elements is designed and implemented. The system realizes the unified coding of Marine and land-sea surveying and mapping results data, can independently judge the priority of duplicate data, and can carry out automatic edge connection operation after data integration, effectively solving the problem of the

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isolation of land and sea data, and providing convenience for the relevant departments of Marine surveying and mapping.

## 2. System Design

### *2.1. Overall Design*

The attribute information and data organization structure of Marine basic spatial elements database and land basic spatial elements database are analyzed to help design the logical model of the integrated database of land and sea basic spatial elements. The storage mode of Marine basic spatial elements database and land basic spatial elements database is analyzed to help design the physical model of the integrated database of land and sea basic spatial elements. Combined with the data model of the integrated database, the framework of the integrated database is finally determined.

The "data center" construction mode is adopted to realize the centralized distributed database management mode, ensure the common use of unified data and other related topics, and use vector data overlay analysis to extract the overlapping area of land and sea data, and determine the factor data in the non-overlapping area as the data required for the integrated database; For overlapping areas, it is detected whether there is the same FCODE (the unique classification code of each type of ground object), and the differentiated FCODE elements are directly used as the data required for the integrated database.

For the same FCODE elements in the overlapping area, TAC policy is used to determine the priority, and the selected elements are used as the data required by the integrated database. There are overlapping areas in the surveying and mapping range of land and ocean, and the elements in the overlapping area are screened by rules, and then the elements outside the overlapping area are connected. The technical route is shown in Figure 1.

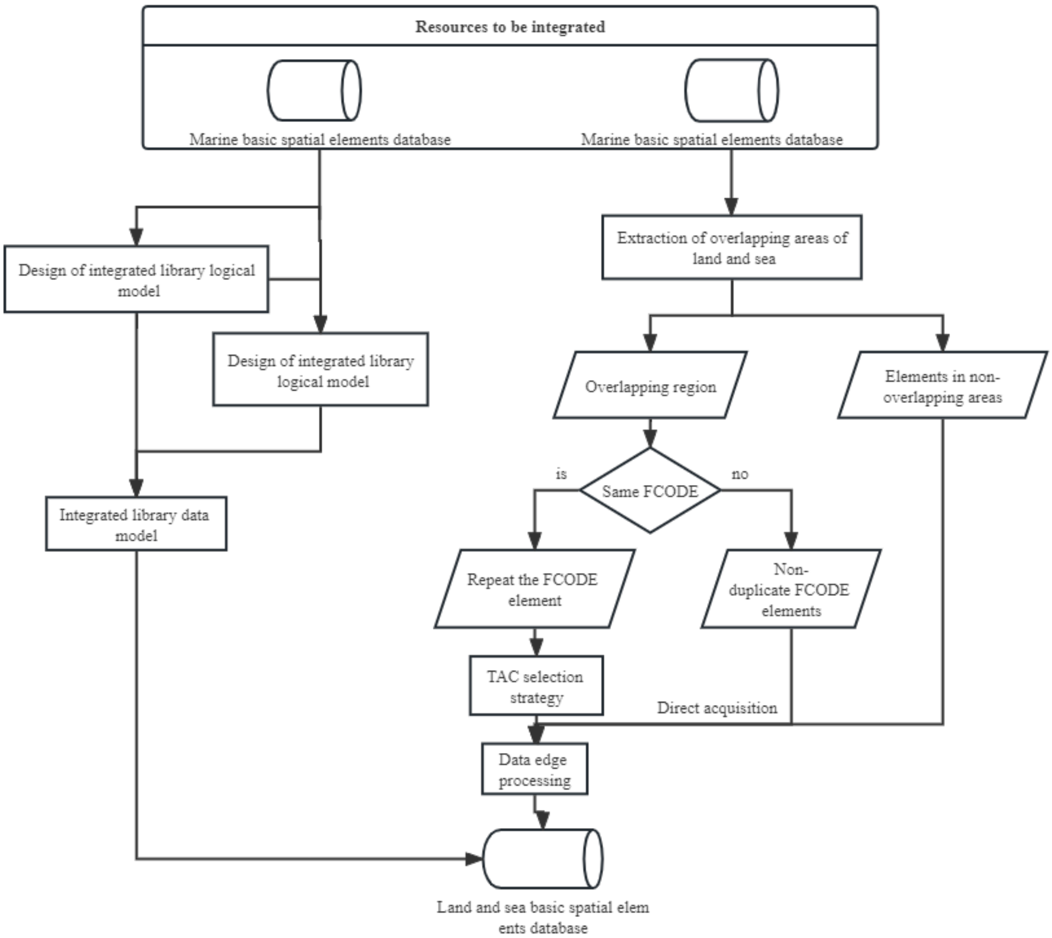


*Figure 1 Schematic diagram of system technical route*

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### *2.2. System function design*

(1) Adopt the "data center" construction mode to achieve a centralized distributed database management mode to ensure that the system data can be referenced by other relevant thematic applications, and also ensure that other thematic data is used by the system.

(2) The system applies ESRI's ArcEngine development platform and SDE database management engine to support the storage and management of various relational databases and massive data;

(3) The system provides management and maintenance of data layers, data structures, data dictionaries, metadata, etc.; The security of the system can be strengthened through user permission setting, password setting, backup and recovery, error handling, log, etc., and the system can be upgraded without loss.

(4) The system provides integrated management functions of vector data and raster data, and raster data can be superimposed from files and raster databases; Support vector data and raster data overlay display, printing;

(5) The system provides a variety of query functions, including custom query, combined query, map mutual search, land registration information query; Area query calculation, length query calculation and other functions;

(6) The system can output and compile class maps, standard subdivision maps, regional maps, arbitrary area clipping maps, other types of thematic maps and historical thematic maps, and can define various types of map templates;

(7) The system can generate the statistical summary table required by the relevant specifications, with the function of statistics, summary and query of the table, and the output report format is EXCEL;

(8) The system saves historical information in time increments and has functions such as storage, query and tracing of graph and attribute historical information [6].

### *2.3. System Architecture*

The land and sea basic spatial elements data integration system adopts C/S mode to manage the whole system according to the integrated functional requirements, and uses ASP.NET and Windows Forms to develop graphical interface. In the data access layer, the interface of ArcGIS Engine is used to access the spatial data stored in Oracle through ArcSDE. In terms of non-spatial data, a combination of ADO.NET access stored in the database and C# directly read stored in the file is used. The technical architecture is shown in Figure 2.

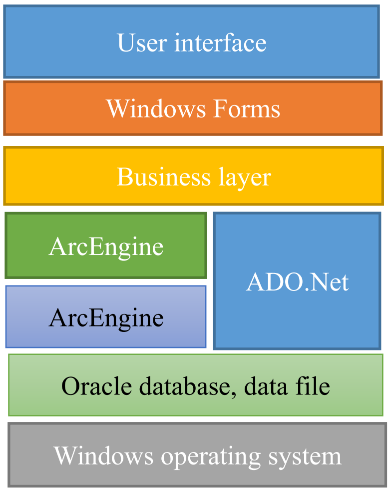


*Figure 2 System framework*

General components of ArcGIS Engine, data access function components, DotNetBar and other components are adopted to provide GIS functions and interface support for the establishment of this system. Through map browsing, query, integrated database generation, data editing, land and sea survey area analysis, integrated rule editing, data interface and data entry to provide users with the operation achieved on the system, with a graphical or tabular way to output the matching process and matching results, to provide users with a graphical interactive interface.

## 3. Key Technologies

### *3.1. Data fusion design*

Spatial database is used for spatial data management and data fusion based on the characteristics of basic land-sea geographic spatial element data. The data fusion technology is based on vector data fusion [7], and the method is extended vertically to achieve a better data fusion effect than a single one. Under the premise of unified land-sea datas and unified factor classification system, Data fusion based on land and sea basic geospatial element data features includes three parts: data structure unification, vector data fusion and data consistency processing(see Figure 3).

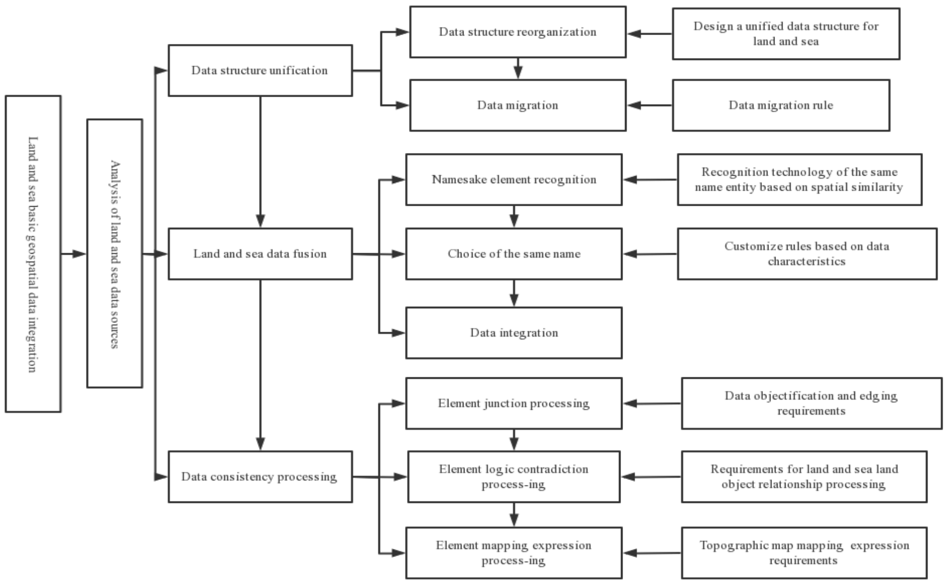


*Figure 3 Technical route of integrated design and processing of land-sea basic geospatial element data*

#### *3.1.1. Unification of data structure*

Data structure unification is based on the data structure of basic database, extending the unique attribute content of Marine database, and forming a unified data structure of land and sea through data reorganization and migration.

#### *3.1.2. Vector data fusion*

Vector data fusion is to use the same name entity recognition technology based on spatial similarity to match the same name elements in the data overlap area, and then determine the same name elements by comparing the timeliness, accuracy and integrity of the same name elements and other data characteristics, so as to retain the unique element object.

#### *3.1.3. Data consistency processing*

Data consistency processing is to eliminate the geometric boundary contradiction, element logic contradiction and element map representation contradiction one by one, and form land and sea integrated data that meets the requirements of data fusion accuracy and element expression.

### *3.2. Element integration system design*

#### *3.2.1. Design of integrated element classification system*

China's existing basic spatial element data classification and code standards include GB/T 13923-92 "Land basic Geographic Information data classification and code", GB 14084-93 "1:500 1:1000 topographic map elements classification and code" and GB/T 15600-1995 "1:500. Classification and

Code of topographic map elements 1:10,000 1:25,000 1:50,000 1:100,000, etc., the land basic spatial elements defined by it are divided into eight categories, namely control points, boundary lines, vegetation and land, water systems, transportation, landforms, residential areas, facilities and pipelines. Based on the consistent geospatial framework and element classification and coding system, there are some differences between the basic database and the Marine database in data acquisition methods, data scale, element content expression, data structure, current situation, etc., and then their respective data characteristics are formed. In this regard, in the process of land and sea data fusion, in addition to using the traditional vector data matching and fusion technology based on geometric features, data feature conditions such as data current status, data accuracy and element content integrity should be fully added to adapt to the accurate fusion of land and sea data most effectively.

#### *3.2.2. Selection method of basic spatial elements*

The data in the land-based spatial element database and the Marine DLG database are the results of field surveying and mapping, and the description and expression of the geometric features of geographical elements are accurate. However, the mapping scope of land and ocean overlaps. In order to prevent the redundancy of the land-sea integrated basic spatial database after integration, this paper defines certain rules to set the selection priority of repeated elements.

(1) timeliness: It refers to the time to acquire the attributes and characteristics of geographical entities, which is an important factor affecting the quality of data. The stronger the current status of the data source, the more it can describe and express the real state of the geographical entity at present.

(2) accuracy: It refers to the degree to which the location accuracy and detail expression of the entity with the same name in each data source are close to the truth value of the described entity.

(3) completeness: refers to the completeness of data sources.

In this paper, the first letters T, A and C are taken to indicate the current situation, accuracy and completeness respectively. The TAC principle is set according to the needs of customers. In this paper, the rule is set as current status > accuracy > integrity. If the integration priority of entities a and b with the same name is determined, if the current state of a is greater than the current state of b, then T(a)=1, T(b)=0, and so on, then the TAC of entities a and b can be calculated respectively.

### *3.3. Method of element junction processing*

The integration of heterogeneous data may cause the uncertainty of time and space, resulting in the segmentation or spatial dislocation of the same geographic target entity, so it is necessary to carry out edge operation [8]. The mapping scope of land and ocean overlaps. After the elements in the overlapping area are prioritized, they need to be connected with the elements outside the overlapping area. The elements that need to be treated with edge mainly include line elements and surface elements.

#### *3.3.1. Line element bonding*

This paper assumes that if the distance between two line element endpoints (starting point or ending point) is less than threshold $\sigma$, the two line elements are the side to be connected. Specific operations are as follows:1. First, extract the boundary line of the overlapping area, and find the elements in the buffer (cache area is $\sigma$) with a certain distance from the boundary line of the overlapping area, as shown in Figure 4.Through the buffer of the boundary line segment of the overlapping region, five elements of the edge line to be connected, such as A, B, C, D and E, are obtained. 2. Candidate factors are divided into two categories. Factors in overlapping areas are classified as category 1, while those not in overlapping areas are classified as category 2.As shown in Figure 4, A, C and E are category 1, and the remaining B and D line elements are category 2. The elements in category 1 are connected with those in category 2. 3. Find the elements whose d is less than the threshold value $\sigma$ in Class 1 and Class 2 elements, and connect the elements that meet the boundary.For the elements of line A and line B in Figure 4, the minimum Euclidean distance da and B of the endpoints of elements A and b (endpoints a and b in the buffer) are calculated (d is used below to represent the minimum Euclidean distance of the endpoints of elements of two lines). If $d_{a,b}<\sigma$, then a and b are connected, and the elements of line A and line B are merged into one element. Merge the attributes of A and B simultaneously.

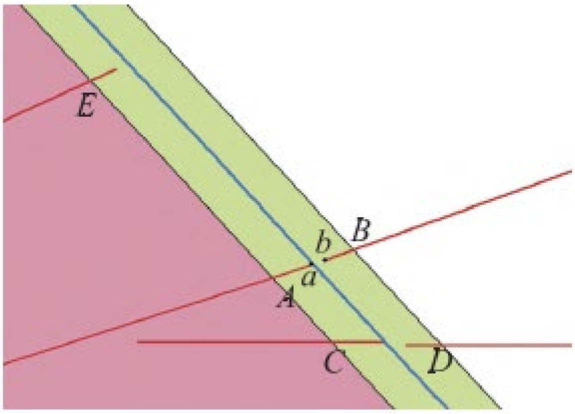


*Figure 4 Schematic diagram of line element connection*

### *3.3.2. Surface element bonding*

The junction of surface elements is more complicated than that of line elements, so the junction end points can be obtained by using the method of finding candidate junction end points of line elements proposed in this paper,As shown in Figure 5,$a_1$with $b_1, a_2$with $b_2, a_3$ with $c_1, a_4$with$c_2$is an admissible end point.When handling at the junction side$a_1, b_1, b_2, a_3$closed generating surface,$a_3, c_1, c_2, a_4$closed generation.The specific operation is as follows: 1, according to the above method to find adjacent endpoints, obtain 1 type endpoints$a_1, a_2$is adjacent endpoints,2 types of endpoints $b_1, b_2$is adjacent endpoints;2, the $a_1, a_2$ (or $a_1, a_2$ as the end of the line segment) and $b_1, b_2$(or $b_1, b_2$ as the end of the line segment) to establish A convex hull, generate the edge of the surface D, and finally merge the A, D and B, while the attributes of A and B are merged, the surface elements of the edge is completed.

Due to the different error ranges of data from different sources, it is difficult to determine the threshold σ of the element junction. In this paper, an error is introduced to determine the data boundary threshold σ. According to the cartographic error theory, middle error is used as an indicator of data quality and map synthesis, and its size varies with the change of scale, so it can be used as the range of data uncertainty [9]. For elements A and B to be connected,Assuming that their median error is $\rho_A$and $\rho_B$ respectively, this paper takes:

$$\sigma = 2 \cdot \max(\rho_A, \rho_B) \tag{1}$$

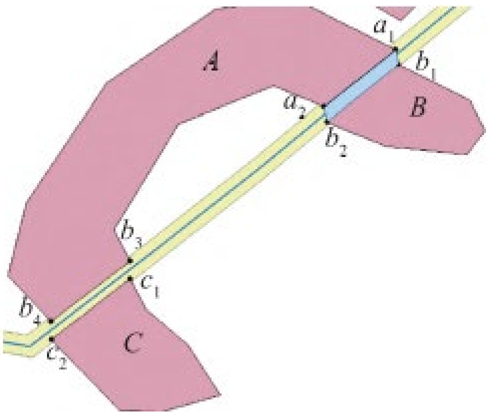


*Figure 5 Schematic diagram of surface elements connecting edges*

## 4. Implementation Effect and Application

Based on the vector data integration technology and the requirements of data integration of land and ocean surveying and mapping results, an integrated data integration system of land and sea basic spatial elements is built in this paper. According to the designed data fusion technology route and method, the vector data fusion technology, the same name entity matching based on spatial similarity and the element fusion technology based on data characteristics, combined with the requirements of data integration of land and ocean surveying and mapping results, the integration of basic database and ocean database was completed in the way of human-computer interaction. A basic geospatial element database integrating land and sea has been formed (Figure 6), and an integrated data system integrating land and sea basic spatial elements has been built.

The functional area integrates ArcGIS Engine component to develop and process basic spatial element data, and realizes the automatic integration and data management of land and sea basic spatial element data. Core functions include mapping the corresponding layers of the Marine and land basic database, detecting the attribute fields of the corresponding layers, merging their attribute fields, adding initial fields, end fields, data source fields, and entity unique fields, and adopting the "data center" construction mode to achieve centralized distributed database management mode. According to the timeliness, accuracy and completeness of the integrated data, the retention and abandonment of the integrated data are determined, and the Marine and land elements are automatically retained and discarded according to the integration rules. Then, the retained data is screened and tested, and the data automatic interfaces with repeated parts are selected, so as to complete the automatic integration of land and sea spatial elements.

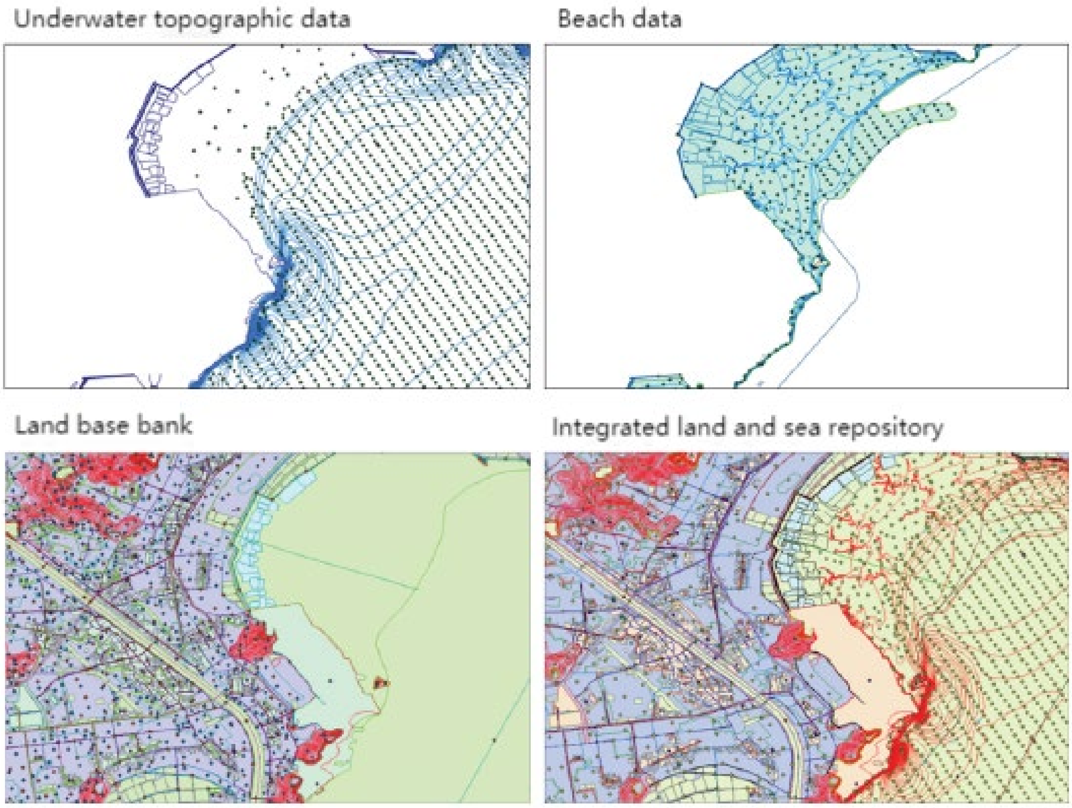


*Figure 6 Comparison of land and sea data before and after integration*

## 5. Conclusion

The system designed in this paper includes a set of factor classification system and freely edit-oriented priority judgment rules for land-sea basic spatial data integration, as well as an automatic data edging method based on median error, which better realizes the automatic integration technology of land-sea basic spatial factor data. It solves the problem that the basic data of land and sea can not be included in the unified production and management system, greatly improves the work efficiency of surveying and mapping workers, solves the problems of traditional decentralized storage, reuse difficulties and low data storage security of massive multi-source heterogeneous data, and realizes the integrated storage and display of surveying and mapping data in the system. At the same time, based on the characteristics of safety, stability and reliability, it supports the multi-field retrieval query of surveying and mapping data, data attribute viewing, data download and other functions.

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