MANAGEMENT OF DIGITAL DESIGN DATA IN BUILDING DESIGN AND CONSTRUCTION UNITS

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ABSTRACT : The problem of managing digital design data including drawings, specifications and other technical data in building design and construction units is a real challenge, especially when there is a need to structure the design information across building design companies. The main difficulty in this information management is the shortage of unified rules (or standards) on how the digital design data should be gathered, archived, and preserved in the most efficient way for building design and construction units. The most important issue, which addressed in this work, is the standardized reference of all design data definitions.

Key words : Computer aided design, electronic document management, Open Archival Information System.

1. INTRODUCTION

There is an emerging demand for management of digital design data in building design and construction units, which associated with achieving the higher level of efficiency by reduction of the project development time and costs. Architecture, engineering and construction enterprises are seeking for a new efficient ways to allow engineers to collaborate on the same project and efficiently communicate engineering data and changes to the rest of the organization.

The management of digital design data involves the complete life cycle of design documentation and design-related data inside CAD applications. Project development time is typically long due to a considerable amount of design data that required to be transferred between the members of different project team. Another possible reason for high project development time and costs is that even typical projects have to be developed from the bases, because there is no centrally and easy accessible information storage. It is based on well-know fact that designers spend 75% of their time searching for the required project data, and only 25 % of the time actually modifying it [1].

As an efficient solution the mentioned above problems is the application of the electronic document management (EDM) system, that facilitate the management of documents pertinent to particular enterprises, projects and work groups in computer networks. In addition to the basic file management capabilities, EDM systems contain enhanced features related to the life-cycle, revision history and version management of particular classes of documents [2]. An application model attempting to achieve unification of all the models used by individual participants into one universal model fulfilling the functions of all models combined, along with horizontal and vertical integration in the management of the building construction process is proposed in [3, 4].

A number of commercial tools have been created for document management, project information sharing, online communication, design workflow, construction workflow, time control, and securing information.

In this work, management of digital design data was performed by employing the electronic document management (EDM) system which was improved by the request of building design and construction company. When applying this system, an attempt has been made to put forward the unified rules (or standards) on how the digital design data should be gathered, archived, and preserved in the most efficient way for building design and construction units. The most important issue, which addressed in this work, is the standardized reference of all design data definitions. The standardized attributes were attached to classified digital design data, so that they can be referred. Besides, standardized tags of the project data were defined and the framework was developed to represent the hierarchy of the building design project. Those features constitute a dynamic archive of the digital design data, which was modeled on the bases of reference model for an Open Archival Information System (OAIS).

Implemented and improved solution provides complete control of the flow of project documentation in both directions: **producer – archive – consumer** which are archived and stored in one structured way and ready for re-use. They also reduce overall engineering costs by diminishing the project development time and cycles.

2. ENVIRONMENTAL MODEL OF INFORMATION FLOW

A growth of the work intensity in building design companies creates the difficulties of management information flows in the projects. In fact, project management can be accomplished as document life cycle control. The successful application of EDM systems strongly depends on the appropriate structure of the central archive for design information. Preserving information in digital forms is much more difficult than preserving information in forms such as paper. This is not only a problem for traditional archives, but also for many organizations that have never thought of themselves as performing an archival function. The workflow presented for the archive of the construction design documentation is based on ISO Reference Model for an Open Archival Information System (OAIS) for a data repository system [5, 6, 7]. Environmental model of an Open Archival Information System is presented in Figure 1. The role provided by each of the entities in OAIS can be described briefly as follows:

- **Producer** is the role played by those persons, which provide the information to be preserved.
- **Management** is the role played by those who set overall OAIS policy as one component.
- **Consumer** is the role played by those persons, that interact with OAIS services to find and get interested preserved information.

Every submission of information by a Producer, and every dissemination of information to a Consumer, occurs as one or more discrete transmissions. Therefore, it is convenient to have three different types of the packages:

- **Submission Information Package (SIP)** is a package that is delivered by the Producer to the OAIS for use in the construction of Archival Information Package.
- **Archival Information Package (AIP)** is a package, consisting of the Content Information and the associated Preservation Description Information.
- **Dissemination Information Package (DIP)** is a package, derived from AIP and received by the Consumer in response to a request to the OAIS.
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Figure 2 represents Archival Information System where three component parts of the design chain displayed in different colored rectangles:

- **Ingest** provides the services and functions to accept Submission Information Packages from Producers and prepare the contents for storage and management within the archive.
- **Archival Storage** provides the services and functions for the storage, maintenance and retrieval of Archival Information Packages.
- **Access** provides the services and functions that support consumers in determining the existence, description and availability of information stored in the archive, and allowing consumers to request and receive design data.

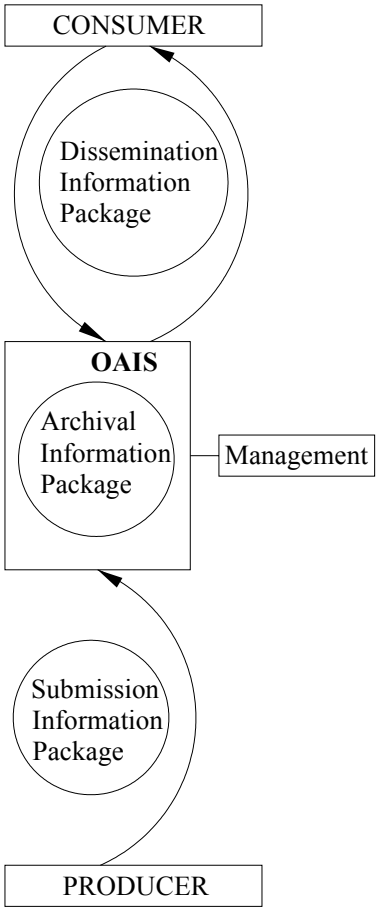

Figure 1. Environmental model of an Open Archival Information System.

3. FRAMEWORK FOR ARCHIVING DIGITAL DESIGN DATA

Having model of the Archival Information System was begun the job of the framework for archiving project documentation. The archive is meant to store in on structured way all project documents types. Due to the project-centric nature the structure of archive reflects the main parts of the project. Lithuanian classification of the project documentation is presented in Figure 3. This classification is governed by Lithuanian construction regulatory laws [8, 9]. Document classification of Technical Projects Stage is shown separately in Figure 4. This stage belongs to the documentation of construction projects (Figure 3).

Lithuanian standardization organizations, professional associations, user groups, individual companies don't have unified rules of CAD standards and guidelines in building design industry. This is a first attempt in Lithuania to provide unified reference of all document definitions. The standardized reference is the most important issue for development of the efficient IT applications.

The direct implementation of the project document classification system leads to overcrowded hierarchical tree of project information. In order to overcome these

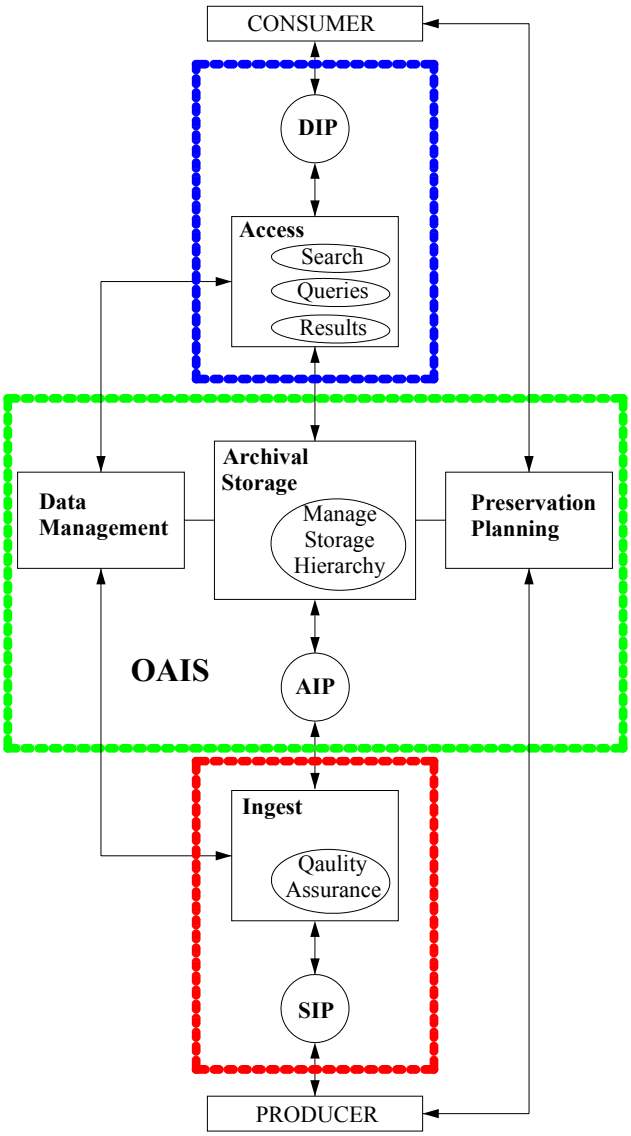

Figure. 2. Archival Information System

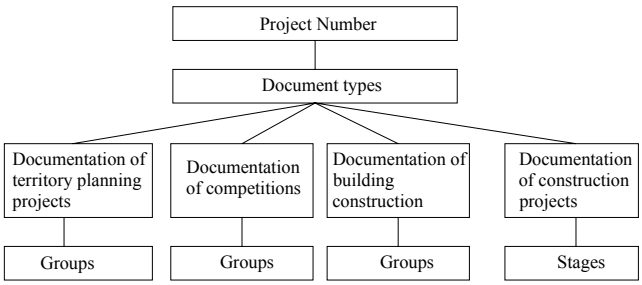

Figure 3. Lithuanian classification of the project documentation

difficulties document file naming schema is established for native CAD documents. This file naming schema is associated with standardized project document classify-cation. The specific CAD document is named beginning with five digit project code followed by:

1. Project number;
2. Construction number;
3. Project stage;
4. Discipline designators;
5. Case number.

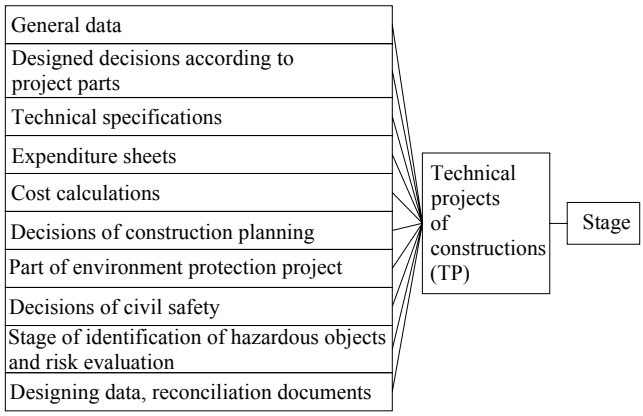

Figure 4. Document classification of Technical Projects Stage

In a similar way, file organization structures are defined to represent the hierarchy of the building design project. The file naming schema is associated with standardized project document classification. File directory organization (Figure 5) together with file naming schema provide an effective framework for archiving digital design data.

Having classification of the project documentation, file directory organization, file naming schema and chosen electronic document management solution "eChange" from "Empresa Solutions", the structure of the archive and project documentation flow were modeled.

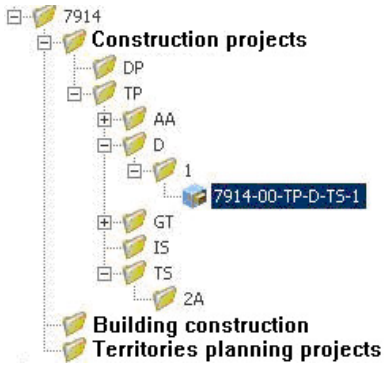

Figure 5. Design information file organization

4. IMPLEMENTATION TECHNOLOGY OF AEC DESIGN ARCHIVE

4.1 Metadata

All digital design data in proposed archive have metadata associated with them. Metadata are used in archive cataloging and have become an integral part of the search on the World Wide Web.

One of the most basic and widely used metadata schema is proposed by Dublin Core Metadata Initiative (DCMI) [10]. The common set of Dublin Core metadata is designed to allow for discovery of content across digital repositories

worldwide through what is called the Open Archives Initiative (OAI). Since Dublin Core developed from a bibliographic point of view and was designed primarily to store and make available written documents in a digital form, this scheme does not accommodate a hierarchical data structure for the metadata, but rather is a flat record.

Another metadata scheme called Categories for the Description of Works of Art (CDWA) was specifically designed for describing works of art, architecture, groups of objects and visual and textual surrogates. [11]. CDWA does not prescribe a data structure for the metadata, but it does suggest a metadata hierarchy that allows information to be recorded at both a master level and at a component level.

4.2 Proposed metadata schema

In our case we have two types of data structures (Table 1):

1. **Master** - accommodates metadata tables and fields related to the project documentation classification;
2. **Component** - accommodates metadata tables and fields related to retrieval and searching of the appropriate digital design data.

Table 1. Master/Component Data Structure

Data Structure	Master	Component
Project number	X	
Project name		X
Project address		X
Customer		X
Project leader		X
Leader of design part		X
Stage	X	
Document ID		X
Document name		X
Construction number		X
Construction name		X
Date		X
Document type	X	
Designed parts	X	
Case number	X	
Keywords		X

Metadata fields in Master records reflect classification of the project documentation (Figure 3). Hierarchical tree of project documentation allows metadata to be "inherited" from one level to the next. The records of these metadata fields appear automatically by default when new document is entered into the archive. This is metadata about the container.

Metadata fields in Component records must be filled by designer (producer). Having an archive inside the company sometimes becomes an extra load for designer, who is involved in design chain and usually not qualified to maintain it. The design process in the chain producer-archive-consumer can be slowed down because of the existence of the archive.

By this reason this job is done by administrator of the archive or project leader who has all knowledge about executive project. With entering new document into archive every time administrator of the archive must enter all records. Metadata fields in Component records will be entered during Ingest, while metadata for the individual document records will be entered before documents have been approved.

In order to overcome these difficulties the proposed metadata scheme requires customization in three areas: additional metadata tables and fields, refinement of the Component data structure and reduction of data redundant entry. There was designed an inheritance “tool” for data redundant entry. This is metadata about the container’s contents. Metadata about the container’s contents shares several fields across record types, with some key differences. Every Master container can have Component records as much as it need. It belongs to the structure of the project. Administrator of the archive assigns Component records to each Master record. For example, “Project number” container has “Project name”, “Project address” and “Customer” metadata fields. These metadata fields with entered records will be inherited to each document which lays in this project.

4.3 Developed model

For the implementation of the developed model [12], the Architecture, Construction and Engineering (AEC) digital design archive was chosen, that is “eChange” EDM software of the company ”Empresa Solutions”. For more information about basic features of “eChange”, the interested reader is referred to [2].

While “eChange” was designed with the CAD sector and engineers as the primary users, the system can be used to store any type of file that can reside on a computer’s file system. In our case the largest Lithuanian building design company use “eChange” to manage all of their office documents in addition to the CAD drawings they generate. Lithuanian company performs complete residential and industrial building design that includes architecture, construction and engineering. Lithuanian Construction Design Institute (Lietuvos Statybu Projektavimo Institutas), which is engaged in the design of construction units and project management has increasing the number of projects per year, at the same time having designed more and more complex objects, the implementation of efficient EDM system has become essential. Tasks that need to be performed for achieving the dynamic archive with information flows in the both directions of the design process chain producer-archive-consumer, included:

1. Initialization file organization sheet with prescribed project number;
2. Preparation of digital design data;
3. Automated digital design data transmission from SIP to AIP;
4. Usage of the archive inside the design chain. Workflow.

The workflow schema across design chain is presented in Figure 5.

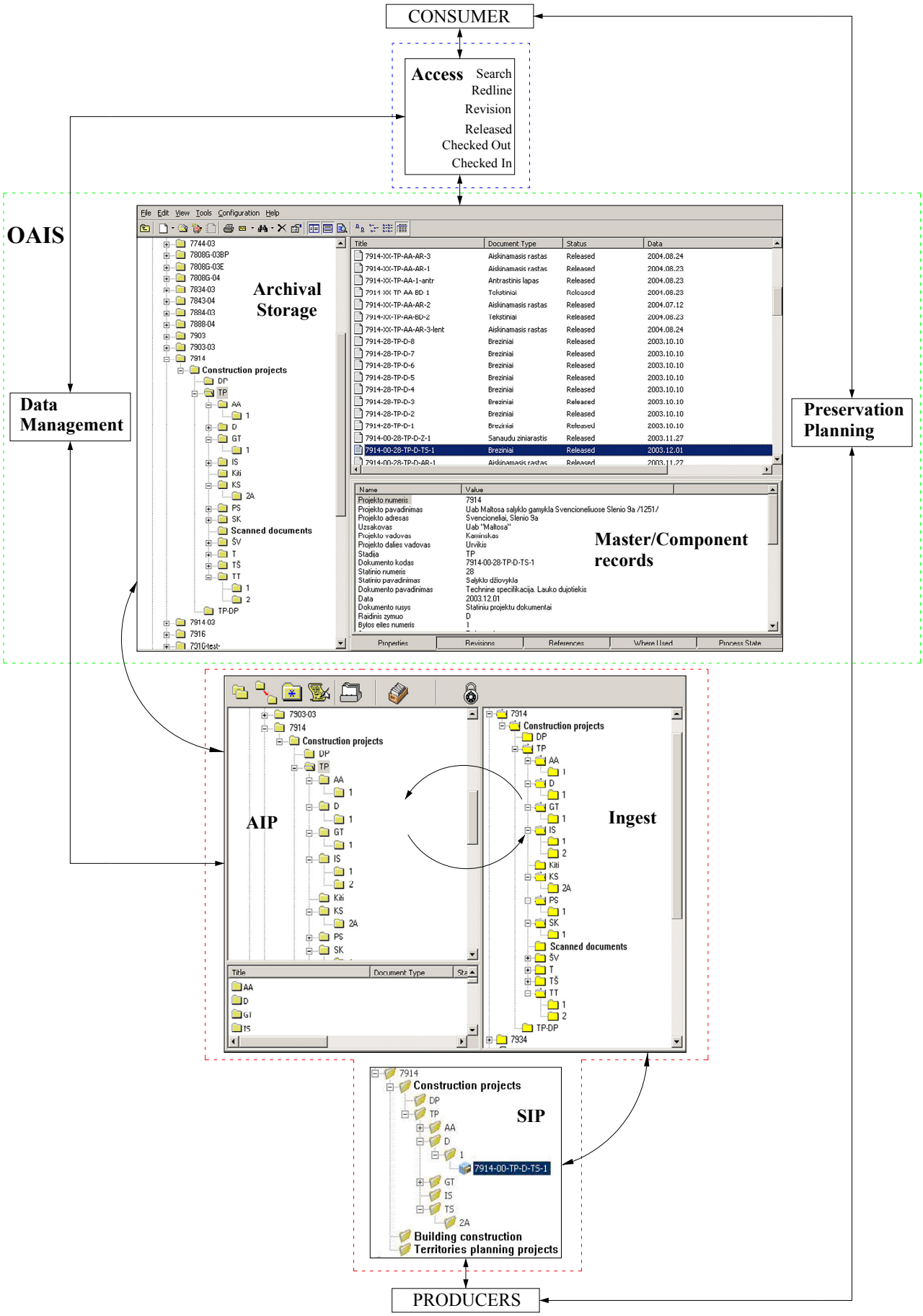

Figure 5. Workflow across design chain

The first step in the creation of a successful digital design collection must begin in the designer's office. Each designer (Producer) of the building design company working with "Architectural Desktop" software and using "Project Navigator" directly connects to general file organization vault system. Each designer has knowledge about development of the whole project bringing separate CAD documents into project structure adequate catalogues (Figure 5 SIP). If changes are made in one part of the project documentation the system automatically shows and other designer can follow what's going on.

But before that, than designers could begin work within new entered project, the project leader or the administrator of the archive must initiate this process by entering new project number. By this operation, in the vault of the technical documentation a new tree representing structure of the project documentation is appeared and the SIP of the new project is initialized.

The same tree structure of the project documentation is appeared in the AIP where EDM system "eChange" is.

The initialization of the same new project structure in SIP and AIP is occurred through the Ingest module where conjunctive and transformation "tool" is (Figure 5 Ingest). There is inheritance "tool" for data redundant entry. This tool is managed by project leader or the administrator of the archive.

All design information in one step is transformed by archive administrator from SIP into AIP by using Ingest module. The primary goals for Ingest are to check the design data and to transform the Submission Information Package (SIP) to an Archival Information Package (AIP). The dialog window of Ingest transformation module is divided in two parts: right part represents SIP, left part represents Electronic Document Management system of "eChange" (AIP).

In AIP all project documentation gains "Released" status and if all information is correct documents gain "Archived" status.

After transforming from SIP into AIP all project documentation obtains metadata properties. There is underway of automated attribution of properties and all documentation is placed in to project structure adequate catalogues. Hereby all project information being in "eChange" system is accessible for users and groups according to permissions for each document type. The "eChange" system also provides different levels of access rights to documents View/Copy, Check Out/In, Release, Archive, and Delete.

Incorporation of Electronic Document Management system into design chain "**producer-archive-consumer**" allowed to refuse Dissemination Information Package. "eChange" solutions provides secure, scalable, and affordable document control, revision history, and workflow across a whole design chain.

5. CONCLUSIONS

An attempt has been made to put forward the unified rules (or standards) on how the digital design data should be gathered, archived and preserved in building design companies. The first digital project documentation archive is developed in Lithuanian AEC industry. The main strategy was to develop the dynamic archive with information flows in the both directions of the design process chain: producer-archive-consumer. The workflow presented for the archive of the construction design documentation is based on ISO Reference Model for an Open Archival Information System (OAIS). The management of digital design data was performed by employing the collaborative design change and document management system "eChange" of "Empresa Solutions".

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