

Advanced Aircraft Design-Certification Framework with Database Development

Tun Lwin, Jae-Woo Lee*, Sangho Kim, Yung-Hwan Byun and Nhu Van Nguyen

Konkuk University, Seoul, South Korea, 142-701

[tunlwin, jwlee, kimsh85, yhbyun] @ konkuk.ac.kr

Abstract

Nowadays, Database Management Systems (DBMS) and Databases Designs are main subject in large business system and engineering framework. In this paper, Aircraft Design and Certification Framework (ADF) and database are developed and step by step developments are described. In this framework, we consider user requirements, preliminary sizing, conceptual design, geometry generation, load analysis of aircraft programs with checking and validation of airworthiness regulations. The Federal Aviation Regulation (FAR) Part 23 and Korea Airworthiness Standard Regulation (KAS) Part 23 are constructed in certification database. The graphical user interface is developed by using Microsoft .Net framework 2010 with visual basic language. The DB connector object is developed from data input and output processes into database. And also, task creation, file operation, document management and error controlling processes are integrated in this framework.

1. Introduction

The impact of computer technology on organizations and society is increasing as new technologies evolve and existing technologies expand. Because of the influences of the innovations in the computer technology, people can also build their own computerized systems with easy-to-use construction tools [1]. Management is a process by which certain goals

are achieved through the use of resources like materials, people, money, time. These resources are considered to be inputs, and the attainment of the goals is viewed as the output of the process. So, that database systems continue to be a key aspect of computer science and engineering today. A database is in essence a collection of information that will exist in a period of time, information that is managed for a database management system (DBMS) [2]. A DBMS supports logical view, physical view, data definition language, data manipulation language, data integrity and security [3]. The database design requires understanding both the operational and user requirements of a system as well as the ability to model and realize those requirements using a database.

In today's aircraft technology, aircraft safety regulation is minimum requirements of aircraft creation. So, aircraft design certification is important and necessary process in aircraft manufacturing industry [4]. So, we studied the database development of aircraft design-certification framework. The aircraft design program is implemented with MATLAB programming language which calculates sizing, aerodynamics, propulsion, mission, performance, stability and control and weight of aircraft. The certification database establishes based on FAR Part 23 (Federal aviation Regulations) which were issued by Federal Aviation Administration (FAA) of U.S department of. The FAA is responsible for overseeing the designees' activities and determining whether the designs meet the FAA's requirements for safety. The safe

and efficient use of navigable airspace is one of the FAA's primary objectives. The FAA operates a network of airport towers, air route traffic control centers, and flight service stations. It also develops air traffic rules, assigns the use of airspace and controls air traffic. The FAR-23 regulation is for normal, utility and acrobatic category airplanes. The FAR-25 regulation is for transport category airplane. The FAR-33 regulation is for aircraft engines, FAR-35 regulation is for propellers and so on. The FAR 23 is responsible for the small airplane directorate [5]. The technical guidance for FAR-23 restricted category airplanes, airworthiness standard for gliders and airships, and technical guidance for primary category airplanes.

In author's previous studies, the ADSP (Aircraft Design Synthesis Program) was implemented by FORTRAN programming language for design analysis. That program gives the aircraft design configuration data, aerodynamics data and performance data. The Model center commercial software was used for

data linking between each module and run optimization process.

This paper will be described the development of aircraft design-certification framework and database design. In section 2, we will show an introduction of the framework development processes. In section 3, we will present the development process of the database including database normalization, entity-relationship diagram. A conclusion will be mentioned in section 4.

2. Aircraft Design- Certification Framework's Architecture

Aircraft design certification framework is a fully event-driven program development and execution framework, based on Microsoft .Net framework with visual basic language technology.

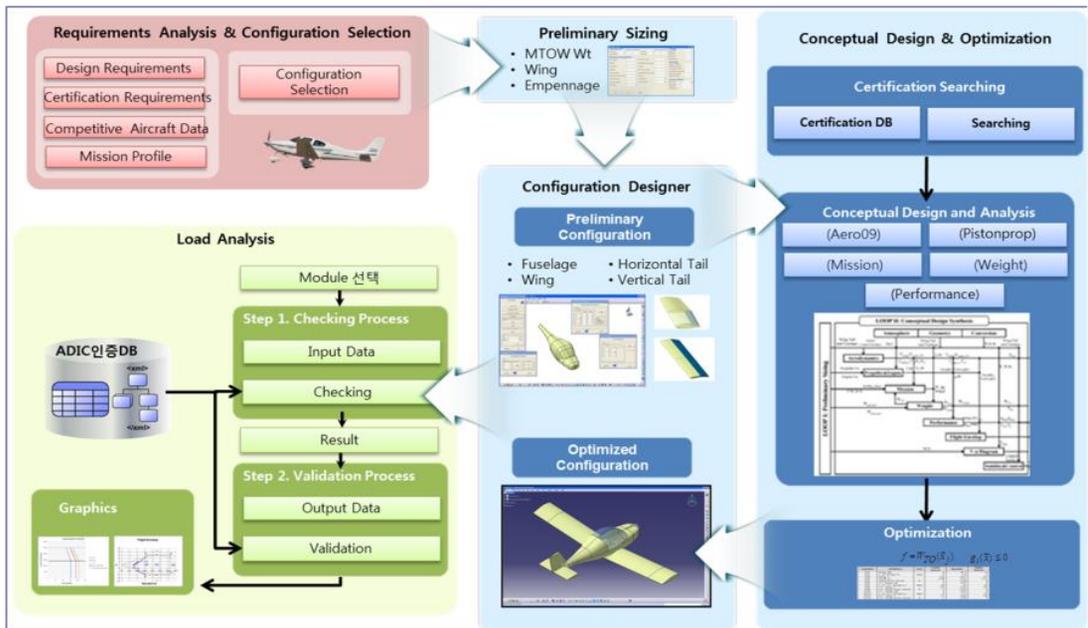


Figure 1. Architecture of Aircraft Design-Certification Framework

Figure 1 shows the architecture of the aircraft design-certification framework. In this framework, requirements analysis, preliminary sizing, configuration designer, conceptual design, optimization and load analysis programs are included and linking data between each module.

2.1. Processes Flow of Framework

Firstly, the designers have to define their requirements of the aircraft specification from design requirements program and describe mission profile for the required aircraft. According to this user request information, the preliminary sizing program calculates aircraft data and generates draft geometry modelling with CAD commercial software (CATIA – Computer Aided Three-dimensional Interactive Application) from DASSAULT SYSTMES. The fuselage, wing, horizontal tail and vertical tail data from configuration designer link automatically to conceptual design module (Aircraft Design Synthesis Program). The conceptual design module combines aero09 program, mission program, performance program, weight program, propulsion program and stability and control program. The conceptual design module calculates aerodynamics data of the aircraft and details aircraft design data. The certification database checks and validates the result of conceptual design data which is satisfied or not with FAR regulations. For the optimization, genetic algorithm and sequential quadratic programming Plug-In module from model center are used. The load analysis module consists of 20 difficult modules. The purpose of this program is to provide and calculate Federal Air Regulations Part 23 flight loads, horizontal tail loads, control surface and system load, vertical tail surfaces, wing flaps and special devices, engine loads and ground loads. This

FAR-23 load program consists of Weight Estimation, Weight-CD, Structural Speed, Mach Limitation, Air Loads, Aero coefficients, Flight Loads, Aileron Loads, Flap loads, Wing Inertia, Net Loads, Engine Mount Loads, Landing Loads, Tab Loads modules.

2.2. Program Development of Framework

In aircraft design certification framework, design function, analysis function and modify function are involved. The graphical user interface is created by Microsoft .Net with window form application and coding with visual basic language [6]. The SQL Express 2008 is used for database management system in this framework. The SQL engine model serves data selection, updating, deleting and inserting into the database. The framework has user working control and system service. The user working control performs create new user, modify job process and data modification such as working data file storage, output data generation and error controlling. The system service serves CAD modeling user interface, file operation, data generation and system configuration. The system configuration includes database connection and programs connection (See. Figure 2).

3. Database Development Process

The database design involves constructing a suitable of the information. In the large database, database design is divided into three phases [8, 9].

- Conceptual database design
- Logical database design
- Physical database design

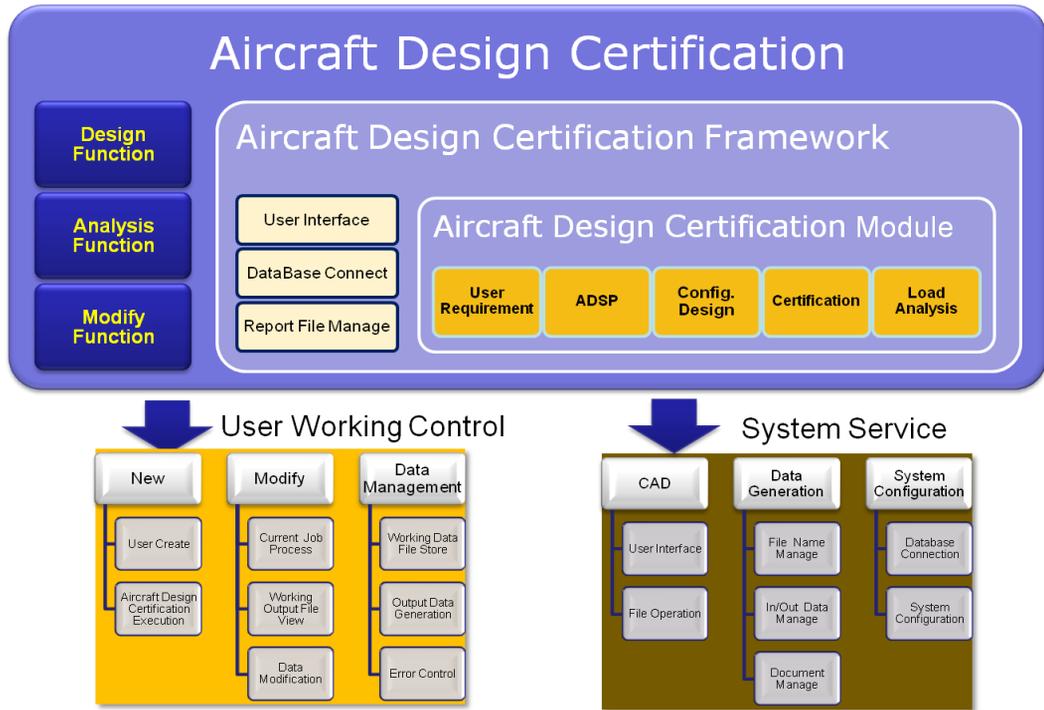


Figure 2. Program development process of the framework

The conceptual database design involves modeling the collected information at high-level of abstraction without using a particular data model or DBMS. The conceptual schema is a permanent description of the database requirements. The logical database model is on logic which is readable method and useful for representation the knowledge

The entity relationship (ER) model is used in the logical database model. The main objective in developing a logical data model for relational database system is to create an accurate representation of the data. The physical design of the database specifics the physical configuration of the database on the storage media. This includes specification of data elements, data types, indexing and data dictionary.

3.1. Normalization of Database

The normalization is the one of the technique to implement database design and to avoid redundancies and update anomalies due to data dependencies and to improve storage efficiency, data integrity and scalability. There are four steps of normalization which are first normal form, second normal form, third normal form or boyce-codd normal form [10].

The first normal form (1 NF) identifies the repeating groups in the un-normalized form and removes the repeating group. The second normal form (2 NF) identifies the primary key for the 1 NF relation and identifies the functional dependencies in the relation. The third normal form is a relation that is in 1 NF and 2 NF and in which no non-primary-key attribute is transitively dependent on the primary key.

ProjectName	FolderName	subFolderName	moduleName	objectName	FARNO	ProjectType	Design Contraints	Design Requirement
FAR23 Class	FAR23 Regulations	Subpart B-Flight	02_Performance	3.0-2.0-1	FAR 23.775(a)	Project	< 61(knots-CAS)	Vso, Vs1
FAR25 Class	KAS25 Regulations	Subpart A-General	01_General	3.0-2.0-2	FAR 23.775(b)	Project	VD>1.4	VS



1 NF

ProjectName	ProjectType	FolderName	subFolderName	moduleName	objectName	FARNO	ProjectType	Design Contraints	Design Requirement
FAR23 Class	Project	FAR23 Regulations	Subpart B-Flight	02_Performance	3.0-2.0-1	FAR 23.775(a)	Project	< 61(knots-CAS)	Vso, Vs1
FAR25 Class	Project	KAS25 Regulations	Subpart A-General	01_General	3.0-2.0-2	FAR 23.775(b)	Project	VD>1.4	VS



2 NF

ProjectID	ProjectName	ProjectType
1	FAR23 Class	Project
2	FAR25 Class	Project

ProjectID	FolderName	subFolderName	moduleName	objectName	FARNO	ProjectType	Design Contraint	Design Requirement
1	FAR23 Regulation	Subpart B-Flight	02_Performance	3.0-2.0-1	FAR 23.775(a)	Project	< 61(knots-CAS)	Vso, Vs1
2	KAS25 Regulation	Subpart A-General	01_General	3.0-2.0-2	FAR 23.775(b)	Project	VD>1.4	VS



3 NF

ProjectID	FolderID	subFolderID	moduleID	objectID
1	21	59	282	772
2	25	66	280	779

objectID	objectName	FARNO	ProjectType	Design Contraint	Design Requirement
772	3.0-2.0-1	FAR 23.775(a)	Project	< 61(knots-CAS)	Vso, Vs1
779	3.0-2.0-2	FAR 23.775(b)	Project	VD>1.4	VS

FolderID	FolderName
21	FAR23 Regulations
25	KAS25 Regulations

SubFolderID	SubFolderName
59	FAR23 Regulations
66	KAS25 Regulations

ModuleID	ModuleName
282	02_Performance
280	01_General

Figure 3. Certification Data Normalization Process

The Figure 3 shows the normalization of airworthiness regulation data. At the 1 NF, repeating fields of project name, project type are removed. In 2 NF, defined Project name, Project type with “Project” table with primary key project-id that links with other. After 3 NF, the project table, fold table, subfold table, module table and object table are obtained. In this step, data are normalized and obtained database schema.

3.2. Data Relationship Process

The Figure 4 shows database system’s Entity-Relationship (E-R) diagram. In this E-R

diagram, all of the input and output tables of the system are mentioned and described data relationship between each tables. The primary key and foreign key are used between data linking between two tables. The primary key (PK) is formed to be used as a discriminator between tables. The foreign key (FK) is to ensure referential integrity of the data. The use management table, program management table, project management table, parameter defined table, input-output file table are linked together with project-id, sequential-id and task-id. In certification database has FAR regulation data table and ATA data table. The parameter-value field from the inout-file table is linked with certification database for checking and validation with regulations. The database is used to

manage current data and processes history data. For the database security, we control each user with USER-ID. A user can access permissible data according to USER-ID level rights, while non-permissible data cannot be identified by the user.

3.3. Database Linking Process

The database connector class interacts between execution program input/ output data and SQL database from data saving and

retrieving processes. The getparameter and putparameter functions provide data input and output processes into the database. Each function has five passing parameter. These are parameter string, parameter type, array size of the first array, array size of the second array and parameter value. The parameter type is defined '0' for integer number, '1' for array of integer number, '2' for real number, '3' for array of real number, '4' for string, '5' for array of string and '6' for two dimensional array of string (shows in Figure 5).

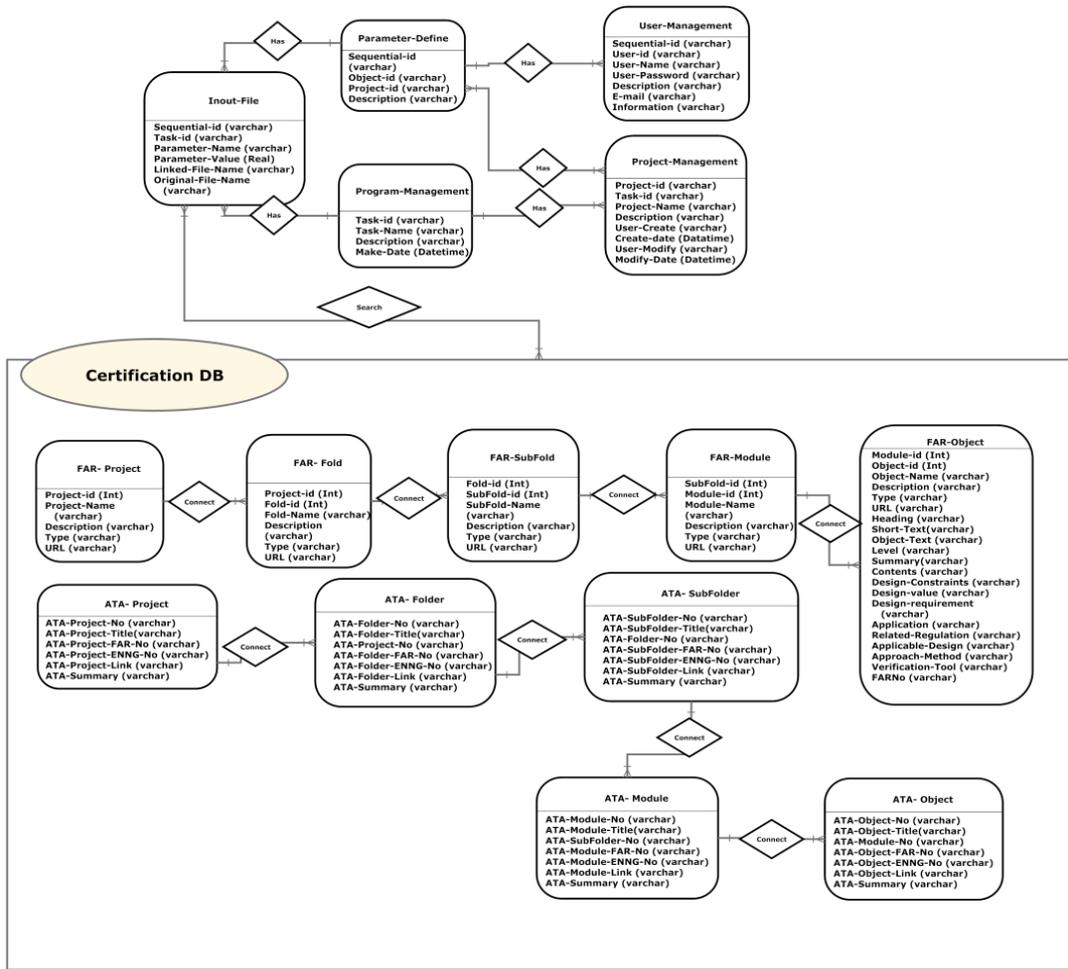


Figure 4. Entity-Relationship diagram of the database

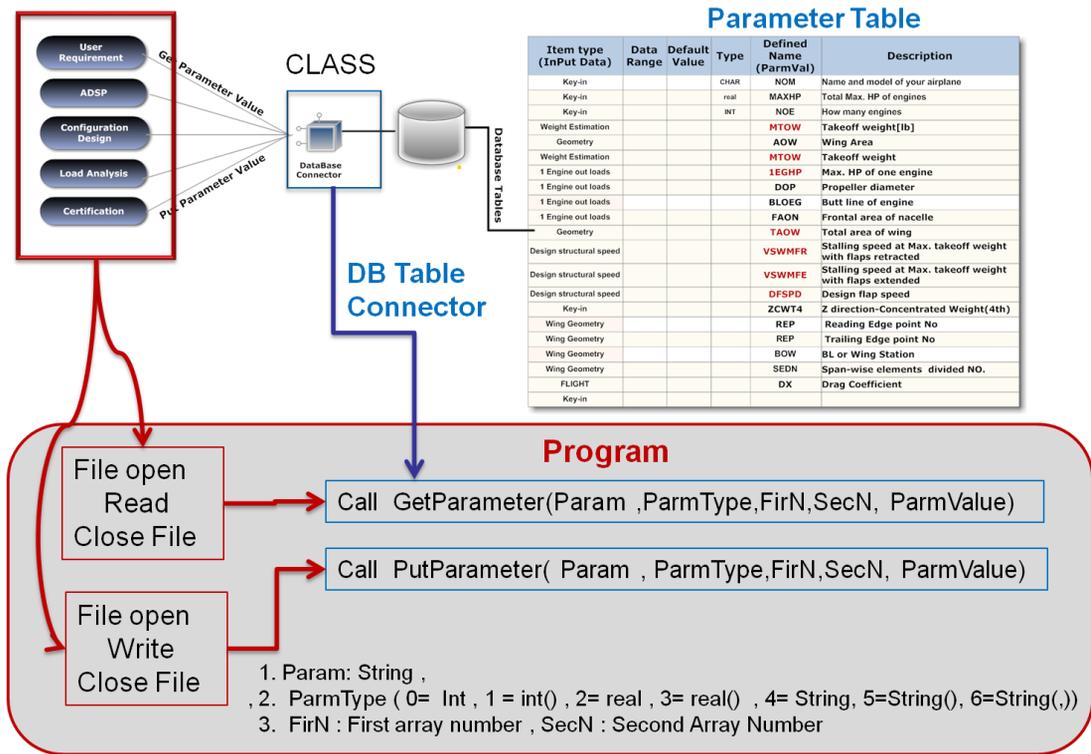


Figure 5. Data input and output process to database [7]

4. Conclusion

In this study, aviation safety requirements related to the development of FAR 23 class aircraft were analysed, and design program and framework were proposed. In this framework, we describe the methodology of relational database design and the step by step normalization process of aircraft design and certification database. And also, details information of aircraft weight, performance, aerodynamics data, propulsion and stability and control are generated. The data are also checked and validated to meets with airworthiness regulations. The parameterized configuration modelling also included in this framework and automatically generated 3D aircraft design by using aircraft analysis data.

From this system, designer can easily to analysis the aircraft data with user friendly graphic user interface. Furthermore, such a system can also be used in educational tool to train for example inexperienced and also be used in aircraft manufacturing industries for preliminary and conceptual design stage.

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