

AN INTEGRATED FRAMEWORK FOR INNOVATIVE COMPOUND GYROPLANE DESIGN SYSTEM

Tun Lwin*, **Ngoc Anh Vu***, **Kim Jimin***, **Jae-Woo Lee***, **Sangho Kim***, **Young Jae Lee****
***Konkuk University, Seoul, Korea 143-701,**
****Hanwha Corporation R&D Center, Seoul Korea 138-740**
tunlwin@konkuk.ac.kr; vna2006@hotmail.com, wlals0329@nate.com, jwlee@konkuk.ac.kr,
kimsh85@konkuk.ac.kr

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Abstract

In this paper, the integration of compound gyroplane designer system has been studied and developed. A comprehensive compound gyroplane designer system (CCGD) integrates the design program with CATIA configuration and X-Plane simulation program. The design related data are managed by the centralized database management system. The database also controls integrity of data, integrity of reference and security of data. To develop a graphical user interface (GUI), VB.Net and Microsoft .Net 2008 classes are used. The design analysis module considers sizing program for analyzing configuration and weight of aircraft, performance program for analyzing performance characteristics and trim program for determining the trim states for the helicopter over all flight conditions. In this design system, Challis Heliplane UAV, Carter Copter and Jet Gyrodyne air vehicles are subjected. The system's running processes are shown with use case and flow diagram.

1 Introduction

A framework is a real or conceptual structure intended to serve as a support or guide for the building of specified design task according to end user requirements. A framework consists of different functions and tasks which are processing to get desire results. To achieve a successful compound gyroplane design system; a number of different technical disciplines are

required such as sizing, performance, trim and flight mechanics. A compound gyroplane is an aircraft which has an auto-rotational rotor and fixed wing. Therefore, loads of rotor blades can be reduced in high speed cruise flight, and the thrust can be obtained by turbofan or turboprop engines. For example, 'Carter Copter' is developed from Carter Aviation Technologies Company in the US¹.

In author's previous studies, the KHDP (Korea Helicopter Design Program) was implemented using a design analysis program together with Graphical User Interface (GUI). KHDP uses FORTRAN programming language for design analysis and Visual Basic 6.0 for GUI implementation. That program gives a rough configuration result quickly which meets specified mission requirements. The power required for hover and forward flight, helicopter sizing and mission performance data were also computed by KHDP Program².

In this paper, a comprehensive compound gyroplane designer system is proposed. This framework is constructed with various compound gyroplane analysis programs, database management system, data linking between each different module, integration of analysis module with configuration generation and flight simulation program. An integration of various analysis codes, which are developed under FORTRAN Programming environment and a complex GUI (Graphic User Interface) are combined for the system. A centralized database has been designed such that all the design related data can be shared among various analysis tools and configuration and simulation

processes. Moreover, data security and consistency has also been considered in database management system. For the configuration generation, the parameterized CATIA configuration has to be enabled in this system.

2 Overall Comprehensive Compound Gyroplane Designer System

The Figure 1 shows the proposed system that integrates all of these elements must be developed to reduce design changes and trial.

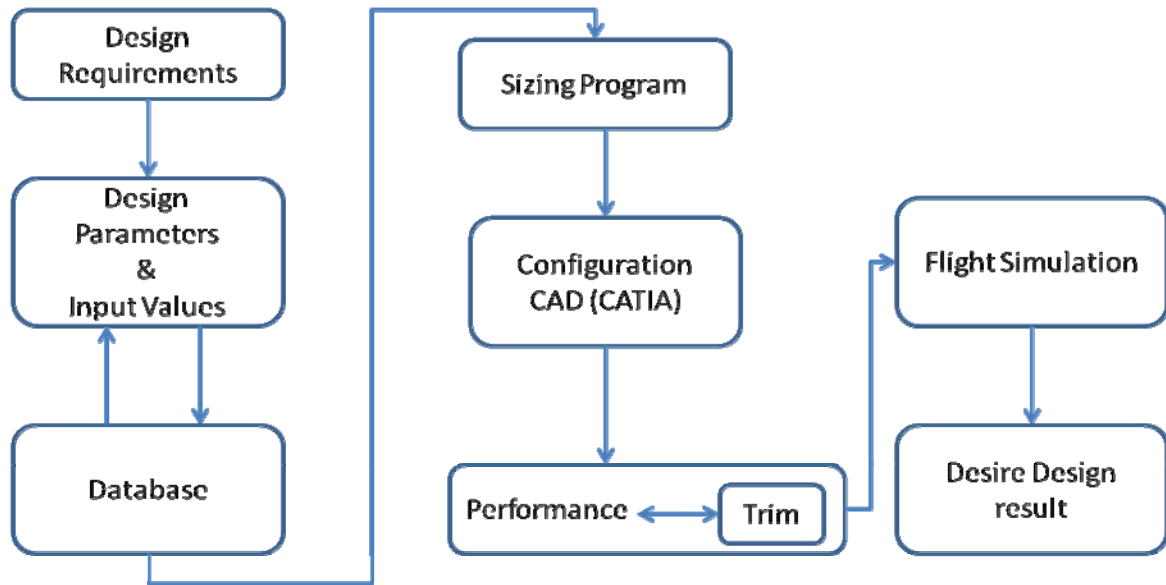


Fig. 1. Implementation of Comprehensive Compound Gyroplane Designer System Usage Scenarios

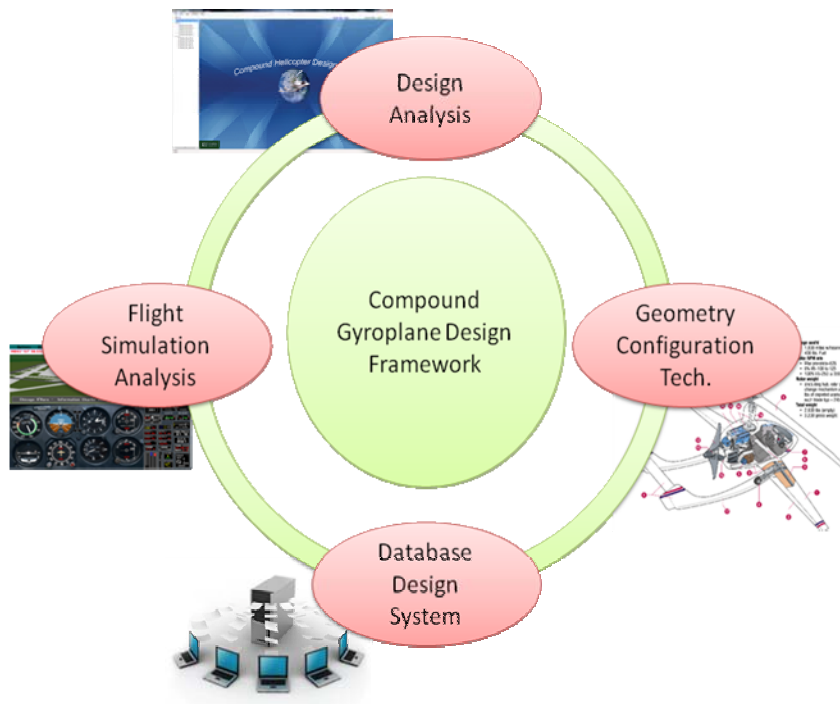


Fig. 2 . Comprehensive Compound Gyroplane Designer System Modules

The system consists of four main modules, design analysis, geometry configuration, database management design system and flight simulation analysis those are shown in figure 2. All the modules are linked together and have flow data relation between each module.

2.1 Design Analysis Module

The design analysis module is established with sizing module, performance analysis module and trim module. In the sizing program development phase, HESCOMP, the rotary wing sizing program and CRW sizing program which has been developed by Konkuk University are used³. HESCOMP can analyze and size various rotary wing aircrafts and the 'winged helicopter' was chosen for aircraft from among these rotary wing aircraft concepts which can be analyzed in HESCOMP. In the performance analysis program, the performance calculations were considered by momentum theory, Blade element theory. The trim analysis module determines the trim states for the compound helicopter over all flight conditions, the aircraft is trimmed when the desired balance is achieved or the aircraft enters a desired steady state⁴.

2.2 Geometry Configuration

In this system, the three-dimensional surface and solid geometries are parametrically defined and modeled in CATIA V5 (Computer Aided Three Dimensional Interactive Application). CATIA is a multi-platform CAD/ CAM/ CAE commercial software suite developed by the French company Dassault Systems and marketed worldwide by IBM. The parametric based CAD Model techniques are considered and controlled the parameters value of CAD model automatically from Graphical User Interface (GUI) form.

2.3 Database Design System

The compound gyroplane design system's database is made up of Oracle 9i data server. Oracle9i database provides efficient, reliable,

secure data management for high-end applications such as high- volume on-line transaction processing environments, query-intensive data warehouses. The Oracle 9i server provides for saving all the input and output data using in this system. By using database component, designers can search for existing aircraft configuration solutions and save new aircraft configuration data. Users can query across solutions and generate plots that display information that is particularly valuable to a designer⁵. The OCI (oracle call interface) component is used to communicate by the client program and central relational database server.

2.4 Flight Simulation Analysis

The X-Plane flight simulation software is used for flight simulation analysis in this system. The X-Plane flight simulation software produced by Laminar Research and was based on blade element theory. X-Plane is capable of modeling complex aircraft designs, including helicopters, rockets, rotor craft and tilt-rotor craft. The X-Plane is also used in non-motion and full-motion flight simulators for flight training⁶. The X-Plane program will be analyzed the flight simulation processes by using the result data of the analysis module. The data will be transferred automatically to X-Plane by using visual basic based GUI form.

3 Comprehensive Compound Gyroplane Designer System Structure

3.1 Comprehensive Compound Gyroplane Designer System Architecture

The figure 3 shows the system architecture of comprehensive compound gyroplane designer system and how to link with CATIA commercial software and X-Plane software together with design program. The centralized database system manages the design programs' input and output data and also CATIA configuration data. The design programs' graphical user interface (GUI) is implemented using visual basic programming language under Microsoft .Net framework window form

application. The OLEDB connection object performs the connection between Oracle DB and Design GUI programs. For linking with configuration shape generation in CATIA, the CATIA VBA APIs are used. The VB shell command runs automatically X-Plan software from GUI and carries out simulation process of design configuration.

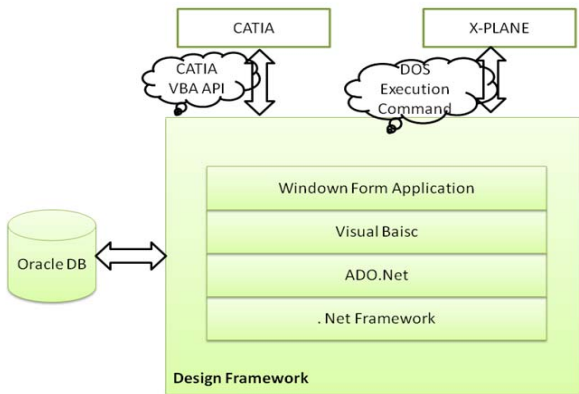


Fig. 3. Comprehensive Compound Gyroplane Designer System Architecture

3.3 Data Flow between Analysis Modules

For the data flow process, the user input data are classified into four different categories: tail geometry data, wing geometry data, engine sizing data and fuselage data. All the input data are delivered into the sizing module (HESCOMP & CRW) and engine sizing data and the result of sizing analysis program are used in performance analysis and trim analysis. For a configuration generation using CATIA, the input data comes from result of sizing analysis module. The X-Plane program uses the sizing and performance analysis result for flight simulation process. Figure 4 shows the data flow between each analysis module, CATIA model and X-Plan.

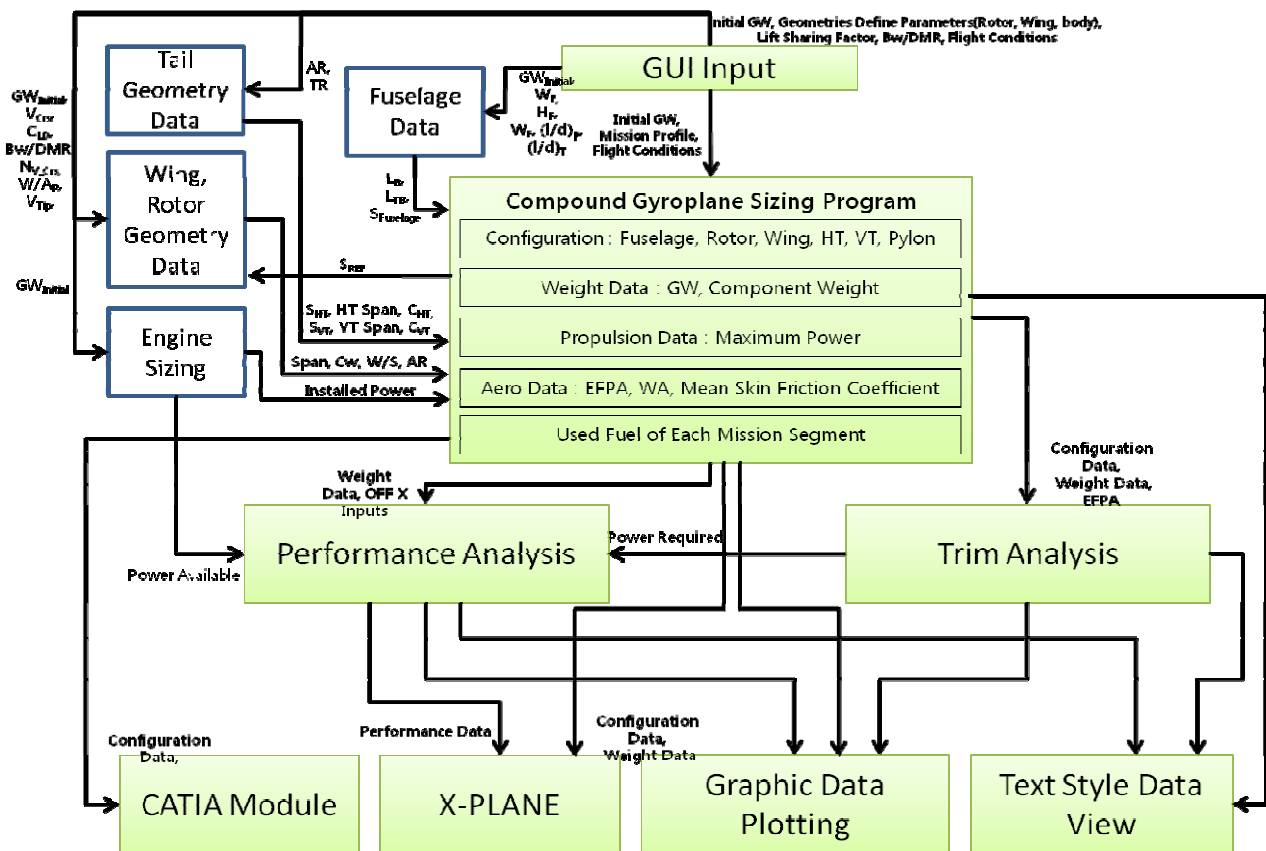


Fig. 4 .Data Flow between Analysis Modules and Other Program

3.4 Program Codes for System

In this study, three different design and analysis codes are used. The codes were well-developed and integrated by Aerodynamics and Analysis Design Lab in Konkuk University. Table 1

describes all the module names those included in this design system and the program names which are used to execute those modules.

	Sizing	Performance	Trim	Configuration	Simulation	Database	GUI
Program Name	VTOLCG.f STOLCG.f	Performance.f	TRIMKU.f	CATIA	X Plane	Oracle 9i	Microsoft .Net 2008

Table.1. Program Codes used in System

4 Comprehensive Compound Gyroplane Designer System Development

4.1 GUI Code Developments

The Main GUI component consists of project folder module, user create module, UI control module and configuration setting module. The analysis component combines initial sizing module, performance module and trim module.

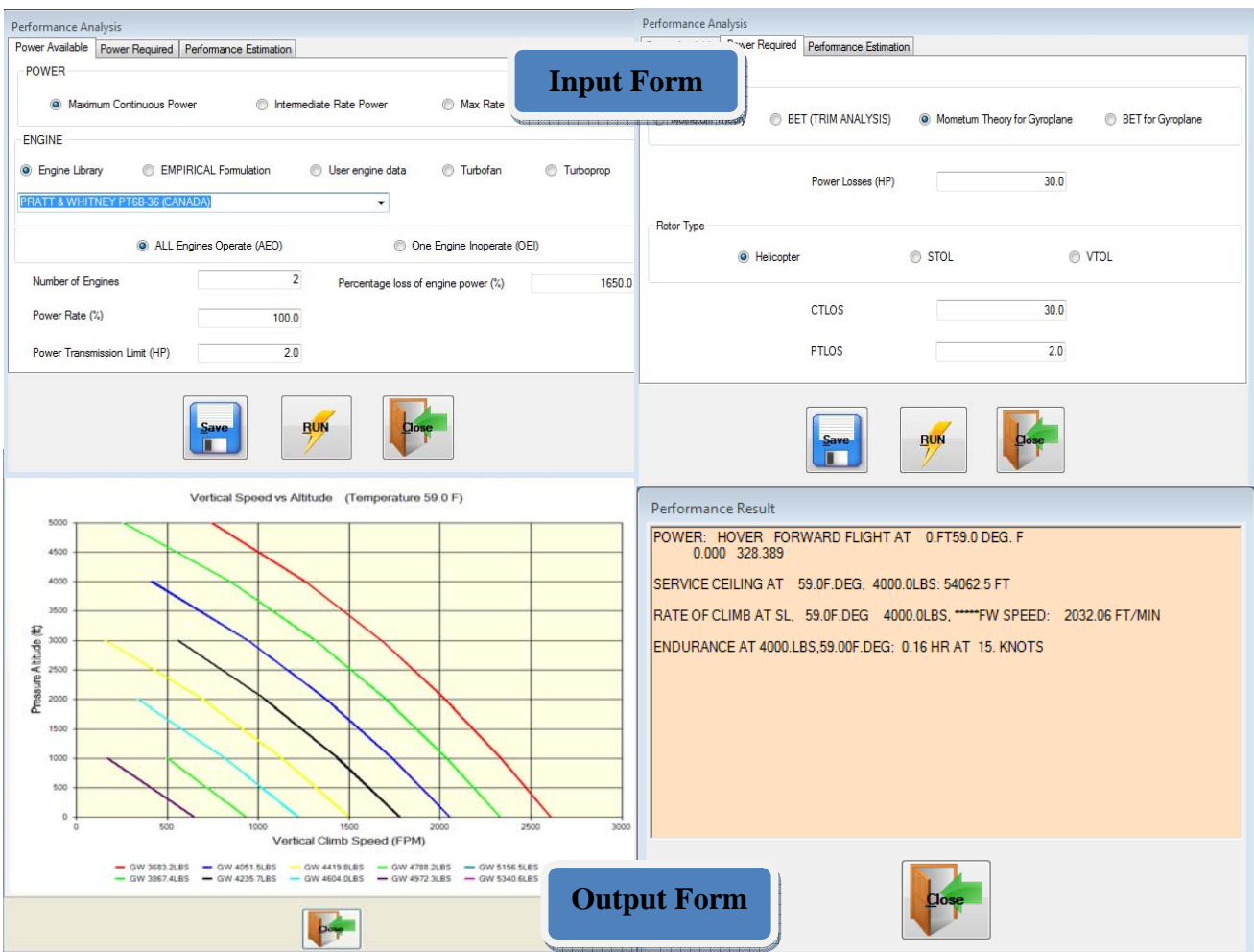


Fig.5 . Simple Performance Module GUIs

The configuration component and simulation component also key components of in this system.

The project and user create programs controls the level of project and configuration, add, modify and change the privilege of users. And also, the user manager program controls the different projects access permissions by each user.

The Menu and tools control are also provided in this system. The error messages should also be supported such that users can easily understand and access the system without any difficulty.

Figure 5 shows an example of the design system user interface of performance module. The Microsoft .Net 2008 Visual Basic programming language⁷ and ⁸ is used to implement the user interface. The 2-D graphic programs are also integrated in this system. The results of performance show with graphic data (such as vertical climb, rate of climb, hover ceiling, service ceiling, cruises speed, Acceleration and Tuning).

4.2 Database Development

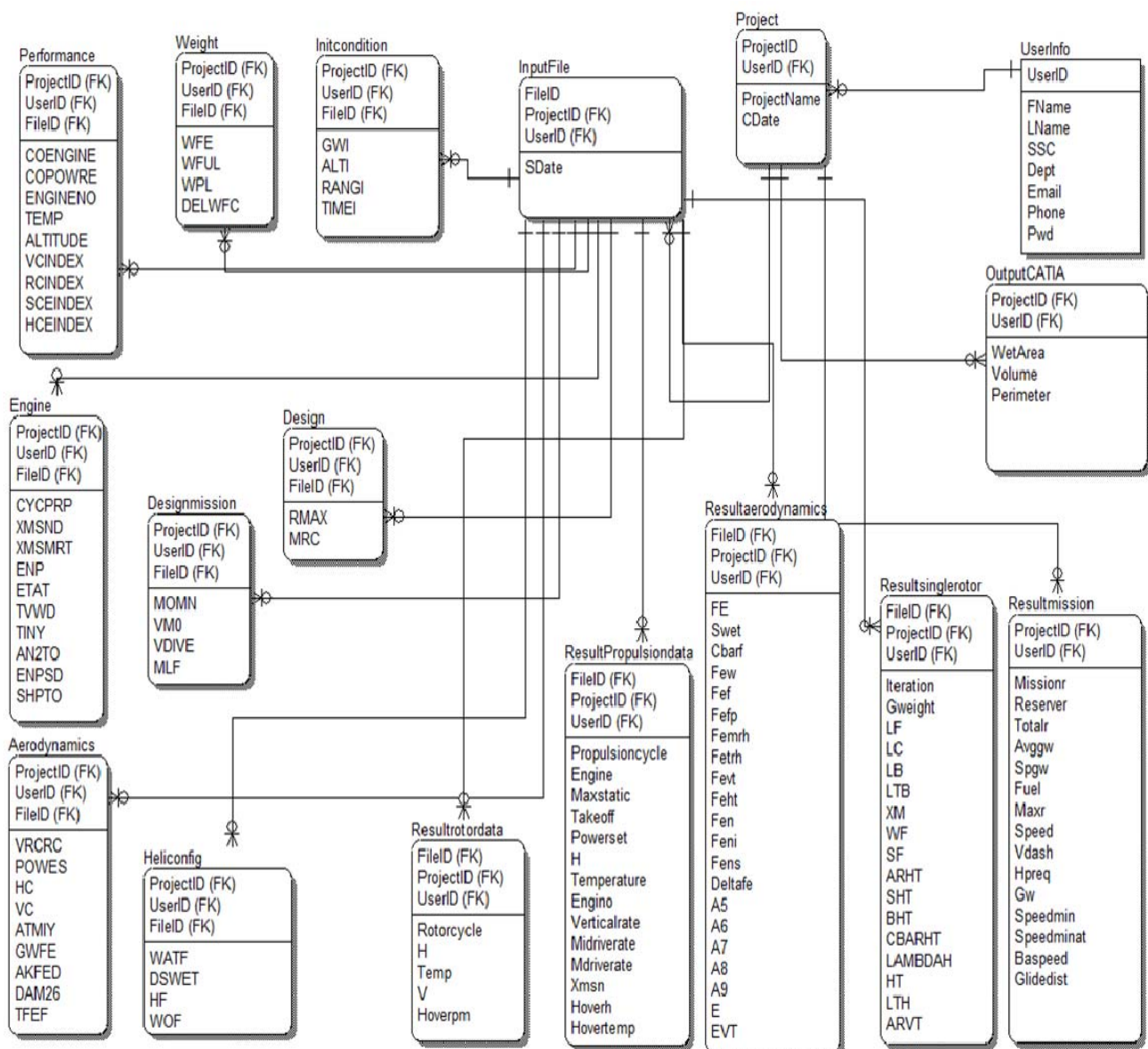


Fig.6. E-R Diagram of Database System

Figure- 6 shows the database system’s E-R diagram. In this figure, all the tables are mentioned using in the system and data relationship between each tables are described. 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. For the method of DB security, security grade is set for each user when user id is created⁹. For this, the database has to be designed by considering integrity of data, integrity of reference, security of data, expandable capability and design history. The database must provide analysis results and configuration data to users. The required data from client program is accessed and updated to database via the SQL engine module that using SQL query language (such as insert, update, select and delete command)¹⁰.

4.3 Configuration (CATIA Interface)

The design data from oracle DB are used the parameter for aircraft design configuration. The CATIA API¹¹ serves to link Microsoft VB.Net window form with CATIA commercial software automatically. The shape on CATIA will change when user changes the input data from GUI. The input parameters data are classified into main body, main rotor, tail rotor, horizontal tail and vertical tail. Figure 7 shows the process of CATIA shape generation with VB.Net program. Also Figure 8 shows VB.Net GUI Program and CAD Model in CATIA software.



Fig.8. CATIA Configuration User Interface and CAD Model

5 Design Program Integrates with Simulation Process (X-Plane)

Compound gyroplane’s configuration is generated through the sizing program results for confirm the similarity and test for the flight simulation. In this phase, plane maker module in X-Plane program is used for modeling and simulation. Carter Copter results are selected to generate the configuration, and flight simulation process .Figure 9 shows the flight simulation in the virtual scenery. The DOS command executes and links directly between X-Plane simulation file and GUI.

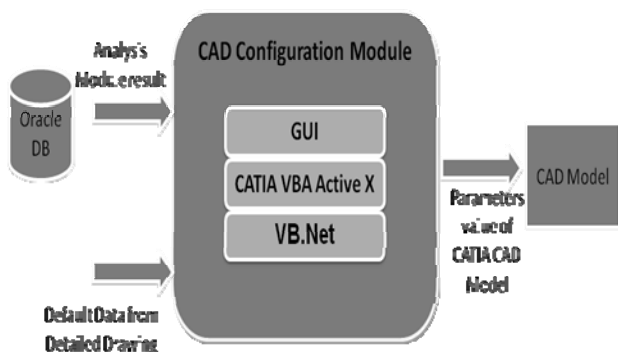


Fig.7. CATIA Configuration Process

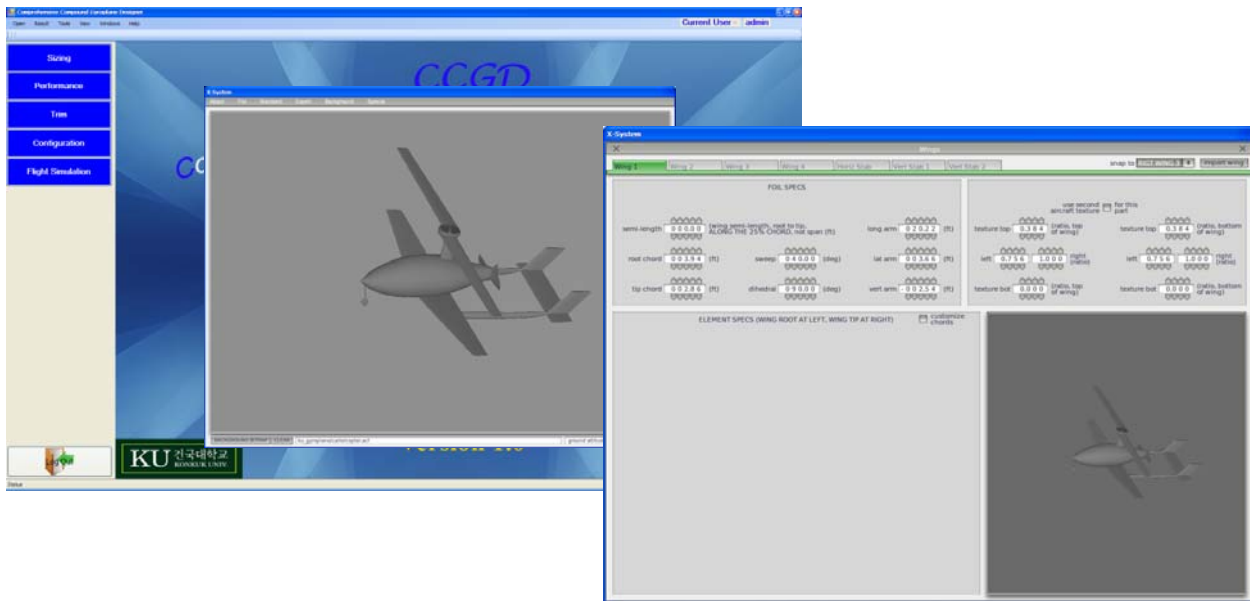


Fig.9. X-Plane Simulation Process Integrated with GUI

6 Conclusions

In this study, the comprehensive compound gyroplane designer system (CCGD) have been implemented and presented using the aircraft design analysis codes. The FORTRAN programming based analysis codes with VB.Net GUI programs are developed. The data and file management issues were handled the use of a centralized database. The parameterized CAD model generation and flight simulation process were also provided in this system. The creation of the GUI including various plots has made the use of aircraft design and analysis codes much easier for the user. So, in order to use of CCGD, the end user does not have to be familiar with the analysis codes. The user can create the necessary analysis input data using the graphical user interface from this system and view the results in the interface.

Acknowledgments

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