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A Research Review on Flight Controls Modeling and Simulation Using MATLAB/Simulink, LabVIEW, and Saber

KEYWORDS: Flight systems, control systems, model based design, monte carlo simulation, simulators.

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ABSTRACT *Model based design has become a standard in aero space industry. Prior to implementation of any physical system, it is better to test the behavior of the system in real environment, where complexity of design and huge cost is involved particularly in avionics. Flight control systems have dynamic and complex behavior. To study the dynamic behavior of flight control systems, model based design approach is preferable. The Model adapts all functionalities of the actual system, so it helps to study the actual system behavior in real time. From the initiation phase to the implementation phase there may be a lot of changes which have been taken place in the design; these changes can take place according to the simulation results of a respective system model. Simulation platform provides the real time environment to the model, so that validation of the system behavior could be done before it is going to the implementation phase. This paper gives insights to the scope and applicability of different simulation tools such as MATLAB/Simulink, Saber, and LabVIEW for flight controls modeling and design.*

I. Introduction

Early verification of the system is possible in the model based design. Model based design yields robust and refined control systems. Model behaves like an actual system, to know the response of the system in critical situations. Complex designs such as aero space flight control systems are mostly depended upon the model based designing tools. Simulation tools can create such an environment that is very close to the real work space, so that testing and validation of design under various environmental conditions will become efficient, such that system design would become robust and effective. Model based designing allows performing iterations for the testing on the single model, so that prediction of system behavior can takes place under uncertain conditions. Software's such as MATLAB/Simulink [5], Saber, LabVIEW provides feasibility for the creation of models in the simulation environment. Especially flight control systems are having highly dynamic and complex behavior, so designing of these flight control systems is a big challenge. Flight control system model could be created in the simulation environment. These simulation platforms expand the scope of testing, and some software's provide friendly tools to interface hardware to the model, so that the scope of validation of model under critical situations is also possible. Statistical analysis of the design predicts the behavior of the system under uncertain conditions.

II. Flight Control Systems

A flight control system is one of the important designing aspects in the aircrafts design. The behavior of aircraft is highly dynamic, complex in nature, and sensitive to environmental conditions. Flight motion is due to the action of the three forces such as yaw, rolling, and pitch. Synchronization between these forces would let the flight to maintain sustainable motion [1]. To provide these controlling forces, controlling surfaces are needed, such as aileron, elevator and rudder. Synchronous action of these controlling surfaces depends upon factors such as pressure, humidity of the air, etc. In designing of the flight control systems, designer should consider each and every point which will have adverse effect on the motion of aircraft. Aileron provides rolling motion, rudder provides yaw motion and elevator provides pitch motion to the aircraft.

III. Simulation Platforms for Aero Space Industry

Validation and early testing of each subsystem of aircraft is necessary in aero space industry. Real time testing and number of iterations of testing is needed in the designing of the aircraft subsystems. So the feasibility of the tools in the software's such as MATLAB/Simulink, Saber, and LabVIEW provides perfect environment for simulation of the models for aircrafts. This paper discusses about designing of the flight control systems using MATLAB/ Simulink, Saber, and LabVIEW platforms and analyzes the scope and applicability of these platforms. Some of these simulation tools provide provision for the model to interact with the external hard ware by using some built in tools. In some critical tests which cannot perform directly on the actual system, the simulation software's plays an important role in modeling. Different parts of the aircrafts are developed at different places across the world, so understanding about each part of the aircraft is not possible. These simulation platforms are helpful in those cases by studying the models of aircraft systems [4].

IV. MATLAB/Simulink Modeling and Simulation

MATLAB increases the speed of computations and deals with practical engineering problems. MATLAB is a computational language and it is highly equipped with built in tools. MATLAB/Simulink provides simulation environment to give the graphical representation. Models can be developed in Simulink environment by dragging and dropping components which increases the flexibility for users. Especially for aero space design, Simulink provides wide scope of designing.

Figure.1 MATLAB /Simulink archtecture

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MATLAB/Simulink provides feasibility in the development of the flight control systems models with complexity. Built in tool boxes such as xPC target, control systems; aerospace tool box provides real time simulation platform for the flight control systems. Figure 1 shows the MATLAB/Simulink architecture. Scope of the Simulink platform in modeling of the flight control systems will be explained by considering the aileron controlling system in Simulink environment. MATLAB provides control system tool box to facilitate linear transfer functions to model control system.

The xPC target setup model will communicate with external hardware, so that the Simulink model will acquire more realistic behavior. To evaluate the uncertain behavior of the system, statistical analysis is needed.

Figure.2 shows the Simulink model for aileron controlling system. Data acquisition from the model to the external hardware and hardware to the model can be possible using data acquisition cards such as national instrument cards PCI6229. Using built in tool creation of the real time environment such as gravity, temperature, mechanical motion, altitude angles etc. is made easier.

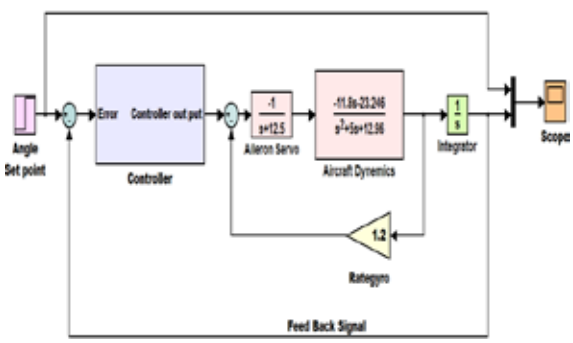

Figure.2 Flight control system model in Simulink

V. LabVIEW Modeling and Simulation

LabVIEW platform is used for the visual programming language and algorithm based design. LabVIEW programs are called as virtual instruments. It provides tools for the user interface designs. Front panel is designed with functional blocks such as user controls test stands. The block diagram panel is used to program the front panel to provide information to the controllers and indicators. LabVIEW provides control design & simulation tool to create simulation platform for all the applications in the control system design. In control design and simulation environment major requirements for the control systems design are PID controllers [6-7], fuzzy logic blocks, signal generators, model hierarchy, linear and non linear functional blocks [8]. LabVIEW provides the facility for host target communication too.

Figure 3 shows the LabVIEW model for flight control system. Key feature for LabVIEW is communication with the hardware instruments using Data Acquisition Cards and supports parallel programming. Co-Simulation between MATLAB and LabVIEW is possible and Simulink models can be converted into LabVIEW.

VI. Saber Platform

Saber is an effective platform for verification of the design functionalities. Prior to the implementation of any design, there is a need to test functional behavior of the system. Saber allows fixing the tolerance values for the parameters values using some statistical method such as Monte-Carlo simulation [9-10]. Domain convertors in the saber are used to interface control signal to the electrical parameters and vice versa.

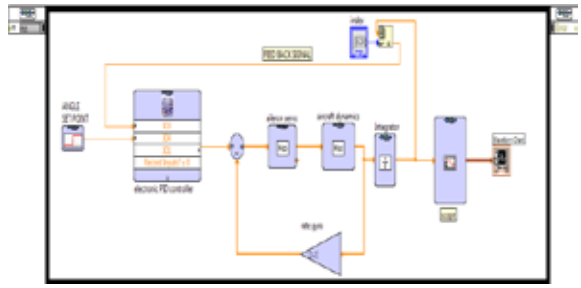

Figure.3 Flight control system model in LabVIEW

Components in the flight control systems undergo drastic changes with respect to the temperature, climatic and ageing effects of the components. Uncertainties in the parameters may cause drastic changes in the controller response, so by using statistical analysis such as Monte-Carlo simulation tuning of the parameter values is possible. Saber provides in-built tools for the wave form analysis in both time domain and frequency domain. Dynamic characteristics of the calculation are easier in the saber compared to other simulation platforms.

VII. Comparitive Analysis

Models for flight control system has been developed using the mentioned software platforms and results were verified. The three platforms have given satisfactory results but out of these, MATLAB/Simulink platform is effective for the flight control system modeling. Because of the richness of the tools in the MATLAB/Simulink, engineer's choice will be the MATLAB/Simulink because of the effectiveness of the xPC target tool box.

The programming present in the LabVIEW block diagram panel provides logic for the front panel. Figure 4, 5, and 6 shows the response of flight control system model in different simulation platforms. Table 1 gives the cumulative comparison of the three mentioned platforms and scope & applicability of the platforms in the Aerospace industry. Time taken to simulate models in each simulation platform is different from other platforms. All the responses of the flight control systems are considered for the Tyreus luyben tuning method.

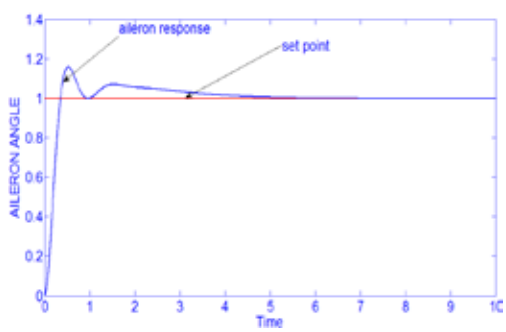

Figure 4 Aileron response in MATLAB/Simulink

Figure.5 Aileron response in LabVIEW

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For the tuning of PID controller despite of many conventional methods Tyreus Luyben tuning algorithm gives best response [11-12].

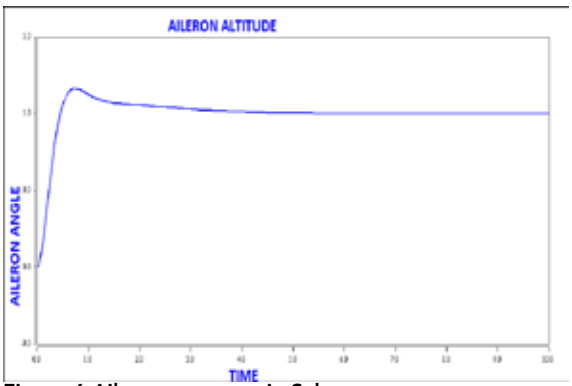

Figure.6 Aileron response in Saber

Table 1: Functionality Study of Various Simulation Platforms

Function	MATLAB/ Simulink	Saber	LabVIEW
Configuration	Easy	Easy	Easy
Tools for modeling	More	Less	More
Analysis of wave forms	Difficult	Easy	Difficult
Real-time interfacing support	Possible	Not possible	possible
Co-Simulation	Possible	Possible	possible
Robustness in design	Good	Good	Good
Support for statistical tools	Built in Tool	Built in Tool	Built in Tool
Host-target communication	Possible	Not possible	possible
Accuracy of results	Good	Good	Good
Optimization of design	Possible	Possible	Possible
Addition of third party tools	Possible	Possible using MAST modeling	Possible
Simulation time	Less	More	More

So, the response of flight controls system for the conventional tuning method Tyreus Luyben is done in different platforms.

VIII. Conclusion

In this paper, flight control system model is developed and simulated in the MATLAB/Simulink, LabVIEW, and Saber platforms. The results show that MATLAB/Simulink platform is having more scope in the aerospace modeling. From table.1, it can be observed MATLAB/Simulink is a better tool for the flight control modeling and simulation.

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