Next generation of avionics learning based on virtual instruments in vocational education

N Hendrarini¹, Ema²
¹Telkom University, Bandung, Indonesia
²Nurtanio University, Bandung, Indonesia

E-mail: ¹ninahendrarini@tass.telkomuniversity.ac.id; ²demadiena@gmail.com

Abstract. At this time aerospace technology is very advanced. This is very closely related to advances in information technology and aerospace, so the learning process in aerospace vocational education also progresses. The learning process that was originally very manual now has used a computer as a support system. Learning methods or content of learning materials are also adjusted. One of them is the next generation of avionics. At this time, many types of aircraft have used electronic flight bags to control the aircraft. This technology is very advanced, using many automatic electronic devices such as sensors, actuators and other sophisticated devices that are connected by wireless networks and applications on computers. Studying the current generation of avionic systems is not easy, it is very complicated and sophisticated. This is a problem whose solution must be sought to provide approach to learning. Studying theoretically and classically in Avionics will be very difficult and boring. A learning method that approaches the real conditions facilitates the process of understanding, namely utilizing virtual instruments. A teaching technique that is supported by applications on computers that resemble conditions in an aircraft. In this paper, a sub-section of avionics is assisted with computer applications, so the actions taken will have an effect on what the conditions of the aircraft are. The perceived benefit is that learning material is easier to understand and implement. This study will present learning methods using virtual instruments. The general design of virtual instruments related to avionics was proposed in this study in order to facilitate teaching avionics to students.

1. Introduction
The rapid development of computers, with high processing speeds and large available memory, equipped with adequate software, has changed many major. The hardware performance begins to be replaced with virtual instruments. It is because the virtual instrument has good interoperability with the other system and it has flexible customization. Today, virtual instruments are used as educational tools for students in various domains. The virtual instrument is also used to design measurement systems. On the other hand, it is used as a simulation tool where people can observe complex system behaviour. Beside virtual instrument assist in understanding various phenomena. This approach is well received by students, to stimulate student design the appropriate virtual instruments. This technology also leads to finding phenomena and develops other innovations. This tool can be used in real laboratories or at home, in virtual laboratories, and also in the transportation system. Aeroplanes are transportation vehicles that use high technology to work with a good degree of accuracy. In the current era, the development of aircraft technology leads to a reduction in aircraft weight. The aircraft applies a large number of electronic devices used to replace mechanical devices and also uses mini-computer...
technology, even use electronic flight bag software applications as a means of controlling aircraft. The development of aircraft technology should be accompanied by technical capabilities. Thus, we sought a method for facilitating avionic learning because aircraft with next-generation avionics technology is relatively complicated. Teaching methods using virtual instruments facilitate learning because they stimulate a variety of human senses so that students’ kinaesthetic and audiovisual learning habits can be accommodated. The virtual instrument also gives a description of the workpiece as if it were real and this is very helpful for students[1]. This study will present learning methods using virtual instruments. The general design of virtual instruments related to avionics was proposed in this study in order to facilitate teaching avionics to students. In this paper, the main language is conveyed in several chapters. After the introduction, section 1 will discuss briefly the development of avionics technology, then explain the terminology of virtual instruments and learning needs in vocational education related to aeroplanes.[8] Chapter 2 will discuss about literature review and the development of virtual instrument technology. Chapter 3 will explain the proposed method related to virtual instrument-based avionic learning. Chapter 4 will propose design of virtual instrument for avionics and Chapter 5 will close this paper by drawing conclusions.

2. Literature Review
The discussion related to avionics and the virtual instrument will be described in this section. The avionics system is the system that will be delivered by virtual instrument. The verification and validation will use the Monte Carlo method.

2.1 Next-generation Avionics
In the next-gen avionics, some massive system functions can be integrated and integrated in a computer-based application. At this time known as Electronic Flight Bag (EFB) which is an embodiment of the application to control several subsystems or functions on the aircraft. The next-gen avionics devices generally use sensors and actuators that will be connected to a desktop or web-based computer application. Federal Aviation Administration (FAA) will impose new requirements for cockpit avionics. The changes of existing cockpit display system will be developed by this institution. They reduce cost by installing 3D Electronic Flight Bag embedded with NextGen avionics sensors. This following figure is an example of a next-generation avionics system[2].

![Figure 1. VOR - NextGen Avionics Device.](image)
2.2 Virtual Instrument
The virtual instrument is a computer-based software application that describes the performance of a system. This virtual instrument can be simulated or emulated. Many fields use virtual instruments to describe the processes that run in a system or show phenomena that occur in a system. The parameters used are like what happens in real conditions. This technology can be used to test system performance, develop systems to carry out measurement processes in various fields. The level of accuracy of this technology can be very similar to the real system or within the limits of accuracy that can still be tolerated. By using this technology several business processes can run and interact flexibly, thereby reducing operational costs. A virtual instrument provides the same functional blocks as its traditional counterpart. The virtual instrument can be reconfigured for a variety of different tasks or completely redefined when an application's needs change. The benefit of virtual instrumentation is flexibility. It can describe the analogue system or digital system.

![Virtual Instrument Radar](image)

**Figure 2.** Virtual Instrument Radar.

This device uses computer to illustrate the region below the aircraft. There are many parameters and the measurement value are shown in this application.

2.3 Virtual Instrument Development and Design Technology
The designation of the virtual instrument must be determined in advance before it is made because there are different mechanisms for each designation. While it is intended for measurement devices, the constraint is the sensitivity and linearity of the sensor or transducer in retrieving data. This is illustrated when programming the processing unit. Determination of input, the algorithm used, the range of measurement becomes important when a virtual instrument model will be made[3]. The validation and verification will enclose the virtual instrument development. Several virtual instrument vendors build the application using the particular pattern of modelling and certain programming method approach. Virtual instrumentation is an innovative solution that can be combined in modular mode; it can also be integrated with flexible hardware. The development and design method can use waterfall, SDLC or others. Below, Figure 3 illustrates the Virtual Instrument Development Scheme.
2.4 Monte Carlo Simulation

Monte Carlo simulations are used to model the probability of different outcomes in a process that cannot be easily predicted due to random variable intervention. This method is used to understand the impact of risks and uncertainties in prediction and forecast models. Monte Carlo simulations can be used to overcome various problems in almost every field such as finance, engineering, supply chain, and science[6]. The Monte Carlo method is a computational algorithm for simulating various behaviours in physical and mathematical systems. The classic use of this method is to evaluate definite integrals, especially multidimensional integrals with complex terms and constraints. This method is proven efficient in solving radians field integral differential equations. In the operation of the Monte Carlo Simulation, a risk analysis is done by modelling the possible outcomes by substituting a range of probability distribution values for factors that have uncertainty. Then the calculation is repeated randomly in order to obtain the possible value. Figure 4 shows the Monte Carlo algorithm mechanism in a simulation of virtual instrument.

![Figure 4. Monte Carlo Algorithm in Virtual Instrument Simulation.](image)

Figure 4 explains how Monte Carlo maps errors so that the quality of a simulator can be evaluated.

3. Proposed Method

In avionics learning, the important thing is knowing at what level the avionics hierarchy will be discussed. The emphasis is on the level of system reliability and stability. The approach used is
optimization and evaluation algorithm or failure analysis test like Monte Carlo. The virtual instrument that will be created is related to the Monte Carlo simulation to assess the performance of an avionics system.

![Diagram]

**Figure 5.** Failure test of avionics.

After conducting a level one avionics system failure test, a simulation is made, adapted from the Monte Carlo approach. These parameters must be determined in advance, then imitation to be made a virtual instrument model. As an example, a virtual instrument which illustrates aircraft subsystem IP based. It is the next generation of the avionics systems, which is using wireless communication. The service level agreement system becomes the reference, which will be the target of performance of the virtual instrument that will be made.

4. Result

Here is a virtual instrument design to facilitate students in learning next-generation avionics. It was said so because this system was integrated with a centralized computer system with Internet Protocol (IP) based. In this design, several avionics subsystems are integrated which in their performance are very influential on each other.
This virtual instrument application IP based can communicate wirelessly to the server. Student can learn the preparation preflight and also while aircraft is flying. Students can choose many from buttons to have experience in what they must do to prepare the aircraft. Student can try many parameters and input the various values to achieve optimum performance.

Figure 7 shows the scheme of how a virtual instrument system is evaluated using the Monte Carlo method. Every part of the system or subsystem is determined in advance by its working patterns, i.e. the parameters, threshold magnitude, and possible failures. When the system or subsystem is integrated and collaborated with various test scenarios, it will produce output like what. This output will be compared with estimates predicted by the Monte Carlo algorithm. The distance of deviation the magnitude of the error will determine the quality of the virtual instrument system that is built or used.
An example of a scenario to assess a virtual instrument system that was built to help the learning process in vocational education is the first determined type of aircraft because each type of aircraft has different specifications. After that, it was continued with testing and verifying the existing system first with manual and operating standards. If testing is conducted using sensors, then, sensors can be activated and the data can be retrieved which will then be analyzed by the data system, by comparing to the normal condition of the device[10]. Figure 8 illustrates a Boeing 737 preflight specification and checklist. The condition and values of the parameters have been set in virtual instrument completely then the students just click the button and see the impact.

**Pre Flight Checklist**

| PARKING BRAKE | SET |
| BATTERY | GUARD CLOSED |
| STANDBY POWER | GUARD CLOSED |
| L CENTER FUEL PUMP | AS REQUIRED |
| LAF T FUEL PUMP | AS REQUIRED |
| APU | START |
| APU GEN | ON |
| POS LIGHTS | STEADY |
| LOGO LIGHT | AS REQUIRED |
| CABIN LIGHTS | AS REQUIRED |
| EMER EXIT LIGHTS | GUARD CLOSED |
| PASSENGER SIGNS | ON |
| PACKS | AUTO / HIGH |
| IRS MODE SELECTORS | OFF > NAV |
| FMC | SET |

*Figure 8. Boeing 737 Preflight Checklist.*

Figure 8 looks very complicated. To make it easier, a more interesting virtual instrument mock-up is built. The following is an example of a simple mockup that represents the preflight preparation process. In this mockup, a button is made which makes it easy and students will see the effect when the button is aimed at a position.

**Mock Up Preflight Virtual Instrument**

*Figure 9. Mock Up Preflight Virtual Instrument.*

Figure 9 shows a plan for a virtual instrument mock-up for the preparation of preflight which will later be connected to an automated system that will show the effect of the button's settings.

**5. Conclusion**

Virtual instruments will provide a real picture of the various processes in a system and stimulate students to be able to absorb knowledge with a variety of learning approaches. This technology can also give students the experience to try and create various test scenarios with ease and low cost. The virtual instrument is a method of approach used in learning avionics. Because without this method students have difficulty in learning avionics that is very complex. This method is quite easy for
students to learn but also has weaknesses, therefore, the Monte Carlo algorithm is used, which provides vigilance regarding the existence of deviations or errors of real performance. To find out how far the deviation is, this Monte Carlo method is used, which gives the estimated output.

References

[1] Gilbert-Rainer Gillicha, Doina Frunzaverdea, Nicoleta Gillicha, Daniel Amarieib 2010, The use of virtual instruments in engineering education. Procedia - Social and Behavioral Sciences 2(2):3806–3810

[2] Mouhamed Abdulla, Jaroslav V. Svoboda, Lous Rodrigues 2005 Avionic Made Simple p 85-101

[3] Jiliang Tu Chengli Sun Xiangyang Zhang Hongliang Pan Ruofa Cheng 2015 Maintenance strategy decision for avionics system based on cognitive uncertainty information processing. Maintenance and reliability vol.17, no. 2, 2015

[4] Federal Aviation Administration Aeronautical Decision Making p 2-18-2-20

[5] Len Buckwalter 2010 Avionics Training Systems, Installation and Troubleshooting p 67

[6] Lee W T, Emmanuel Farhi, Daemen LL, Philip A Seeger, 2002 Monte Carlo Code Comparisons for a Model Instrument, Neutron News

[7] John-Paul Clarke, et al 2006, Development, design, and flight test evaluation of a continuous descent approach procedure for nighttime operation at Louisville International Airport Report of the PARTNER Continuous Descent Approach Development Team

[8] Yuce Ugurlu, 2010, Measuring the impact of virtual instrumentation for teaching and research, IEEE Global Engineering Education Conference (EDUCON) 2011

[9] Nagababu V, Imran A, 2018, Artificial Neural Networks based Attitude Controlling of Longitudinal Autopilot for General Aviation Aircraft, International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering Vol. 7, Issue 1, January 2018

[10] Longbiao LI, Youchao SUN, Hui CHEN, 2013 Assessment of Aero Engine Failure Based on Monte Carlo Simulation, Procedia Engineering 80 (2014) 415 – 423