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A study on the application of Prepar3D-based Aviation's Localizer Performance with Vertical Guidance Approach procedures in the teaching of simulated flight training courses

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Abstract

Firstly, the advantages of flight simulators and the three types of flight simulation software widely used by current flight students are briefly described, focusing on the analysis of instrument landing knowledge, how to read the instrument approach procedure charts, and how to use the flight simulation software to implement various instrument landing systems, so as to make the correct operation according to the approach procedure charts. Based on Prepar3D flight simulation software, Cessna C172R G1000 system was used to demonstrate two different types of precision approaches, so that the trainees could be more clearly and intuitively familiarized with the relevant operation procedures of precision approaches. From the results of the demonstration, it can be seen that flight simulation has the advantages of improving training efficiency, saving training funds, ensuring flight safety, and reducing environmental pollution, etc. The advantages of flight simulation software can fundamentally improve the flight skills of the trainees, increase flight experience, and thus reduce the incidence of major safety accidents.

Keywords

Flight simulator, Instrument landing system, Prepar3D, Aviation's Localizer Performance with Vertical Guidance Approach.

1. Introduction

1.1. Background

Flight simulator is a device that artificially reconstructs the flight of an aircraft and its flight environment for pilot training, design, or other purposes. It involves replicating how an aircraft flies, how it reacts to the application of flight controls, the effects of other aircraft systems, and how the aircraft reacts to external factors (e.g., air density, turbulence, wind shear, clouds, precipitation, etc.). Using flight simulation software not only allows you to learn a lot about aviation by participating in simulated flights, such as the use of various systems and the operational procedures of flying an airplane, as well as many other knowledge closely related to aviation, such as physics, mathematics, meteorology, geography, communications, foreign languages, etc., but also offers advantages over real flights in terms of economy and time, independent of the influence of the weather, field, control, etc [1]. It is even possible to set the weather, set the time, select any aircraft, set the purpose and mission of the flight, and

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familiarize yourself with checklists, various maneuvers and procedures in a very efficient manner.

Flight simulator is a virtual reality system that simulates the environment of an aircraft for a pilot. Flight simulators are primarily used for pilot training or entertainment/games, but can also be used to study aircraft characteristics, control handling characteristics, aircraft design and development. Flight simulators help to artificially recreate the flight environment of an aircraft for pilot training, design or other purposes. The primary purpose of a flight simulator is to help pilots acquire, test and maintain proficiency in the operation of an aircraft without any risk to life or property. And it costs far less than in-flight training.

Overall high efficiency and training effectiveness are the main reasons for using flight simulators as training equipment. Novice pilots can experience the flight environment and learn from their mistakes without any risk. It frees instructors from safety considerations and flight duties. Because it saves crew time, fuel and maintenance of the actual airplane. Flight simulation does not depend on any environmental conditions and also allows repetition of the practice of specific flight phases. Multiple environments and flight conditions can be accurately replicated with a flight simulator.

1.2. Flight simulation software

1.2.1 Microsoft Flight Simulator (Microsoft Flight Simulator)

Microsoft Flight Simulator is a series of flight simulator programs primarily for the Microsoft Windows operating system.It is one of the longest-running, best-known, and most comprehensive flight simulator programs on the market.It is the longest-running PC game series of all time, and is credited with contributing to the emergence of the use of the aviation joystick as the PC's s primary method of control.Bruce Artwick began developing Flight Simulator in 1997, and after a series of updates, eventually released Flight Simulator X Gold Edition on Steam in late 2014 as Microsoft Flight Simulator X: Steam Edition.

1.2.2 P3D (Lockheed Martin Prepar3D)

In late 2007, Aces Game Studio announced Microsoft ESP, and following the closure of Aces Game Studio in January 2009, Lockheed Martin entered into a license agreement with Microsoft to purchase the intellectual property rights to Microsoft ESP products (including source code).On May 17, 2010, Lockheed Martin announced that a new product based on the ESP source code would be called Prepar3D.Prepard3D is available in both single and multiplayer game modes, and also allows the user to join different Virtual Airlines and play in realistic real-world conditions to maximize performance. The software is provided for professional or academic purposes and allows users to create educational scenarios in the air, at sea and on the ground. The software comes with a development kit for customizing scenarios, landscapes and vehicle models.

1.2.3 X-plane

X-Plane sets itself apart from other simulators by implementing an aerodynamic model known as blade element theory. Blade Element Theory improves this type of simulation by modeling the forces and moments on an aircraft and evaluating the parts that make it up individually. Blade Element Theory and other computational aerodynamic models are typically used to calculate aerodynamic forces in real time or to pre-calculate aerodynamic forces for new designs in simulators that use lookup tables.

1.3. Instrument Approach Subjects

The subject of instrumental approaches is divided into 3 main categories: Precision Approach, Non-precision Approach and Aviation's Localizer Performance with Vertical Guidance Approach[2]. The approach is not only more sophisticated, it is also more effective. The precision approach is not only safer, but also improves fuel efficiency, reduces noise levels and minimizes the possibility of hitting obstacles during the final approach phase.

A precision-like approach is a GNSS-based instrument approach and does not meet the ICAO Annex 10 standard for precision approaches, but provides information on heading and glide path deviation. For example, Baro-VNAV, LDA with glide path, LNAV/VNAV and LPV are all classified as precision approaches In the past, civil aircraft usually used the step descent approach when approaching, which requires the necessary positioning points on the segment to maintain the basic minimum over obstacle margin, but increases the possibility of error, so NASA proposed the concept of continuous descent approach, and then in 2011 the FAA issued the Continuous descent final approach, the technology of CDA has many advantages over the previous ground descent approach, such as high descent routes, small thrust required to maintain the engine, shorter time to sustain the landing configuration, reduced noise and reduced emission pollution[3].

2. Study of the C172 G1000 System Implementation Aviation's Localizer Performance with Vertical Guidance Approach

For the purpose of analyzing the demonstration, San Francisco International Airport (IATA code SFO; ICAO code KSFO; FAA code SFO), which has various classes of precision approaches, was selected for the study. The LNAV/VNAV approach is implemented first, as shown in Fig. 1. The simulator is currently at 7,000 feet near the initial approach point, and the flight is planned to fly nonstop to San Francisco International Airport.

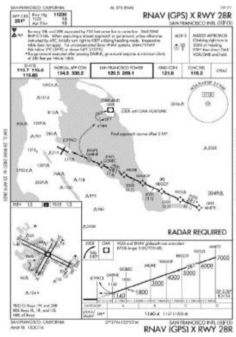

Figure 1: KSFO LNAV/VNAV; **Figure 2:** Primary Flight Display (PFD); **Figure 3:** ACTIVATE APPROACH

2.1. Study of the LNAV/VNAV program

As shown in Figure 2, click FPL (Flight Plan) on the PFD and click PROC (Procedure) on the FPL screen. Select SELECT APPROACH in the PROCEDURES pop-up, and click ENT (enter). Select the "RNAV28RX GPS LNAV/VNAV" that will be used by selecting the knob at the bottom right, i.e., the highlighted text in the screen, and then click ENT. Select the Initial Approach Point, this program only has ANETE at the moment, and then click ENT, and then adjust the Minimus, and then click ENT through the outer ring of the knob of the FMS (Flight

Management System). Management System (FMS) knob's outer ring, adjust the highlights to MINIMUMS, then use the FMS's inner ring, adjust to BERO, by the same way to adjust the decision altitude, through the instrument approach program diagram can be seen here set 1140 (DA 1140ft). The last step is to choose LOAD or ACTIVATE, LOAD adds the procedure to the flight plan but does not execute it, it is suitable for the case of far away from the airport, and need to pass other navigation points on the way, ACTIVATE is direct activation, that is, the GPS guides the airplane directly to the set initial approach point ANETE, since the demonstration airplane is already near the initial approach point, so here Select ACTIVITE directly and click ENT. This time you need to use AP (autopilot), NAV (use GPS mode) and ALT (keep the initial approach altitude of 7000), when you need to activate it, click PROC and select "ACTIVATE APPROACH ", as shown in Figure 3.

When approaching the initial approach point it is necessary to adjust the aircraft's "Autopilot Selected Altitude" to a lower altitude of 6,000 feet using the ALT knob in the MFD. When Vertical Speed DEVIATION and TARGET Vertical Speed are present, VNV, or VNAV, mode pre-positioning is used. At this time the autoflight panel displays white VPTH (Vertical Path), or Vertical Path Pre-position. When the Vertical Speed Offset indication is centered, the VPTH turns green to begin vertical guidance. Before that, you need to set the FPA (Flight Path Angle), click the FPL of MFD, adjust the FPA to 3.0° by FMS knob, at the same time, the VS TGT will be recalculated by the flight management system. Conversely adjust the VS TGT and the FPA will also be recalculated. When the altitude of 6000 feet is reached, the vertical speed offset indicator will suddenly rise, the purpose of which is to prevent the aircraft from suddenly descending below 6000 feet without reaching the point of the path and also to give us time to adjust the autopilot-selected altitude down to 5000 feet[4]. After the airplane's altitude gradually decreases, when the vertical speed offset indicator changes from "V" to "G", you can click on the APR to intercept the chute, and the GP/V pre-position is displayed directly above. Disconnecting the VNAV mode or Glide Path mode overrides the airplane's autopilot selected altitude, making it easier for the pilot to avoid conflicts.

When the downtrack indicator is centered, the white GP/V will change to green GP, i.e., the downtrack is intercepted, and L/VNAV is displayed in the center of the CDI, i.e., the downtrack is successfully intercepted, and the approach is made by LNAV/VNAV. As soon as the approach is initiated, perform the Before Landing Checklist, after which you need to start slowing down to less than 85 knots with 10° of flaps and then maintain 70 knots. The blue V-arrow pointing to 1140 is the BERO MIN setting of 1140 ft. When the airplane descends to the decision altitude of 1140 ft, the blue arrow will turn yellow and the G1000 system will indicate "MINIMUMS" by voice prompts, and you need to click on the AP to disengage the autopilot.

If the runway is visible from the window or the runway lights are visible at night, you can continue descending. If the runway is not visible, retract the flaps and resume flight at full throttle, heading 030 ft, climb to 3000 ft, fly straight towards OAK VOR/DME, go to the top of the OAK nav station, and start the waiting procedure for the approach to Trace 063, or the procedure for the alternate landing.

2.2. LDA with Glide Slope

Click on FPL in FPD, subsequently click on PROC, select LDA28R, click on ENT. select initial

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approach point ANETE, click on ENT. fill in MINIMUMS via FMS in the same way as before, 1140ft, select ACTIVATE, click on ENT. the subsequent interception of the Vertical Path is the same as before, and will not be Demonstration. As shown in Figure 4, at this point it is again necessary to calibrate the FPA in the vertical profile, the problem is that the vertical guidance and the slide are clearly a broken line rather than a straight line, and there are no other markings in the instrument approach charts to indicate the vertical guidance slide angle[5]. The vertical guidance angle is calculated to be 3.04° (Arctan (1000FT/3.1NM) = Arctan (1000FT/18831FT) = Arctan0.0531); the chute angle is 2.96° (Arctan (660FT/2.1NM) = Arctan (660FT/12757FT)) = Arctan0.0517); so the difference between the angle of the vertical path and the angle of the chute is negligible, and the FPA is still set at 3.0. At 3000 feet, the vertical velocity offset indicator changes from "V" to "G". Click on APR and prepare to intercept the Glide Slope, identified in white as "GS" in the picture. Unlike an LNAV/VNAV or LPV, which currently intercepts the Glide Slope, an LNAV/VNAV or LPV intercepts the Glide Path. According to FAA's Aeronautical Information Manual page 41: "The UHF glide slope transmitter, operating on one of the 40 ILS channels within the frequency range 329.15 MHz, has a "Glide Path". The UHF glide slope transmitter, operating on one of the 40 ILS channels within the frequency range 329.15 MHz, to 335.00 MHz radiates its signals in the direction of the localizer front course. means that portion of the glide slope that intersects the localizer.", ICAO defines "A descent profile determined for vertical guidance during a final approach. Glide Slope is understood to be the ground-based navigation equipment slide, specifically referring to the vertical guidance issued by the ILS, while Glide Path is the generic term for the slide path during a final approach. As shown in Figure 5, the blue part is the Glide Slope and the gray part is the Glide path.

Figure 4: CURRENT VNV PROFILE

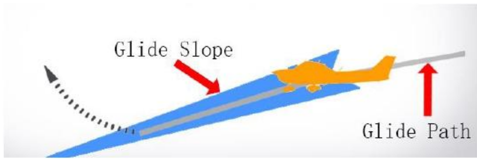

Figure 5: Glide Slope and Glide path

When LOC1 is displayed in the center of the CDI, and it changes from GS pre-position to green "GS", that is, the navigational and glide slopes have been successfully intercepted, and LDA with Glide Slope has been successfully started, as shown in Figure 6. Glide Slope refers to the ILS slide, and LDA with Glide Slope is so similar to ILS that the name of the instrument approach chart is "LDA/DME RWY 28R" instead of "ILS/DM RWY 28R". After checking the related information, the reason is that the Localizer type directional aid (LDA) with Glide Slope is not aligned with the runway, and the position where the aircraft is being guided laterally is not on the runway extension. As shown in Figure 7, the aircraft is on the centerline of the heading station, but not on the runway extension. This is why the decision altitude for LDA with GS is 1200 feet AGL, unlike the normal ILS decision altitude of roughly 200 feet AGL, and it is extremely easy to have a safety incident if you perform an LDA with GS and wait until 200 feet before performing a reentry procedure or other maneuver.

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Figure 6: CDI central display LOC1 **Figure 7:** The aircraft is on the centerline of the heading station.

3. Considerations for the implementation of the Aviation's Localizer Performance with Vertical Guidance Approach Procedure

3.1. Unable to turn on VNV mode

At the very beginning of the implementation of the Aviation's Localizer Performance with Vertical Guidance Approach could not use VNV, check the operation manual of the G1000 found that the VNV mode must be the current altitude is not on the set autopilot altitude can be triggered. Current altitude is 7000 feet, left autopilot setting altitude is 7000, VNV mode cannot be used; right autopilot setting altitude is 6000, VNV mode can be used. Note that it has nothing to do with the vertical guidance in purple.

3.2. Intercepting the Slideway

When the airplane is descending along the vertical guidance, the situation of not being able to intercept the chute sometimes occurs when switching between VNV and APR modes[6]. There are two possibilities, one is because of the low accuracy of the airplane's positioning system; the other is because the red airplane is slightly higher than the vertical guidance path and the black airplane is slightly lower than the vertical guidance path. airplane can intercept the chute (Figure 8-2). Therefore, it is important to note that you should fly as close as possible to the vertically guided path, and if you accidentally fly over the top of the chute, you will need to manually maneuver the airplane so that it descends at an angle greater than the chute to intercept the chute.

4. Summary

By comparing the approach methods of ILS and Precision Class Approach, when using ILS approach, you need to input the ILS frequency and compare the identification code firstly, then you need to adjust the ILS approach track to know the angle of descent and the final approach point, and then you need to continue to land at the lowest descent altitude/height or to resume the flight. To use a precision class approach, you need to select the appropriate approach program on the GPS, and the approach track will be automatically displayed on the GPS, and then you can follow the instrument guidance to execute the precision class approach. In terms of steps, the precision class approach is similar to the ILS approach but the operation

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is slightly simpler, which reduces the workload for the pilot and reduces the probability of error.The decision altitude of the ILS CATI is 200 ft and the visibility is 1/2 mile, the decision altitude of the normal LNAV/VNAV is 400 ft and the visibility is 1 mile, and the decision altitude of the LPV using WAAS is 200 ft and the visibility is 1/2 mile. It can be seen that in terms of accuracy, Aviation's Localizer Performance with Vertical Guidance Approach can be comparable to ILS CATI, ILS ground equipment is expensive and requires maintenance, and only large airports or busy airports will be installed, and ILS signals are affected by the terrain, on the contrary, Aviation's Localizer Performance with Vertical Guidance Approach doesn't need any ground equipment to be installed in airports. On the contrary, Precision Approach does not require any ground equipment to be installed at the airport. Moreover, in countries with advanced navigation, small airports are not suitable for installing ILS, which makes Precision Approach an excellent choice. Currently, large airports or busy airports still use the most accurate ILS CAT IIIC, but due to the limitation of the terrain, in order to save money, the Aviation's Localizer Performance with Vertical Guidance Approach will be the future development direction.

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