Building a Fixed Base Flight Simulator around $100 Software

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Building a flight simulator around $100 software written for the PC games market may on the surface be a rather strange thing for a university to undertake. FS 2002, the latest offering from Microsoft in a long line of progressively improved software, has received excellent reviews from armchair pilots around the world, since its release this year. Due to the phenomenal popularity and open architecture of this product, a vast number of third party developments are available for the program; features that make it possible to use the software in a way that is far removed from the traditional mode of play, involving a gaming joy-stick and keyboard.

The author's objective was to develop a low cost, fixed base (i.e. no motion) simulator that could be used for a number of activities, including an introduction to flying, CRM studies, and as an aid for teaching undergraduate subjects like flight mechanics, stability & control and avionics. The possibility of using it to assess the flight dynamics of student project designs was also considered, although current limitations of the software are likely to restrict this aspect.

A Boeing 707 cockpit was acquired; the airframe was sliced off behind the cockpit door. This large 4-seat cockpit was ideally suited to the development of a Boeing 737 simulator as the physical dimensions are almost the same and the additional space between the pilots' seats and the cabin wall could be utilised for an instructor station and for housing the computers. The lower portion of the cockpit - below the floor beams - was cut off and a metal frame built to support the structure. It was then stripped down to the basic metal shell; wiring, hydraulic pipes, accumulators, and electrical components were removed, but all flight control components (cables, pulleys and control rods, etc.) were left intact. The instrument panel was removed and a new panel manufactured to house six flat panel displays. These displays were selected to replicate the modern EFIS displays in a B737-800. To enhance realism, original hardware was used whenever possible. For example the undercarriage lever was removed, cleaned and reinstalled in the correct position on the new panel. The engine controls required modification by removing two of the four levers. The flap selector was reinstalled and some of the original overhead cockpit lights and switches were refurbished.

Below the cockpit floor the control cable runs were modified. The cables for the pitch and roll control were shortened, additional pulleys were installed and the cables joined to form a closed loop from the port to starboard side. A simple artificial feel system for pitch, roll and yaw commands, was developed based on the use of pneumatic actuators and pressure regulators; all mounted below the floor. Positional information of the flight controls comes from rotary potentiometers and switches; the signals are taken to a customised IO (input-output) card installed on the server PC. This card is programmed to send appropriate signals to the PC in response to the external inputs. For example if the software responds to the keystroke Ctrl U by raising the undercarriage, then the IO card can be programmed to emulate this keystroke when a signal from a hard wired switch installed on the undercarriage lever, is closed. The process works both ways. Flight data on speed, height, heading, etc., used within the program may be made available externally via the IO card. It is possible to develop a fully functional autopilot panel using this feature. (The main difficulty encountered in doing this was obtaining representative switches and lights.) The ultimate objective is to "fly" the software, designed for a standard PC, using the actual flight controls, without touching a keyboard or mouse.

The familiar display format of the PC game, where the instrument panel and the external view are shown on a single monitor, may be substantially manipulated and enhanced using freeware software, which has the ability to separate out individual parts of the display. External views (forward and 45º left and right, for example) may be placed on appropriately installed monitors whilst the instrument panel display may be split up and placed on individual screens. Three high specification PCs (with 1.6 GHz processors) simultaneously run the software, linked through a local hub. The program execution is performed on the server unit, with signals sent to the two "slaves", whose sole function is to provide the visual displays. This ensures a high frame rate and a very smooth graphics display. Each PC is fitted with a duel head graphics card permitting two different views to be simultaneously generated. When identical views are required on two screens, a "splitter" cable is used. In this way it is possible to generate four high quality displays from a single PC. A fourth PC (500 MHz processor) with a monitor, keyboard and mouse is installed at the instructor station. This provides a limited capability to chart the flight profile and monitor progress.

The current status of this project, which has been undertaken by undergraduate students, is that the primary flight controls are complete, the instrument panel and autopilot panel installed and full functionality of the software has been demonstrated. An interim solution for displaying the external views is achieved using Fresnel lenses placed in front of four externally mounted PC monitors. Some secondary controls and the backup displays are outstanding; these will be installed within the next year, as will a projected external display. An evaluation of the capabilities and limitations of the software will commence shortly. In its favour it can be said that the software has undergone a phenomenal improvement in recent years, with each new release providing more realistic scenery and better flight characteristics. With FS 2002 the distinction between home entertainment and pilot training software is starting to blur. What is assured is that future releases of the software will be even more realistic with enhanced inactive features. An adaptable simulation tool, like this one being developed in the B707 cockpit shell at the University of Limerick will find new uses, particularly as the software is Windows based, permitting students to extend the capabilities of the simulator and to evaluate new ideas at very low cost.