Building your own flight simulator cockpit

By Herman Lenferink

Flying in your own cockpit is one of those aspirations many flight simulator users consider out of reach: too difficult, too expensive, too time consuming … but the opposite is true. Both plug-and-play and advanced products are available to build your own flight simulator cockpit in any size and to accommodate every ambition. In this article you'll find a global impression of the options available, plus a list of additional online resources to help you proceed in your quest for your own simulator cockpit.

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1 Introduction

Almost as soon as Microsoft *Flight Simulator* was first published in 1982, a select group of intrepid users began creating enclosed cockpit structures and "real" panels. The development of homemade flight simulator cockpits matured with the release of each succeeding Microsoft *Flight Simulator t*o arrive at today's highly expanded market with a broad variety of suppliers, special interest group activities, and organized events.

1.1 Variations in approach

Everyone has different objectives when it comes to creating a flight simulator cockpit. Some aim to develop a simulator cockpit that is not distinguishable from a real cockpit and go as far as using real aircraft cockpit sections as a basis (examples include Project B737NG, 737 Sim, Project 727, F15 sim, R22 project, Bell 206B), with others focusing only on the interior (such as KennAir, Ian, ConnieSim, CessnaSim, PC9M, 737BBJ, A320ftd, Baron 58, 777 Blog, Hoddo, 747-400). Someone is even building a Spitfire based on original drawings and using original materials (SimHardware). Many follow a more entertainment-directed approach: as long as it resembles an aircraft cockpit, it's fine (examples are Beech 1900D, 777AVG, GLAHBC). Motion-based flight simulator cockpits form a dimension of their own (see 747 Simulator, JimsPage). Finally, one group of builders is more in search of ease of use. They typically gather a series of devices on their desk without the intention of creating something that resembles a cockpit (B767 Cockpit). Explore the links in the Resources section at the end of this article to find many more examples.

2 How to get started

This section will start you on your quest for your own flight simulator cockpit. First an overview of the building blocks is given. Then a high-level road map is detailed, based on the results of five questions. The remainder of the section discusses specifications.

2.1 Building blocks of a flight simulator cockpit

Below is an overview of the building blocks of a flight simulator cockpit. When browsing through the links included in this text and in general on the Internet, you will notice that there are many variations on this topic. There is no single correct configuration of building blocks. In the end, the configuration used is determined by your ambition, technical knowledge, programming knowledge, available budget, and available time.

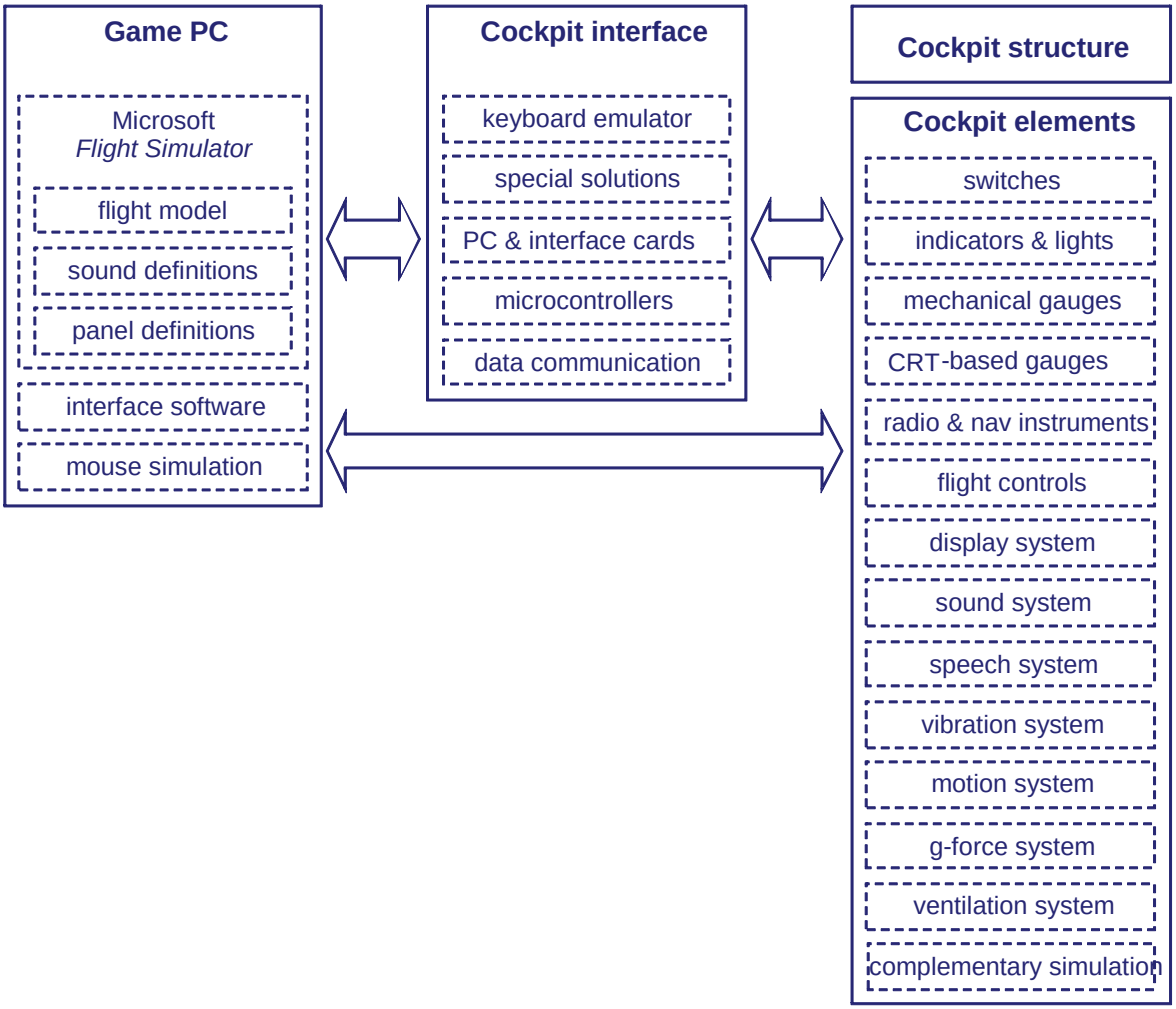

Figure 1: The basic components of a flight simulator cockpit design

2.1.1 *The game PC*

The game PC runs Microsoft *Flight Simulator*. This may be one PC, but in advanced simulator cockpit setups, often multiple PCs are used in a network setting. Microsoft *Flight Simulator* comes with an open interface (SDK), making it possible to fine-tune and/or develop many aspects of the simulation ranging from the flight model of your aircraft to the scenery you fly in. The most relevant SDKs for a simulator cockpit are the flight model, sound definitions, panel definitions, and SimConnect. The flight model configuration file allows you to fine-tune the handling characteristics of your aircraft in considerable detail or even make your own flight model. It is also possible to define your own sound definitions for optimal environmental audio effects in your cockpit. By means of the panel definitions you can develop digital gauges for your panel and additional simulation effects for your aircraft.

The most significant component on the game PC is the actual interface to Microsoft *Flight Simulator* used to read data in order to drive the simulator cockpit and to feed back data to control the aircraft. Until *Flight Simulator X*, the third-party interface software FSUIPC was the dominant route. Based on the installed base, it will play a significant role in this area for the near future. However, with the introduction of FSX, there is now a formally supported interface to Microsoft *Flight Simulator* called SimConnect. The objective of SimConnect is to give full access to all relevant data within Microsoft *Flight Simulator.* If you write your own software to drive your simulator cockpit, this is the preferred route. Note that it is not

necessary to write your own software. If you use prefabricated cockpit instruments and/or Microsoft *Flight Simulator*-focused interface boards, you can often suffice with editing configuration files. In some cases you might want to use add-ons to the flight simulator that only facilitate a mouse interface. By using mouse simulation (such as Key2Mouse), you can turn a key click into a sequence of mouse actions for which no keyboard shortcuts are available. The key click can, by means of a keyboard emulator, be linked to an actual switch or keypad in your cockpit.

2.1.2 *The cockpit interface*

Depending on your setup, the cockpit interface handles numerous functions including switches, control lights, motors that drive analogue gauges or even whole flight computers. As your cockpit project evolves, you will likely include more and more specific interface devices.

One very important interface device is the keyboard emulator. Most commands in Microsoft *Flight Simulator* can be given by a single keystroke or a combination of keystrokes. A keyboard emulator converts a signal given by a normal switch into any keystroke command. Using keyboard emulators can be a very straightforward and elegant way to interface switches to Microsoft *Flight Simulator* without the need of deep technical knowledge. Examples include KE72 Encoder Module, TCP-S2.

There are numerous interface boards available for Microsoft *Flight Simulator*. These interface boards enable you to build your own cockpit components. They can, for instance, be used to drive lights (indicators), servo and stepper motors (gauges), displays (radio stack), etc. Examples include IO-Cards, Remote Mount Kits, SIM-board. In general, Microsoft *Flight Simulator*-focused interface boards come with additional software that enables the configuration of cockpit instruments so no real programming is needed. For complex devices such as a flight management computer (FMC), an interface device with computing abilities is more practical. Until recently, often microcontrollers were used. Besides options for low-level IO, microcontrollers can additionally process signals to and from the device, preventing too much load or programming complexity on the game PC. Examples of microcontrollers include OOPIC, BASIC Stamp. There is, however, an increasing trend to use standard PCs instead of microcontrollers. The main reasons include the relative low costs, increased ease of interfacing, and use of normal programming environments or standard software from interface board suppliers.

2.1.3 *The cockpit*

As stated in the introduction, a cockpit can vary from arranging some extra devices around the computer screen to the use of a cockpit section of a real aircraft. A large group of flight simulator cockpit builders build their own cockpit hulls using materials such as wood, polyester, and Plexiglas. Additionally they often use multiple displays or a beamer to display the outside world. Some modify real gauges while others build gauges with servo motors from scratch or buy ready-made simulator gauges from a supplier. With respect to digital gauges (screens), there is a whole range of commercial, shareware, and freeware gauges that can be connected to the game PC with extra screens (on the same PC) or via extra PCs (in a network). Cockpit controls like yokes, pedals, and throttles can be homemade or obtained from a supplier. As you can see in the figure above, there is a whole range of additional cockpit elements that can be added. In the Cockpit Elements section, you will find a systematic overview of the cockpit elements.

The remainder of this section will show you how to begin the actual cockpit construction.

2.2 The five questions

First you need to get a grasp of the basic components a flight simulator cockpit (see Figure 1 above). Then it is time to have a big look around on the Internet to get acquainted with the various approaches you can follow. As a starting point, use the links in the Resources section at the end of this article. Browse through sites of cockpit builders, read their stories, visit the various cockpit builders' communities and resources on the Internet, and check out the many sites of suppliers. Invest some time; it will pay off because you'll get a basic feeling for the options and their implications.

Once you've done this, you'll be heading for some crossroads. Following are five questions to ask yourself to help define the kind of cockpit you're ready to invest in.

1. *What are your skills, and do you want to develop new skills?*
   Are you going for ready-made components, or are you going to develop components yourself from scratch or by using parts or half fabricates?
   If you want to build a flight simulator cockpit based on ready-made components, you are limited to either the specific aircraft types offered by the suppliers or a more generic cockpit setup. If you want to move more into the area of the actual construction of components, there is a much larger range of aircraft from which to select. If you additionally have or are willing to develop some programming skills, there is basically no limitation to the aircraft you can select or level of realism you can achieve. In all of these dimensions, available budget and/or available time plays an important role.
2. *What is your time line?*
   In what time do you want to fly in the first version of your own flight simulator cockpit? For your own satisfaction and motivation, it is better to follow small steps to ensure you can fly in your own cockpit setup (under development) at almost any given moment.
3. *What is the space you have for your cockpit setup?*
   Some have a corner in a study they share with other family members, some have a corner in their bedroom, and others have a dedicated room or attic. Space will help determine the size of the cockpit you can build, which will influence all other factors.
4. *What is your overall ambition?*
   What level of realism do you want to achieve, at the start and at the end? How many PCs do you want to use? What is the budget you want to spend?
5. *And finally, what aircraft do you want to fly?*
   Some do not want to make a choice and go for the more generic cockpit of an airliner, small aircraft, etc. If you want to build a flight simulator cockpit based on ready-made components, you are limited to the specific aircraft types offered by the suppliers. If you are in for building the cockpit parts yourself, you can choose from aircraft that are included with Microsoft *Flight Simulator* or are offered by commercial or freeware add-on suppliers and that you trust because they've been around long enough.

2.3 Cockpit specifications

If the objective is to develop a flight simulator cockpit based on a real aircraft, one of the first steps is to work out the correct specifications. An important step in creating a cockpit structure with a realistic interior (and possibly exterior) is to obtain a blueprint and/or manuals. Finding good materials is not always easy and often requires significant search efforts (on the Internet). Besides eBay, other possible sources include Avsoft, AvTrainingSolutions, eFlightManuals, EsscoAircraft, FlightManualsOnCD and RareAviation.

Fellow cockpit builders are also often a useful source of information. Examples include A340 project ("file" section), B767 dimensions, B777 dimensions or 747 Simulator ("Pictures of design" section).

Keep in mind that making detailed construction drawings is not a "must." It is very possible to build your cockpit based on very global hand-drawn sketches--whatever fits you best. An overview of free CAD drawing programs can be found at FreeByte.

2.4 Panels

The term "panel" refers to the boards in the cockpit that hold the gauges and switches. With respect to cutting and engraving, the term "front plate" is also used.

When constructing a panel, the first step is to define the layout. If you are planning to model a real aircraft, the issue is to find quality documentation about the panel layout (the shape of the panel and sub-panels, and the type of gauges and switches needed including their locations). Since you will spend a considerable amount of time on the panel, some additional effort in this area will pay off. The best start is to see if you can find an original manual. See the Cockpit Specifications section, above, for links.

In general, manuals do give detailed information about the layout; however, it is often hard to deduce the exact dimensions of the cockpit from these manuals. Additional sources are often needed, but in many cases they are much harder to find. Examples are Varxec and Pietila. It is also possible to deduce sizes by using the size of a cockpit element you know the size of as a reference. For instance, on eBay it is possible to get dimensions for single cockpit elements out of the product description, or you can ask the seller a question about dimensions.

Instead of designing the panel by yourself, it is also possible to buy ready-made templates for panels. Simple to even very advanced panels can be obtained from suppliers such as VFR-cockpit, Hispapanels, Flightdeck Solutions, Cockpit Sonic, Engravity and others; check the Resources section at the end of this article.

When you make the panels yourself, note that the professional method of cutting and engraving a panel often requires special equipment. One option is to look for a local supplier. An interesting alternative is offered by a company that facilitates the online ordering of the panel design you made. This is a very advanced service where you can design your own panels: FrontPanelExpress (for North America) and Schaeffer AG (for Europe). Some cockpit builders develop their own CNC machine (e.g., 737 Basement Simulator, Norbert Bosch); a good general starting point is CNC zone. You can also check for local suppliers that make panels (front plates) based on CAD files made by you.

Instead of engraving a panel, you can use adhesive materials for lettering. Examples are the computer labels made by 3M ScotchMark and Dyna Laser. Another approach is to use printable overhead sheets or paper and put them behind a perspex sheet (e.g., Boeing Cockpit Project, Heideveld or f16simulator).

An area that requires special attention is back-lit panels. The principle is that the lettering lights up when the panel lights are turned on. It is not really possible to copy a professional back-lit panel construction without special equipment and material. There are, however, very good alternative approaches. Examples can be found on the sites F16Simulator, Biggles, Hans Krohn, and xFlight/F16 in the "Simulator / Panels" section.

2.5 Hull construction

There are many variants on how to build the hull of your flight simulator cockpit. However, the more enclosed the design is, the more a flying experience will be obtained. Other things to consider are: easy breakdown for transport, dimensions that fit through your doors and go down stairs as needed, accessibility and comfort, and easy modification of (panel) parts (as you may well develop advancing ambitions). If your final goal is a motion-based cockpit, the structure should have enough strength of its own.

All kinds of materials can be used to get the effects needed. For instance, specific metal structures can very well be copied using MDF, hardboard, rounded nails in place of rivets, and a layered (and sanded) multi-colored paint job for a worn impression. Depending on your level of ambition, you may want to use more advanced methods to construct parts. At eMachineShop you can design your own parts and have them custom made, or you can also look for a local supplier. If you need multiple copies of a part you can use materials such as Alumilite Casting Resins.

It is also possible to buy real aircraft parts. Sites for buying real aircraft parts include BoneYard2U, Desert Air Spares, Scroggins Aviation, Warbird Parts, and Konfederate Klassiks.

There are various approaches for cockpit construction. The table below outlines the basic principles and lists some examples.

Real cockpit segment	The start for the flight simulator cockpit is the cockpit section of a real aircraft: - WV838 - Alan Dyer's site
Hull-cockpit structures	Flight simulator cockpit builders who want the outside of their cockpit to look like an aircraft can build part of the hull structure: - SimHardware
Cockpit structures	If the objective is to have a look-alike effect on only the inside of the cockpit: - Pascal Vonsey - Nixon & Thomas
Portable cockpit structures	For those who will not claim a permanent "footprint" for their flight simulator cockpit, there is the option to develop a portable cockpit structure: - xFlight/F16 (SimLight section) - ABC
Advanced desktop structures	If there isn't enough room, ambition, or time to create a complete cockpit structure, the alternative is an advanced desktop structure: - Francisco Garcia Garrido - The V-Pit (cockpit in a closet) - Monitor Canopy
Desktop structures	A desktop++ is shown on: - Frank Bond

A large number of simulator cockpit builders explain on their site how to construct a cockpit hull (e.g., A320 FTD). Examples of suppliers are InnovativeFSP and FlightDeckSolutions.

3 Cockpit elements

Some suppliers offer more or less complete working cockpit setups, either as a whole or in separate elements. For example, SIMKITS offers all the parts for a complete light aircraft cockpit, and Project Magenta provides almost all the ingredients for a full Boeing or Airbus glass cockpit. Other suppliers include Plug and Fly and Precision Flight Controls. It is also possible to construct your cockpit based on separate parts that you purchase or (partly) build yourself.

Within the cockpit there are a whole range of components. Some components are driven directly by *Flight Simulator*, such as the joystick, pedals, or video cards. These devices typically are controlled by standard device drivers. Many ready-made products have product-specific interface devices and controlling software. In the case of self made components you often use more generic interface devices and self-developed software.

3.1 Switches and indicators

Within a cockpit there is a wide range of switches. When you begin to explore the options, you will soon discover that switches have a lot of variation in characteristics, such as the number of pins, whether they are non-shorting, etc. Following is a brief overview of the various types of switches. A search on the Internet and information provided by simulator cockpit suppliers will provide you with additional details.

A large number of switches are used to make a selection, such as lights (on/off) or fuel tanks. The most common group includes toggle switches, rocker switches, and push-button switches. These switches are typically used to switch a device (e.g., a light) on or off. The toggle switches have a more classic style, while the rocker and push-button switches are more modern. With respect to the toggle and rocker types of switches, it is important to be aware that there are many variations: on-off, on-off-on, and (on)-off (where the indication '(on)' means 'momentary'; pressing the switch to the left side makes contact, but when released the switch goes back into the 'off' position). Rocker and push-button types of switches are available with built-in lights.

It is also possible to make a selection by turning the knob on a rotary switch. These are called rotary select switches and allow you to select from two or more positions. Each position has its own contact pins and represents a specific selection. A special version of the rotary switch is the thumb wheel switch, used in classic radio stacks and older fighter planes. Within an average cockpit there are a considerable number of rotary-type knobs (rotary switches) to tune instruments, radio equipment, and navigation equipment. In a simulator cockpit, this type of tuning is often processed by generating pulses that in turn drive, for example, a keyboard emulator.

There are basically three types of rotary switches that generate pulses. The most practical in use are the rotary pulse switches. The basic principle of these switches is that they have four pins (A, B, C, D). If you turn the switch clockwise, a pulse (contact) is made on the pins 'A' and 'B.' If you turn it counterclockwise, a pulse is made on pins 'C' and 'D.' For many applications related to digital control, these switches are very useful and practical. The other variants are incremental rotary encoders and absolute rotary encoders. A search on the Internet will provide you with all the details you need.

Panel-mounted indicator lights are easy to acquire. Some general issues to consider:

- Some types of lights can generate a lot of heat. Heat is an issue inside a simulator cockpit with respect to both safety (fire) and comfort.
- Low-voltage lights are safer.
- LED lights are more durable.

3.2 Gauges

There are four kinds of mechanical (classic) gauges you can place in your cockpit:

1. Instruments that are simulated by using a monitor behind a panel template.
2. Ready-made gauges (kit).
3. Gauges you make from scratch.
4. Old aircraft gauges you can purchase and adapt.

Mechanical gauges can be simulated by displaying them on a monitor and placing a front plate in front of it. This can easily be done with the standard *Flight Simulator* gauges and the use of multiple monitors. But you can also use third-party gauges from companies such as Reality-XP, Project Magenta, and Flyware. VFR-Cockpit, for instance, includes panel kits that can be used as a mask on the monitor(s). Following this route, you can have a realistic-looking, low-budget simulator cockpit in hours.

You can buy mechanical gauges ready-made or as kits. On SIMKITS, kits and prefabricated gauges are offered for a large number of mechanical gauges. In addition, they provide an interface board with driver software to drive the gauges. Flight Illusion also offers a wide range of gauges driven by a custom interface board. Along with the standard small and large single- and dual-needle gauges, they offer gauges with additional digital displays. Low-priced kits are offered by Simulated Aircraft Instruments; instead of a motor-driven approach, air-core meters are used (the instruments do, however, require an analog 0-5 VDC output signal).

It is also possible to construct a gauge using servo or stepper motors. Detailed instructions on gauge construction are beyond the scope of this article, but the links in the Resources section and a search on the Internet will lead you to more detailed information. It is important to know that building gauges yourself does not require very deep technical knowledge. Suppliers such as Phidgets and Parallax provide easy, programmable plug-and-play interface devices for servo and stepper motors. Programming knowledge on a beginner's level is sufficient to get started. A very interesting book for those who also want to develop the electronics driving the gauges is *Building Simulated Aircraft Instrumentation* (Mike Powell). This is an in-depth introduction to making 'steam gauge'-style engines and flight instruments for use with flight simulators. It describes in deep detail how air-core movements, servos, and stepping motors work, and is illustrated with working projects.

There is a market for old (broken) real aircraft instruments; eBay is a very good starting point for a search. Existing aircraft instruments in general have a complex structure based on principles such as pressure, electric pulses, and voltage levels. The easiest approach is to replace the inner works with a servo or stepper motor directly connected to the needle or plates, and to connect rotating buttons to, for instance, rotary pulse switches.

In many modern cockpits, you'll often find one or more CRT-based gauges (or nowadays, LCD). In a sense they can better be viewed as a type of console since in general they give integrated access to a range of functions. Gauges that are CRT-based can be constructed based on the gauges you can define for Microsoft *Flight Simulator* panels. They can be arranged in your cockpit using multiple monitors and

undocking panel windows. Third-party suppliers that provide CRT-based gauges include Project Magenta, AST, and Majestic. Specific keyboards for units such as a CDU (Control Display Unit) can be obtained from Flight Deck Solutions as well as other suppliers. A construction example can be seen on the site of Norbert Bosch.

3.3 Radio and navigation instruments

Ready-made radio and navigation instruments can be obtained from a number of suppliers such as Precision Flight Controls, GoFlight, and SIMKITS. It is also possible to make these instruments yourself. There are many examples on the various sites of fellow cockpit builders.

See the Switches and Indicators section for details on the various types of switches that are used. For the displays, small USB-driven LCD screens (e.g., Phidgets) can be used. With an additional bezel, a seamless integration of the LCDs in your panel can be obtained. Again, as with the gauges, with the current state of technology you don't need deep technical knowledge to build a radio stack yourself (see Heideveld, VanDerWiele, OpenCockpits).

3.4 Flight controls

There are a number of suppliers that offer ready-made flight controls varying from standard to advanced (for example, CH Products, Flight Link, Airplane Stuff, GoFlight, Logitech, Precision Flight, and Thrustmaster). It is also possible to make the flight controls yourself. Microsoft *Flight Simulator* allows the control of several so-called 'control axes' by means of a game card or USB device. Interface cards that behave like a gaming device are offered by Fly-by-night, SIMKITS, and Bodnar, as well as others. A set of very instructive tutorials can be found on FlightSim. There are many examples online (e.g., Norbert Bosch). If you build a cockpit for a lighter aircraft, it is worth the effort to search for parts at specific suppliers such as Aircraft spruce.

A special area of interest is the use of flight controls with force feedback. This can even be enhanced using a utility called FS Force that will allow for additional types of force feedback during flight. Although you can buy force feedback off the shelf, you can also create your own feedback. Doing this will give you more options to simulate real-life behavior. It is important to make a distinction between vibration-like effects (formally called tactile feedback; e.g., turbulence, canon shots) and effects that simulate force (formally called haptic feedback, caused by speed and g-forces). With classic aircraft, such as the DC-3, haptic feedback is very important: the higher the speed, the more force needed to handle the yoke. The most basic variant is to create contra force with a bungee: the more you pull, the greater the force. A more advanced approach is to stretch the bungee with a device such as a linear stepper motor, where the result depends on the speed of the aircraft: low speed becomes low force, and high speed becomes high force. Similar issues play a role in aircraft such as the F-16, where more force is needed on the joystick when speed increases (called "actuated stick control"). If you have higher than average ambitions with respect to flight controls, take a look at Universal Flight. They offer, in addition to a yoke, a stick shaker used in airliners for stall warnings.

3.5 Display system

The display system is an important area of attention for most simulator cockpits. How to proceed depends on your cockpit type as well as your ambitions. Using the correct graphics cards (e.g., NVIDIA and Matrox), it is easy to expand your system with multiple monitors. It is also possible to simultaneously view Microsoft *Flight Simulator* on multiple PCs. Wideview is popular among simulator cockpit builders for creating a multi-monitor setup using networked PCs. Each PC runs a copy of the simulator. The PC where the pilot actually flies—and where the input peripherals are connected—is considered the server; the other PCs are considered clients.

A low-budget approach to magnifying a display is the use of a Fresnel lens. There are a variety of types and sizes available. A general rule is that higher groove density allows higher-quality images but loses more light. Suppliers for the visually impaired are a good place to begin your search. Additionally, they often offer mounting devices (see Edmund Optics). Bugeye Technologies offers multiple monitor systems based on Fresnel lenses.

A more professional approach is to use monitor-based collimated display systems. These systems are designed to provide an out-of-window view by displaying a scene with realistic depth-of-field cues for the pilot/operator. The downside of a collimated display is that, in order to see the correct image, the user must keep his or her head (eyes) within a small area. Examples of providers are Glass Mountain Optics and SEOS. Examples of flight simulator cockpit builders with more advanced display systems are Rick Lee's flightsim pages and 737sim.

The third option is to use a beamer. There is a lot of information about beamers on the Internet. There are two special issues to consider:

- The beamer should have sufficient resolution (at least 1024x768) to see all of the effects in Microsoft *Flight Simulator.*
- The beamer should support moving images; i.e., the refresh time should be fast enough (old models sometimes have a slow refresh time that blurs moving pictures).

The Hi Resolution Image Generator is an example of an advanced beamer system designed to warp and edge blend any image on any curved surface—for instance, a 45-degree circle area.

3.6 Sound system

Within a simulator cockpit, sound plays an important role, allowing you to really submerge yourself in the environment. (Issues related to sound with respect to generating vibrations in your cockpit setup are discussed in the Vibration System section.) By means of the Microsoft *Flight Simulator* Sound SDK, you can tune the sound effects that you generate from within the simulator. Although Microsoft *Flight Simulator* offers a range of sound effects, additional sound effects can increase the realism of your simulator cockpit. Several add-ons are available that provide means to add sounds. They allow for sounds to be triggered by events occurring in *Flight Simulator* or on request from self-developed gauges/logic. An example is pmSounds, which allows you to specify sounds depending on flight data.

With *Flight Simulator X*, you can assign multiple sound cards to groups of sounds. This means multiple sound systems (e.g., headset for ATC, speakers for ambient sounds) can be installed in the cockpit. Using a headset is an option that allows you to become more submerged in your simulator cockpit while flying, or to avoid disturbing the people around you. There are many general suppliers for headsets (e.g., Headsets.com).

An interesting device is the Audio Over Ride Box (Jeff McCracken) that lets you combine several different sources of sounds. If you already own a real-world pilot headset, then you can use the PC Flight Simulator Headset Adapter (Pilot Products Distributing), which allows you to use your headset with Microsoft *Flight Simulator.* On FlightSim there is an article by Alan Bryant on adapting an aviation headset for use with a PC sound card. An even more Microsoft *Flight Simulator*-specific solution is the GF-ATC Headset Comms Panel (GoFlight). Interacting with air traffic controllers over the Internet, or with the built in ATC, is made more realistic by volume and squelch knobs. Responding to the menu-based air traffic control in

Microsoft *Flight Simulator* can be done using a rotary knob with integrated push switch and a single-digit LED display.

3.7 Speech system

Most flight simulator pilots fly alone, with no co-pilot ... only the PC. Along with the possibility of feeling lonely, handling more complex situations and aircraft can start to feel less realistic due to information overload. An automated checklist either in text only or in text-to-speech mode can help. The same applies for the use of voice commands. If you need an extra pair of hands to fly the way you would prefer, this may be your solution.

There are some very interesting solutions using voice commands. When used with Microsoft *Flight Simulator*, voice commands add to the feeling that you're in the cockpit of an aircraft, giving instructions to a co-pilot. Voice Buddy, one of several options intended for use with Microsoft *Flight Simulator*, is a combination of headset and software for speech recognition. More advanced voice interaction is offered by VoxATC, which provides a simulated ATC environment with integrated voice recognition. These programs allow you to talk to the controllers. As well as listening to your requests, they check your read backs.

Speech can add serious value to your simulator experience. A 'talking' checklist or 'talking' warnings can reduce the information overload in the cockpit, making it more realistic (and more fun) to fly more complex aircraft. There are several commercial products available that add a 'digital' co-pilot to Microsoft *Flight Simulator*. Examples are FDC Live Cockpit and FS Flight Keeper. The downside of these packages is that they work based on real sound bytes: a voice can be added and applied only within a fixed framework. If your ambitions are higher, it is possible to develop your own digital co-pilot. During recent years, developments with respect to speech generation have reached the level that with moderate effort you can develop a text-to-speech application. For programmers, the starting point is the Microsoft text-to-speech support. There are also commercial libraries that can be included with, for example, a Visual Basic program. The use of these libraries is often a bit easier than using the SDK; an example is Chant. If you are not deep into software development, then there are even hardware solutions available such as Triangle Digital and Digital Acoustics.

3.8 Vibration system

By adding vibrations, your cockpit will come to life. When positioned correctly in the cockpit, the touch of your flight controls and the feeling in your back and feet will convince you that you are on the move. There are two main routes to generating vibrations: tactile transducers and vibrators. Tactile transducers cause you to feel the sound in your body, which is missing when sound is played back in a standard way. They produce vibrations between 1Hz and 800Hz. An example of a supplier offering a range of tactile transducers is Clark Synthesis. Examples of vibration systems that use embedded electro motors to generate vibrations are the ButtKicker and TFS2. Instead of transferring sound waves through the air, these devices attach, for instance, to seats and floors, sending vibrations directly into the listener's body. The perception is stated to be better than tactile, and the sound pressure of the low vibrations disappears.

3.9 Motion system

The sense of motion in real flight is generated by G-forces resulting from a combination of movement and the position of an aircraft. This sense of motion in many cases does not directly correspond to the position of the flight controls during flight. Compared to the generation of vibration in a simulator cockpit environment, it is much harder to generate a sophisticated movement experience in a simulator cockpit.

The ultimate motion system has what is called six degrees of freedom (6 dof):

1	Roll	X-axis/rotational: acceleration, deceleration, bumps
2	Surge	X-axis/longitudinal: strong acceleration, strong deceleration
3	Pitch	Y-axis/rotational: acceleration, deceleration, bumps
4	Sway	Y-axis/lateral: slip
5	Yaw	Z-axis/rotational: slip
6	Heave	Z-axis/vertical: bumps, vibrations

The rotational movements around the X-axis and Y-axis (bank and pitch) are the most important to generate a moving sensation.

A unique low-price do-it-yourself motion platform is the JoyRider (acesim). They offer detailed construction drawings, a construction guide containing step-by-step directions covering every detail of each assembly operation, and a complete parts lists and sources. Although driven by stick position, this platform may be a basis for a motorized version. A similar approach is followed by Flight Control Simulator, SimCraft, and DreamFlyer. Documentation on the predecessor of SimCraft is available on SourceForge.

Classic Flight is a unique supplier. They offer boards and software to control the motion platform—basically all you need for building your own motion platform without getting into all the programming details. A range of motion platform configurations is supported.

Examples of ready-made motion platforms with 2, 3, or 5 axes that can serve as the basis for a flight simulator cockpit can be found at SimWare, Real Sims, InMotion Simulation, and Force Dynamics. A new approach on motion can be found on MORSIM.

Home-based examples, including documentation, can be found at FMFSP and ClassicSim.

3.10 G-force system

G-forces are a side-effect of being in motion. They are the result of a strong movement combined with acceleration, deceleration, or turning. It is possible to obtain G-force data from Microsoft *Flight Simulator*. Using this data, it is possible to simulate G-forces by means of physical force. Examples of effects:

- Activating an inflatable pad inserted under the cushions of the cockpit chair simulates increasing G-forces. A pad under the seat gives the feeling of being pushed in the seat, while a pad in the backrest simulates acceleration. Using multiple pads spread under seat and back could in a very advanced setting produce simulated directional forces.
- By tightening and loosening the seat belts using servos, stepper motors, or hydraulic/pneumatic tension, similar effects as above can be achieved.

- Attaching a helmet to servos or stepper motors with elastic strings gives the ability to produce force effects.

An example where a real G-suit is integrated in the simulator cockpit system can be found on MMMS.

4 Off you go!

Whether your dream is to have a real B737 cockpit section in your garage or just a set of pedals below your desk in addition to your joystick, just about anything is possible. When going for high-end results, however, it is important to keep your hobby to a manageable size. Aiming for a B737 cockpit but running out of budget, knowledge, money, and/or time will only lead to frustration. A B737, for instance, comes with over a meter of manuals, while a Cessna 172 will do with only several centimeters—a measure of required time and commitment.

Following a phased approach is probably the most rewarding. Don't make your stages too big; otherwise you might not continue enjoying the activity of flying while working on your project. Keep in mind that defining phases should facilitate your ambitions. Setting a timeline can be a self-inflicted wound if it creates stress and/or frustration, and should therefore be avoided. Sites of fellow simulator cockpit builders can offer good insights into all issues that play a role. Strolling through these sites on a regular basis can be very instructive and motivating.

Creating a simulator cockpit—whether simple or elaborate—will certainly enhance your Microsoft *Flight Simulator* flying experience. And the experience of attempting to realize your ambitions can be a whole new inspiring challenge.

5 Resources

5.1 Sites

- CockpitSolutions
- Flightdeck Builder
- Flight Simulator Cockpits
- FScockpit
- HSB Registry
- MyCockpit.org
- Mikes Flight Deck
- OpenCockpits
- OpenCockpits (German user group)
- Simbuilders Wiki (and forum)
- Simpits (and mailing list and WebRing)
- Simprojects
- WebRing SimPits

5.2 Forums

- 747 cockpit builders forum
- AVSIM cockpit builders forum
- Check-Six! cockpit builders forum
- Fighter Ops cockpit builders forum
- FlightSim cockpit builders forum
- FlightXpress cockpit builders forum
- Frugal's world cockpit builders forum
- FS Forum cockpit builders forum
- FS Magazine cockpit builders forum

- Hovercontrol cockpit builders forum
- Polish VATSIM cockpit builders forum
- SimFlight Network cockpit builders forum
- Simviation cockpit builders forum
- ThaiFlight cockpit builders forum
- ViperPit cockpit builders forum
- VATIL cockpit builders forum
- Worlds Serious Pilots cockpit builders forum
- Usenet (regular items on flight simulator cockpits)
  + rec.aviation.simulators
  + comp.sys.ibm.pc.games.flight-sim
- Yahoo
  + Construccion de Cabinas cockpit builders forum

5.3 Simulator cockpit-related suppliers

3D Flightsim
737NG Sim
Advanced Rotorcraft Technology
Advanced Simulation Systems
Aerodeck Engineering
Aerosim Solutions
AIMSWORTH simulation
Aircraft Simulation Techology
Aircraft Spruce
Air-Crafts
Airplane Stuff
AITI
BETA Innovations
BR Simulations
CH Products
Classic Flight
Cockpit Sonic
CockpitWare
Command Fliteware
CP Flight
CSI Cockpit Simulations
Cyber Seat
Cyberdome
Daken Skys
D-Box
Desktop Aviator
Dessert Air
Dream Flyer
Effects In Motion
ELITE
Ellie Systems
F-16 simulator
Flight & Motion
Flight Control Simulator
Flight Illusion
Flight Link
Flightdeck Software
Flightdeck Solutions
Flightdeck Technology
FlightPanels
Flightsim Consoles
Flightsimulator CH
Fly by night
Fly engravity
Flyingdash
FlySim
Flyware
FSHW
Geo Sim
Go Flight
H.E. Simpanels
HCB Parts
Heli-kit
HeloSims
High Rev Simulators
Hispapanels
HomeSim
HotSeat
ImmersaView
In Motion Simulation
Innovative FSP
ITRA
Joy Rider
KwikPit
Lausitz Aviation
Logitech
Majestic
Mason
Microspace Flightware
Montreal AeroPlus
Moto Tech Cockpits
MRVC
Northern Flightsim
Open GC
Pacific Simulators
Peix software
Plug 'n Fly
PolDragonNet
Precision Flight Controls
Project Magenta
Quickshot
Raven Cockpits.co.uk
Real Simulator
Reality XP
Realsims
Routech
Saitek
Sea Gull
SEG Motion Tech
Sim Cockpit System
Sim Control
Sim Hard
Sim Knobs
Sim Motion
Sim Werx
SimCraft
Simelations
SIM-Instruments
SIMKITS
Simparts
SimPit
Simulated Aircraft Instruments
Simzation
Thai Flight Simulator
Thrustmaster
Two Plane Guys
Universal Flight
Van den broeck
VFlight
VFR-Cockpit
Viper-pits
VistamareSoft
VKB Flightsim Controls
Xesa Systems
Xmotion