There comes a time in every homebuilt project when the design and construction of the instrument panel must be tackled. For a some, this is a process long anticipated, perhaps as an opportunity to express their creativity and vision for their aircraft. For others, possibly even the majority of builders, it's a process which, if not actually dreaded, is associated with considerable trepidation. The unknown can certainly be intimidating and it's my hope that a clear step-by-step examination of the process of designing and building an instrument panel will encourage many builders to undertake it themselves.

Before buying any of the components for your new instrument panel and long before beginning to cut metal, you should have settled a number of questions in your own mind. The most important of these, and the one from which all other considerations will devolve, is: What is the basic mission of the airplane? With respect to panel design, that boils down to VFR vs. IFR. While we've all seen VFR panels equipped with every gadget under the sun and IFR panels getting by with little more than a single nav/comm, those airplanes represent the exception, not the rule. Generally speaking, the reverse is far more common. Without belaboring this somewhat obvious point, suffice it to say that the basic weather mission of the nascent panel should be given due consideration and a conclusion reached.

Some other topics to consider up front:

- Budget. It is, for most of us, if not our primary concern, at least one of the most important. Having decided to spend a certain sum of money on an airplane project, it's all too easy to find oneself going around and around over where and how best to allot those funds. Suffice it to say that budgetary concerns will likely affect all other decisions made on the project.

- Do you prefer analog or electronic gauges? Both will do the job, but each type of instrument presents its information to the pilot in different ways. Most of us are accustomed to flying with analog instruments and their interpretation has long been automatic. Flying with electronic instruments will require a period of acclimation as you learn to both manipulate their controls and interpret their data in flight. Perhaps a combination of both types will suit your needs best? Detailing the pros and cons of each sort is beyond the scope of this article, though you should come to your own conclusions before beginning the layout process for your new panel.

- Will you incorporate gyroscopic instruments in your panel? The answer to this question will follow directly from the conclusion you drew as to the weather mission of your airplane. If you've opted for a VFR panel, you may or may not plan to install gyros. The simplest panels will forego them entirely, though there's nothing wrong with including gyros if you're accustomed to flying with them. An argument could certainly be made that the presence of gyros in a VFR airplane provides some measure of safety in case of an inadvertent encounter with weather. If you've decided on an IFR panel, then you're going to be installing attitude and heading gyros, as well as a turn coordinator.

- If gyros are going to be a part of your panel, then the next point to ponder is whether they're going to be of the vacuum or electric sort. Vacuum gyros will require the installation of a vacuum system (pump, regulator, filter and suction gauge), adding weight, complexity and possible failure modes (usually pump failure) to your airplane. Electric gyros obviate the need for the supporting system hardware, but are much more expensive. They also represent an additional load on your airplane's electrical system with their own possible failure modes. Whichever type of gyro your choose, if you're going to be flying IFR, you should give some thought to a backup system.

- Will you be flying aerobatics in your airplane? If so, you'll want to include a G-meter in your panel plans. Also, if you decided to install gyros, you should give some thought to protecting those expensive instruments, possibly by building a removable sub-panel to hold them. When it's time to yank and bank, simply remove the sub-panel from the airplane and go play.

- Attention should be paid in the planning stage to the configuration of your airplane. Side-by-side and tandem configurations each have their attendant panel space limitations. A side-by-side airplane will have more panel real estate available and may be more easily adaptable to an IFR installation. Tandem airplanes will have correspondingly smaller panels and, though it's certainly possible to equip one for IFR (especially with the utilization of some electronic instruments), are generally better suited to VFR installations.

- Give some thought to a couple of other design considerations: the overall concept of symmetry and whether or not to center the traditional 'six-pack' (if using one). The advantages of centering the primary flight instruments in front of the pilot should be obvious, though some tandem designs may require a slight offset if you want to fit your radios in the main panel. Centering the radios themselves, if panel space will allow it, permits the stack to be easily accessed by either pilot in a side-by-side design, or manipulated by either hand in a tandem airplane.

- Don't forget to take note of any structural members behind the panel and plan ahead to avoid interference with your instruments and avionics.

Having thought through these issues for yourself and, hopefully, reached some conclusions, it's now time to think about laying out the panel. The complexity of this task can run the gamut from fairly straightforward (with a simple VFR panel) to extremely intricate (with a complicated IFR setup). Regardless of the detail involved with any particular panel, several different approaches can be taken at this point. Commercial software (such as Panel Planner) may be purchased which can go a long way toward helping to visualize the completed panel. Online tools (such as epanelbuilder) are available which perform many of the same functions as the commercial software at a far lower cost (usually free). Either of these packages can be used to generate not only an image of the panel itself, but also running totals of cost, weight and electrical load, as well as providing an indication of required depth behind the panel. One old-

fashioned method is still extremely effective: simply make full-size cutouts of some generic instruments and avionics and then affix them to your actual panel blank with double-sided tape. You can easily move them around as inspiration strikes you.

Using any of these panel design methods should be considered an iterative process. You'll go through several (maybe many) versions of your panel before deciding which one to actually build. You'll find that, as you consider each version over time, you'll make progressively fewer and smaller changes. When you've arrived at a static design or two, go ahead and take the trouble to print them out full-size and then spend a few days visualizing how you'd actually fly with each particular panel. After some time spent contemplating the options, your final decision will (hopefully) be obvious.

Now that you've arrived at a final design, it's almost time to start cutting. Take time now to draw some layout marks on the panel blank. Find the center and draw a vertical line from the top to the bottom of the panel. This will be your primary reference line and will greatly assist you in locating the exact positions of all your instruments. Before beginning to measure and mark up your panel, remember to take each instrument's flange into consideration. In other words, take note of the extra material (usually square around a round instrument) that surrounds the instrument's visible face. Since the instruments will be mounted from the back of the panel, the flange material will not be seen, but you'll need to space each flange a small amount (1/4" will do) from its neighbor on each side, both for cosmetic reasons on the front of the panel and for ease of installation on the back side.

There are a variety of ways by which you can actually cut the panel. Various commercial firms will be all too happy to laser cut the panel to your specifications, either from a CAD file or simply from your detailed description. If you're careful and patient, however, you can do an excellent job yourself with some simple tools. The round holes for instruments can be cut with a flycutter, holesaws, or punched with an instrument punch. A reversible punch designed for this specific purpose can be purchased, with which perfect 2 ¼" and 3 1/8" holes can be made. Rectangular holes (such as those for radios, trim indicators, gloveboxes, etc.) can be made with a nibbler, either manual or pneumatic. After making the basic cutouts, each instrument will most likely have to be custom fit to its designated hole. This can be readily and quickly accomplished with a sanding drum on a Dremel. The same sanding drum can be used, perhaps in combination with a small burr, to create the extra corner relief required by some instruments (such as altimeters). With all the instruments and avionics now custom fit to their cutouts, a template (readily available from the usual aircraft tool supply houses) should be used to precisely locate all of the screw holes. Having located the holes, centerpunch and drill them to #6, or as required by your hardware. Brass instrument screws should be used to eliminate any possibility of electromagnetic interference with your instruments (particularly the magnetic compass, though others are also susceptible).

Take the time now to construct a sturdy radio rack to support your large, personal investment in the aviation electronics industry. A radio rack serves a couple of principal purposes: it ties all of the trays together and provides a means of attaching the grouping to the panel; and it also enables

you to easily brace the entire stack to the airplane. The whole radio rack should be sturdily braced to some solid structural member behind the panel in order to help take the weight that would otherwise be borne by the panel alone. Remember to take into account the fact that the entire radio stack will weigh up to six times (in an aerobatic airplane) its 1g weight in the course of flying through the airplanes' normal flight envelope. That's a lot of weight to support only at the front, as well as a large strain on the panel itself. Use some aluminum angle to tie the radio trays together in four places, two on each side front and back. The angles can be readily attached to the individual radio trays by means of small screws inserted from inside the trays out through the angles. Use the pre-existing holes in the trays or drill new ones if necessary. Use (or placement) of the holes along each tray's longitudinal centerline will keep the screw heads from interfering with the smooth insertion of the radio into the tray. The front angles will butt up against the back of the panel and will serve to anchor the rack to the panel. The rear angles simply tie the back of the rack together and also provide a convenient place to attach the structural bracing angles.

Now that the basic structural work on the panel has been completed, a decision must be made on how to finish it. Some builders choose to have their panels commercially powdercoated, which makes for an attractive and durable finish. It's also possible to purchase custom-made panel overlays of various materials (including exotic woods, if that look appeals to you). Having come this far along, however, toward completing the new panel unassisted, why not paint it yourself? A very fine finish can be achieved in the home workshop with the use of a spray gun. Some builders prefer a matte black panel for its anti-glare properties, while others find a light gray to be similarly glare-resistant and more attractive to boot. The choice of a light gray panel will also add some flexibility to your labeling options. Various labels and placards will have to be affixed to the panel and several methods of accomplishing the task are in common usage. Professional silk-screening is certainly an option, as is the purchase of a backlit panel overlay. Very nice results can also be achieved on your own with the use of a Brother P-Touch labeling device. This extremely handy little gadget will print custom labels in various sizes on a wide assortment of available label stock. The best choice for our instrument panel purposes (if using a light colored panel) is black-on-clear. This works out just as it sounds, producing black letters on a clear background that will nearly disappear after application. Easy to do, relatively inexpensive, easy to modify in the future, and looks great!

Having designed, laid out, cut, drilled, painted, and labeled the panel, it's now time to install it in the plane for (hopefully) the last time. It's usually much easier to install the panel in the plane before attaching the instruments to the panel, if only to avoid having to manhandle the much heavier, fully populated panel. Once the panel is fixed in place and the instruments have been mounted, it's time to start on the task that will turn what is presently a large, very expensive paperweight into a functioning instrument panel: Wiring…

Wiring an airplane is a topic on which entire books could (and have) been written. Fully covering this subject is far beyond the scope of this article, which is merely to elaborate for the novice the necessary steps in constructing one's own instrument panel. It should be stated up

front that there are currently two factions, representing distinct and opposing viewpoints, on how to properly wire a modern homebuilt aircraft. The first camp maintains that the use of traditional aeronautical circuit breakers is the way to go, and the other group advocates the use of automotive fuses. Each method has its merits and its disadvantages and it behooves the prospective aircraft wiring acolyte to read up on both, talk to some experienced builders of his acquaintance, and decide for himself which path to follow. This is one of those topics likely to start a religious war amongst otherwise rational and good-spirited homebuilders and I mention it partly to spur individual research and reflection, and partly as a warning against ever bringing it up in public…