What's On Your Horizon?

Equipment Descriptions to Assist with Your Avionics Purchases

NAVIGATION EQUIPMENT

The use of radio navigation equipment dates back to the early 1920s, where in 1928, the Aeronautics Branch of the Department of Commerce commissioned the first radio range beacon on the Federal airways at Bellefonte Station, Pa. Since that time, the navigation system of the United States has grown in strength and usability, until it has reached the point we are today—the ability to navigate nationwide, and make precision instrument approaches, all without having to look outside the cockpit!

Very High Frequency Omni-Directional Range (VOR)

The Very High Frequency Omni-Directional Range (VOR) navigation systems are used for enroute and terminal navigation purposes. When used in conjunction with distance measuring equipment (DME), localizers and glideslope receivers, VORs can be used for precision approaches and landings.

VORs operate within the 108.0 to 117.95 MHz frequency band and have a power output necessary to provide coverage within their assigned location. The VOR system is subject to line-of-sight restrictions, and the range varies proportionally to the altitude and quality of the receiving equipment and antenna, and the strength of the transmitter.

To get the most out of your VOR receiver, it must be properly maintained. Accuracies of plus or minus 1 degree are expected for the system, with some exceptions. For example, some VORs may have minor course roughness, as seen by the course needle or brief flag alarm activity, while stations in mountainous terrain may occasionally cause the pilot to see brief course needle oscillations, similar to the indication of "approaching station."

Pilots flying over unfamiliar routes are cautioned to be on the alert for these vagaries, and in particular, to use the "to/from" indicator to determine positive station passage. In addition, on rare occasions, certain propeller RPM settings or helicopter rotor speeds can cause the VOR Course Deviation Indicator to fluctuate as much as plus or minus six degrees. If you find yourself with this problem, a slight change to the RPM setting will normally smooth out the roughness. More importantly, you should try changing your ROM before you report a VOR station or aircraft equipment for unsatisfactory operation.

Distance Measuring Equipment (DME)

DME operates on frequencies in the UHF spectrum between 962 MHz and 1213 MHz. The DME sends out paired pulses at a specific spacing, and are received at the ground station, which then transmits paired pulses back to the aircraft at the same spacing but on a different frequency. The time required for the round trip is measured in the aircraft's DME unit, and is translated into distance from the aircraft to the ground station.

This provides a very accurate indication of an aircraft's speed and distance from the station, however; distance information received from DME equipment is the SLANT RANGE distance and not actual horizontal distance. This means that the distance incorporates both your distance above the ground, as well as your distance from the station. For example, if you cross a DME station at 5,280 feet, you will see 1 nm distance from the DME, even as you cross it.

With the advent of the accuracy and proliferation of IFR certified GPS systems, the AIM allows pilots of aircraft in the U.S. National Airspace System to use IFR certified equipment in place of the DME for en route and terminal operations.

Global Positioning System (GPS)

GPS is a U.S. satellite-based radio navigational, positioning, and time transfer system operated by the Department of Defense (DoD). The system provides highly accurate position and velocity information, along with precise time on a continuous global basis to an unlimited number of GPS users. The advantages of GPS over other navigation systems such as LORAN, or LOng RAnge Navigation, is that GPS is unaffected by weather, and more importantly, provides a worldwide reference system.

The GPS constellation is comprised of 24 satellites, and is designed so that a minimum of five are always observable by a user anywhere on earth. The way GPS works is that it ranges and triangulates on the satellites in space, which act as precise reference points. The portable or panel mount GPS receiver measures distance from each visible satellite using the travel time of a radio signal. Each satellite transmits a specific code, which contains information on the satellite's position, the GPS system time, and the health and accuracy of the transmitted data. Knowing the speed at which the signal traveled (approximately 186,000 miles per second) and the exact broadcast time, the distance traveled by the signal can be calculated.

Using the calculated pseudorange and position information supplied by the satellite, the GPS receiver mathematically determines its position by triangulation. The GPS receiver needs at least four satellites to yield a three-dimensional position (latitude, longitude and altitude) and time solution. The GPS receiver computes navigational values such as distance and bearing to a waypoint, ground speed, etc., by using the aircraft's known latitude/longitude and referencing these to a database built into the receiver.

GPS provides two levels of service: Standard Positioning Service (SPS) and Precise Positioning Service (PPS). SPS, otherwise known as selective availability (SA), provides horizontal positioning accuracy of 100 meters, or less, with a probability of 95 percent and 300 meters with a probability of 99.99 percent. PPS is more accurate than SPS, and removes the "intentional error" introduced by selective availability. Since SA was turned off in May of 2000, SPS errors have ranged in the area of around 5 to 10 meters, 95 percent of the time.

Localizer

The localizer transmitter provides signals that present the pilot with course guidance to the runway centerline. The system operates on one of 40 Instrument Landing System (ILS) channels within the frequency range of 108.10 to 111.95 MHz.

In technical terms, the localizer provides course guidance throughout the descent path to the runway threshold from a distance of 18 NM from the antenna between an altitude of 1,000 feet above the highest terrain along the course line and 4,500 feet above the elevation of the antenna site. To visualize the signal, imagine that the airplane is flying into a cone—as the plane gets closer to the cone, the guidance narrows to provide a very precise point at the end, which is typically aligned with the runway.

Off-course indications are provided to 10 degrees either side of the course inside a radius of 18 NM from the antenna, and are increased to 35 degrees either side of the course when inside 10 NM from the antenna. The localizer signal is transmitted at the far end of the runway, and is adjusted for a course width of (full scale fly-left to a full scale fly-right on your course deviation indicator) of 700 feet at the runway threshold, to assure that pilots flying inbound have a high probability of making visual contact with the runway.

Glide Slope/Glide Path

The glide slope transmitter

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works in conjunction with the localizer. Where the localizer provides horizontal guidance to the runway centerline, the glide slope provides vertical guidance to the end of the runway. In this manner, the system can place an airplane at the end of the runway, as low as 200 feet above the threshold, depending on the approach, making it possible to land in conditions with low ceilings that would otherwise be impossible.

The UHF glide slope transmitter operates on one of the 40 ILS channels within the frequency range 329.15 MHz, to 335.00 MHz, and radiates its signals in the direction of the localizer front course. The term "glide path" means that portion of the glide slope that intersects the localizer. The glide slope transmitter is located between 750 feet and 1,250 feet down the runway from the approach end, and is offset 250 to 650 feet from the runway centerline. It transmits a glide path beam 1.4 degrees wide (vertically). The signal provides descent information for navigation down to the lowest authorized decision height (DH) specified in the approved ILS approach procedure.

The glide path projection angle is normally adjusted to 3 degrees above horizontal so that it intersects the middle marker at about 200 feet and the outer marker at about 1,400 feet above the runway elevation. The glide slope is normally usable to the distance of 10 NM. However, at some locations, the glide slope has been certified for an extended service volume, exceeding 10 nautical miles.

Transponder and Altitude Reporting

The forerunner of today's beacon system was developed during World War II to enable radar operators to identify targets as either friendly or enemy, and was originally called "IFF" for identification friend or foe. The current transponder system consists of airborne and ground based systems. The ground transmitter sends a signal to the aircraft transmitter, which in turn, replies in a set code, depending on how the pilot sets the transponder code.

As a result of mid-air collisions, the Air Traffic Control Radar Beacon System (ATCRBS) was developed which provided the controller with continuous reliable and accurate information concerning the position and identity of all transponder-equipped aircraft within an area by a series of coded replies that appear on the radar scope.

The current transponder technology uses 4,096 individual codes in addition to the Mode C, or altitude information replies from aircraft transponders. Mode C altitude reporting provides information on an aircraft's altitude in 100-foot increments. With this system the controller is able to identify any ATC transponder-equipped aircraft up to a distance of 200 nautical miles and at an altitude limited only by the service ceiling of the aircraft, or ground obstructions for the radar.

To meet the operational requirements of Part 91, ATC transponder equipment installed must meet the performance and environmental requirements of any class of TSO-C74b (Mode A) or any class of TSO-C74c (Mode A with altitude reporting capability) as appropriate, or the appropriate class of TSO-C112 (Mode S).

Mode S transponders provide more data to the controller, to assist in aircraft handling. The additional information includes the aircraft registration number or flight ID, the transponder capability, and the maximum airspeed range. Many Mode S transponders can now receive Traffic Information Service (TIS) data in those areas equipped with the necessary support radar system. When connected to a compatible multi-function display (MFD), reasonably accurate traffic information can be provided to the pilot for traffic avoidance.

COMMUNICATION

Audio Panel

The audio panel is the switchboard of the aircraft's radio stack. This device coordinates the audio output from your nav, com, DME, ADF, and even airborne entertainment systems, and provides quality audio to your headsets or aircraft speaker. It also selects which com radio will be used, in aircraft with multiple com radios, and is the interface to airborne telephones.

IFR versions of the audio panel typically include a Marker Beacon receiver, which is used to detect the various marker beacons that are part of the Instrument Landing System. Muting is available to allow pilots to silence the markers once they have been received. The latest audio panels can accept several entertainment source inputs, with the ability to automatically mute those inputs when radio signals are received.

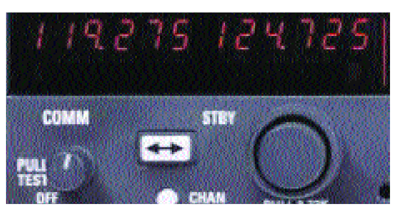
The latest audio panels include a full-featured intercom system, which allows clear communications between the headset-wearing occupants of the aircraft. The interface controls typically include volume, and the ability to separate the pilot or the pilot and copilot from the passengers, or to have everyone able to communicate with one another, as desired.

Com Radio

Today's 760 channel com radio has evolved from its past incarnation as a simple communication device. Rather than just being able to listen to a single frequency, some of today's com radios can transmit and receive on one frequency, while listening to the standby frequency. Others can listen to NOAA radio, and have multiple memory frequencies to make it simple to pull up your most frequently used channels with a minimum amount of dial twisting. Today's coms operate in a frequency range from 118.000 MHz to 136.975 MHz in 25K Hz increments.

The advent of GPS/com receivers and MFDs has also had a positive impact on the com. As an example, the typical GPS/com or MFD can automatically tune in your next frequency, when you need it at the touch of a button. Another advantage to the com produced today is that it is more electrically efficient, and more reliable in the long run in your aircraft. As a direct result of improvements in technology, today's coms have slightly improved modulation, which means you will sound clearer than ever in your transmissions.

The question of whether to purchase a stand-alone unit, or a com that is part of a GPS/nav/com or nav/com combination may be a matter of personal preference. Some pilots prefer stand-alone units, since a single failure of a circuit breaker only disables the powered component, and doesn't suffer any loss of efficiency from multi-unit devices. This was more of an issue in the past. Today the level of component integration has increased to the point where failures are improbable, and the functions of the avionics are sufficiently tested and discreet to avoid any conflicts.



The com radios available today offer considerable improvements over those available in the 1970s and early 1980s. If you are flying around with one of the older, mechanically tuned coms, you are missing out on all the new features that are available to you. Whether you need remote tuning with your GPS/MFD, or just some frequencies in memory to help reduce your cockpit workload, today's coms will help you communicate more effectively and efficiently.

AUTOFLIGHT

Autopilot

The purpose of the autopilot is to act as an aid to the pilot in maintaining their course, altitude, and even rate of climb in some advanced models. In doing so, this system helps to remove

some of the stress on the pilot who flies with it. The autopilot systems that are currently available range from the simple wing leveler, which will maintain the wings of the plane level and in doing so, maintain course; the tracker, which can be used to follow a VOR radial or GPS course; to the "fully coupled" autopilot, which can not only climb to and maintain an altitude, but can intercept and establish a radial or course as needed. The fully coupled autopilot can fly an ILS virtually hands-off, provided the proper power settings are made.

When properly installed, an autopilot will reduce the cockpit workload for the pilot, allowing them to maintain a better scan of the airspace around them for other aircraft, as well as to assist

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the pilot flying single pilot IFR when it is necessary to refer to charts or approach plates. In doing so, they help pilots avoid mid-air collisions, as well as altitude or course busts while flying on instruments.

IN-FLIGHT ENTERTAINMENT SYSTEMS

Another recent innovation has been the introduction of entertainment to the aircraft cabin. These systems, which include AM/FM radios, AM/FM CD players, and even DVD and satellite radio systems, can help to get music and even video into your

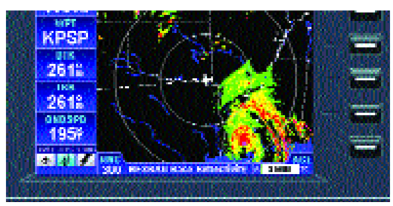
aircraft. Some systems have the capability to perform two tasks at the same time, allowing the pilot and co-pilot to listen to the radio, while the back seat passengers watch a movie. The latest audio panels will automatically mute the music inputs, allowing the pilot to concentrate on any ATC communications with little effort.

DISPLAYS

Multi-Function Display

The purpose of a MFD, or multi-function display, is to integrate various elements in the cockpit into a single, easy-to-use source. As an example, MFDs exist which combine course information with airborne weather, lightning detection, radar, terrain, and even traffic, all into one display.

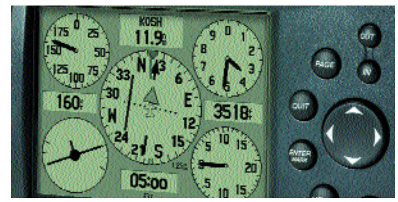
The advantage of the MFD is that the pilot has one place to look for all critical information. These systems are available in a variety of combinations, with even portable units available. The system you choose for your airplane should match your flying needs closely. For example, if you are flying in hard instrument weather conditions, and already rely on weather radar, then a system that has a radar interface can be used, and linked to airborne weather to further enhance your situational awareness.



Conversely, if you happen to spend more time flying in visual conditions, a large screen GPS display, with an interface for traffic or lightning detection may be more than sufficient to meet your needs. Each display available has strong points, so it will be important for you to know what you expect the display to do in order to be able to find the display that provides the best return for your installation dollar. Whether you are VFR or IFR, the addition of a MFD to your cockpit can only improve your situational awareness, and in doing so, give you a tactical edge in your flying to better avoid hazards.

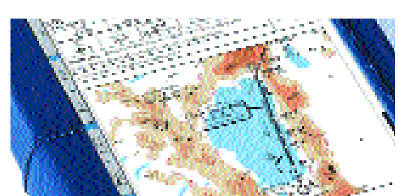
Portable Display

Interest in handheld GPS units and moving maps has spawned a flurry of products ranging from yoke- and glareshield-mounted to kneeboard positioned devices. The popularity of these units is strong because of their low (if any) installation costs and their ability to perform much like their panel mounted brethren.



Powered by alkaline or rechargeable NiCad or NiMH packs the portable GPS and moving maps have become trustworthy standbys for VFR operations.

Although never a substitute for the instrument approach, portable devices provide a myriad of reference data for the pilot. Databases include, among a host of other things, all pertinent airport information and airspace information. It's essentially all of your chart data electronically displayed with details of your current flight overlaid. The number of pages and page options seem to grow exponentially each year. Among the various types are position pages, moving map pages, flight planning pages, notes pages, and an HSI page. Each page contains even more data including ground track, groundspeed, GPS altitude, ETE, ETA, fuel data, winds aloft, user defined waypoints, obstacles, SUAs, frequency information, track history, E6B functions and more.



The ideal option for the frequent aircraft renter, portable displays allow you to carry some semblance of cockpit familiarity from one plane to the next at a fairly reasonable price. It also allows the owner/pilot to explore the usefulness and efficiencies of GPS technology before diving right into the full panel mount retrofit, which is simply a matter of time once exposed, to the endless amenities in today's displays.

SURVEILLANCE

Traffic

One of the most important parts of flying is avoiding other traffic. In the terms of our instructors, this "see and avoid" technique requires the pilot to scan the sky for other traffic, and if other traffic is sighted and is a threat, to take the correct evasive action to safely avoid the other aircraft.

The Aeronautical Information Manual suggests that for every four or five seconds spent scanning the instrument panel 16 seconds should be spent scanning the skies. Even with the best of scan techniques, finding other traffic in the sky, which may be headed directly towards you as fast as you are flying towards it, can be difficult.

Fortunately, modern cockpit technology has several solutions to offer, which can aid you in your efforts to see and avoid other traffic. As an example, Traffic Advisory Systems (TAS), are now available to help you find traffic in the area. In areas that are equipped with Traffic Information Service (TIS), this new generation of relatively inexpensive Mode S Transponders can help you to identify aircraft in your general area. These devices will show you the traffic in relation to your plane's position, what vector the traffic is generally headed in, and what altitude and vertical direction the other aircraft is headed.

How many times have you heard the controller say, "Cessna 34333 Xray, traffic 10 o'clock, 3 miles, opposite direction, squawking VFR?" As a pilot, you quickly start your scan, working hard to identify the traffic, so that you can initiate actions to avoid it if necessary. With a TAS System on board, you would have seen the traffic at about the same time the controller did. Better yet, with the vector line provided, you could easily see if the aircraft is a threat, and be able to take actions to avoid it long before it could get close enough to see in most cases!

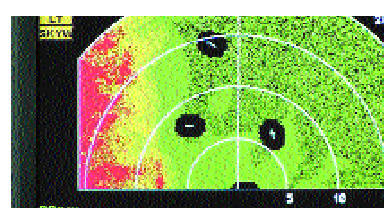
Pilots who have flown behind these systems in the areas where TIS is currently active, which includes such busy airspace as Los Angeles, Chicago, Boston and Orlando, have noted that they are literally astounded by all the traffic that they can now see, that they could not previously. Much as multi-function displays have worked to revolutionize pilot awareness of their position in the sky, these new TAS systems perform the same function for traffic.

While the TAS system is fine, TCAD, or Active Traffic Advisory Systems are TSO'd to C147 and require a horizontal situation display that indicates presence and relative location of intruder aircraft, and an aural alert informing the crew of a Traffic Advisory (TA) for Class A equipment. Class B equipment incorporates an aural alert and a visual annunciation for added protection.

As nearly everyone knows, a mid-air collision is seldom survivable. If you find yourself flying through such airspace, the purchase of one of these new traffic systems should be considered a priority in your avionics upgrade.

Terrain

Terrain Awareness Warning System (TAWS) and Enhanced Ground Proximity Warning System (EGPWS) are systems that are intended to prevent CFIT, or Controlled Flight Into Terrain. These systems started to be required in commercial aircraft following several high-profile accidents in recent years, the systems provide visual and audio cues of the aircraft's proximity to the ground, to alert pilots to hazardous situations. However, recent advances have reduced the price of these marvels, making it possible for more aircraft to be equipped.



These systems provide a "look ahead" warning to pilots, by comparing their present position and altitude to an extensive database of GPS coordinates and obstruc-

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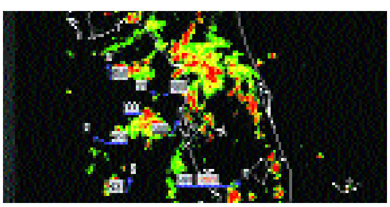
tions, which are displayed in colors to indicate conflicts. Pilots can then safely take actions to avoid these ground-based threats, and in doing so, maintain safe flight. In addition to the display, annunciators are also used to alert pilots to these threats, so that they can have the best opportunity to avoid them.

Weather

There are three different types of weather systems in the air these days. The oldest of these systems is the airborne weather radar, which scans the horizon for precipitation. The radar systems "paint" this weather in color codes on the display, allowing the pilot to gauge the storm's intensity, and to judge whether the storm may be transited or needs to be avoided.



The second most common weather detection system is the Lightning Detection System. These atmospheric or "spheric" systems are designed to detect lightning discharges in mature thunderstorms, and to show their rate of accumulation (build-up rate) and density (intensity) on a display. Pilots can then interpret this information to determine the relative strength of the storm, and what course should be flown to avoid it. Note: In general, any lightning should be avoided by aircraft. The wind shears that can be generated by a thunderstorm can result in severe damage to the aircraft up to and including structural failure, and have been known to propel aircraft above their service ceiling.

The most recent and exciting addition to the weather picture has been datalink airborne weather. This new weather, which is uploaded to the plane from ground or satellite sources, can be obtained in both text and graphical formats and provides immediate tactical information to the pilot so that they can make the right decision in terms of how to navigate in the area of a storm. Live weather graphics can be directly overlaid on top of moving map information on multi-function displays, providing the pilot with an unbeatable tactical display with which to better navigate the hazards that the weather presents. ■

Information presented in this section was consolidated from various Federal Aviation Administration (FAA) and other government sources. Special thanks to George Wilhelmsen for his editorial contributions and pilot's perspective. Further information of the various systems and operating procedures and their limitations can be found in the Airman's Information Manual.