Using Global Position System (GPS)©
The accuracy of GPS is unsurpassed. It is the programming of the system by the pilot that poses potential problems and dangers. The system software is relatively complex to program. This is especially true for the couputer illiterate. GPS will replace all ground based navigational systems and LORAN. The latest improvement to GPS is a wide-area augmentation system (WAAS). IFR approaches will be possible to any airport with accuracy within seven meters.

The Navstar GPS is a constellation of orbiting satellites (24 + 2 reserve)providing navigational data to military and civilian users around the world. Provides 24-hour services. These include accurate three-dimensional (latitude, longitude, and altitude) velocity and precise time, passive all-weather operations; continuous real-time information; support to an unlimited number of users and areas; and support to civilian users at a slightly less accurate level. The signals are so accurate that time can be figured to within one-millionth of a second, velocity within a fraction of a mile per hour, and location to within a few feet.

GPS as used by civil aviation has a built in inaccuracy to prevent bad-guys from targeting the U. S. Civil limits are about 60 feet as compared to within one foot for the military. Military signals are accurate so that time can be computed within one-millionth of a second, velocity within a fraction of a mile. This variation of accuracy is called 'selective availability (SA). Groundspeed error in a hand-held GPS will be less than two knots. With SA off the error is less than one knot. The system has 24 satellites circling at 7500 knots at 10,898 nautical miles high. They complete an orbit every 12 hours while continuously transmitting their position. They are line of sight but each satellite can see 40% of the earth. When a GPS receiver locks on four satellites a multi-dimensional fix is possible. GPS satellites get new data every hour. Receiver Autonomous Integrity Monitoring (RAIM) checks the minimum signals required for a fix.

The military has the capability of distorting the GPS signal to prevent use of the system against the U. S. When distorted, the signal would not be useable for navigation. The FAA has contracted for 35 ground based wide-area augmentation system (WAAS) to improve error detction, 7 meters accuracy and availability. By the year 2000 GPS will be the only aircraft navigation system.

GPS is going to change the way instrument navigation and approach are flown. Every runway can have a straight in approach. Alternate arrivals will be easily possible. There is no VOR cone of confusion or DME slant range errors. The course deviation indicator (CDI) can be programmed for scaled deviation according to use for navigation, non-precision, or precision use. GPS can be used to confirm information from heading indicator, altimeter, airspeed indicator, VOR, ADF or DME. During airport arrivals or approaches the GPS can even show the runways. You can fly a serpentine river with a properly programmed GPS.

In October of 1994, Stanford research showed that a small and inexpensive addition to the surface of any runway and to the aircraft could allow accurate landings at any airport and any runway. Accuracy was to within one inch of location and alltitude. It was tested with 110 landings. A processor on the plane compares GPS signals to those of the runway transmitter to give relative runway positin. Aircraft instrumentation remains the same in functin and appearance. In 1995

Category 3 level instrument approaches have been flown using differential GPS systems. This requires a local ground-based GPS antenna that allows correction of GPS errors. The accuracy of the differential system is within one foot.

The moving map indication makes situational awareness less of a problem since the active waypoint, the track and next waypoint can be mapped as well as altitude minimums. How well any of this can be done depends on the installed database. We are well on the way to a paperless cockpit.

I recently flew from OAK to YUM non-stop. This is a straight line distance of 485 nautical miles. I had forecast 33Kt tail winds for the route at 9,500'. Under non-GPS conditions I have always stopped at BFL for fuel. This time I made BFL in 1.5 hours and my GPS said that I could make YUM with VFR reserves. For the remainder of the flight the GPS kept me advised of ETE so that I could manage my fuel in case tail winds did not continue.

I would recommend that a handheld GPS be considered in preference to Panel installed. In the event of total electrical system failure or emergency landing in an isolated area, the handheld GPS can become a very useful aid. A recent 1994 development allows the placement of a GPS transmitter on the runway surface that will allow precision landings regardless of aircraft type.

If your aircraft has GPS or LORAN you will be expected to be able to use it for navigation and emergency purposes. You should be able to get time, speed and distance information. The student should be trained in programming, and storing flight plans, waypoints and direct operations. Later skills in airport information, nearest-airport, airspace, malfunction, and emergency use should be covered. Additionally you will be expected to be able to navigate without GPS by using other traditional aids. This means a student must be competent in the use of the sectional, VOR, E6B, and approximate headings as required by the Practical Test Standards. Special emphasis should be make regarding pilotage, since GPS and other aids tend to reduce skilled and practiced usage of surface orientation.

LORAN

The LOng RAnge Navigation system was developed during WWII by the Navy for ships. Because of vacuum tube size and power requirements ship LORAN was too large for aircraft. By 1943 an airborne LORAN the APN-4 was small enough to be used on large bombers and patrol aircraft. The APN-4 consisted of two units each about 1' x 2' by 2.5'. One unit was the power supply while the other contained the oscilloscope display tube and timing circuits and receiver. Together they weighed about 80 pounds. By 1945 the APN-9 came into use weighing 40 pounds.

The oscilloscope screen was about four inches in diameter and would display a station master and associated slave signal from about 1500 miles over water and 600 miles over land. Once the two signals were recieved and aligned a timing circuit could be displayed to measure the micro-second difference between reception of the two signals. A LORAN chart of the area had numbered parabolic lines which mapped out the lines of position for each time difference between the two stations.

Once this was done the process had to be repeated using another pair of master/slave station signals. The Chart had different colored parabolas for each pair of stations. With practice a fix could be determined in about three minutes. The minimum error for navigating the 1400 miles to Japan from Tinian was about 28 miles. With two successive fixes ground speed, drift, and ETA could be determined. As more islands were made available a third pair of stations could be added to improve fix accuracy. The relative simplicity of LORAN and the fact that it could be used regardless of weather made it invaluable until landfall on Japan enabled airborne radar to make a better fix. Fuel savings made possible by LORAN probably saved more lives than did the capture of Iwo Jima.

For some unknown reason the Japanese either never tried or failed to jam any of the LORAN systems. Loran - A as this WWII system was called existed worldwide up until 1985. The military sets were over APN-35 and had been reduced in size to less than a shoebox and had completely automated locating the fix while including ground speed, distance travled, distance remaining, and ETA.

In the late 1980s LORAN - A was being replaced by LORAN - C. Loran - C used a chain of stations and a Loran reciever that programmed the station components of the chain so that multiple LOPs (lines of position could be simultaneously recieved and translated into longitude and latitude coordinates. Loran -C can compute from your departure point or your present position to a destination a direct bearing, distance, ground speed, and ETA.

The low frequency of Loran removes the VOR line-of-sight problem. The entire U.S. is covered by 23 stations that give an average accuracy of less than 1/8 mile. There are limitations depending on the data base used. If your data base does not have terrain elevations, Loran can fly you a direct route from CCR to Merced via Mt. Diablo. Class C and B airspace may not be included or kept up to date. Your Loran may die of a voltage spike to its power transistor. Use it and trust its accuracy but don't depend on its ability to always be available. Pilotage is the only navigationsl system that doesn't quit until you do.

On the West Coast we have the 9940 chain. The master is at Fallon Nevada with three slaves stations at George (Central Washington State), Searchlight (Death Valley, and Middleton (Between Calestoga and Clear Lake). The 9940 designation has to do with the total number of microseconds (99400)it takes for a cycle of signals to go between the stations. At 99400 microseconds the data of the Loran reciever clock is updated about 15 times a second. Your Loran reciever uses the time difference of the signals recieved from the master and each of the three slaves to get three simultaneous LOPs (Lines of position). As you fly beyond one chain you are going to be in range of another. Just how the change will be made, manual or automatic, depends on the sophistication of your Loran.

One of the displays on the Loran is a Course Deviation Indicator or CDI. More expensive displays may have a moving map indicator. These displays will indicate which direction and how far off the straight line course originall selected you have flown. Some displays will give you headings required to establish yourself back on course. Some data bases have about 30,000 waypoints so that you do not need to enter in longitude and latitude. Longitude and latitude does work. Over ten years ago I figured the longitude and latitude of Medford, Oregon and put it into a Loran when leaving Nut Tree. It read 1/2 mile when we were on short final.

Loran - C is operated by the Coast Guard at a price of $25 million a year. With the advent of GPS it is not long for this world.

How do I know all this? I taught LORAN-A in India and on Tinian to replacement crews as they arrived from the States. I was assigned to the Wing Training School of the 58th Bomb Wing of the 20th Air Force. (B-29s)