The Trailing Edge

December 2024

ATC Communications and Instrument Flying in 1962 versus 2024

(*This is another article from the EAA Chapter 1000 newsletter leftover bin. I conceived this article in 2019 while doing instrument training in the Bearhawk with Gary Aldrich. That effort came to an abrupt end with the start of the pandemic in March 2020 and the fear of not being able to find a DPE willing to fly during the pandemic. In the end, I decided not to finish the instrument rating because the Bearhawk is not a very stable instrument platform, and the weather here in the desert is mostly VFR, so there is little perceived need to fly in IMC. The effort required to maintain instrument currency was not justified for the unlikely possibility of needing to let down through an undercast way far from home. I wasn't pursuing an airplane CFI or a commercial airplane rating, so I didn't need an instrument rating to support either of those.*)

When I was a kid, my goal for pilot training was limited to simply a Private Pilot certificate with an Airplane Single Engine Land rating. For the recreational flying I planned to do, that was all the credentials I needed. I knew that the only way I could afford to get a job flying commercially was if the Air Force or someone else paid for my training. I didn't have interest in spending all of my free time being at the airport teaching someone else to fly, so I didn't need an instructor certificate. Since I could pick when I wanted to go fly, if the weather was bad, I could just wait until another day. Thus, there was no strong requirement or motivation to get an instrument rating.

Sometime in the early 1990s, my wife and I spent the weekend in the Ventura area with her Great Aunt. The Great Aunt's husband, who I never met, was an avid General Aviation pilot, and had quite a collection of flying-related books. I picked up a book titled *I'd Rather Be Flying: Instrument and Multi-Engine Flying for the Week-End Pilot* by Frank Kingston Smith (Ref 1). With little else to do, I started reading and surprisingly finished off the book within a few hours. The first part of the book was the story of the author training for his instrument rating, and I always remembered the description of a procedure turn because it was presented so well.

Sometime around 2017, Gary Aldrich suggested to me that he could teach me about instrument flying in my Bearhawk. After all, I had equipped it for instrument flight. What a deal! Free flight instruction and the cost of flying was no more than I would spend anyway. With an offer like that, I couldn't pass it up. I studied for and passed my FAA Instrument Knowledge Test in 2018. We started flying, and in the end completed 33.5 hours, including 6.7 hours in the simulator.

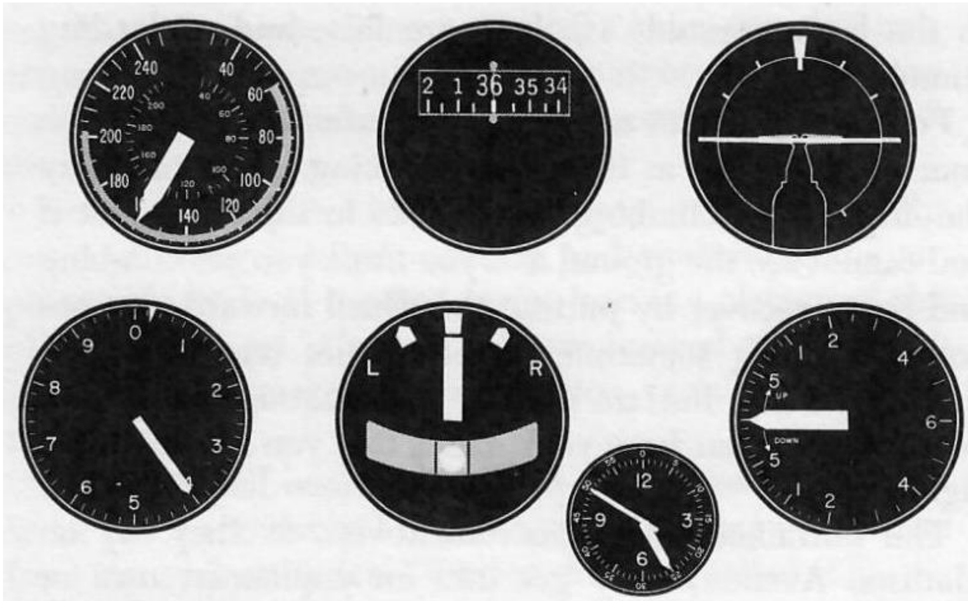
While doing all of this flying without looking outside, I was remembering that book I read about instrument training lo those many years ago. Through the miracle of the Internet, I was able to purchase a used copy of *I'd Rather Be Flying!*. As I read through it, I found that it seemed different than I remembered it. I also started to realize that many of the procedures that the author was describing were noticeably different from the procedures I was being taught. The more I looked into this, the more I realized how things had changed over the years as better avionics and better infrastructure became available.

Training Requirements

Currently, per 14 CFR §61.65(d)(2), a minimum of 40 hours of actual or simulated instrument time is required to test for an instrument rating. In the 1962 book, there was apparently no such requirement, as Mr. Smith arranges with his instructor to fast-track his instrument rating, completing it in one week. Clearly Mr. Smith had the whole week to dedicate to flying. Taking out time for briefing, debriefing, and lunch (all of which are covered in the book) leaves a maximum available time to fly of 4 to 6 hours per day. Multiplying by 6 days, this only leaves 24 to 36 hours of training time. In the past, aviation magazines were full of advertisements for schools where you could get your instrument rating in a week. However, if you read the fine print, you had to have already passed the FAA knowledge test and completed several other prerequisites.

Flight Instruments

The flight instruments available in Mr. Smith's Piper Comanche in 1962 would seem very foreign to a 2024 instrument student learning on a G-1000 or other "glass cockpit". They would be slightly more familiar to someone who learned to fly on a "six pack" of "round dial" gauges. These would include the airspeed indicator, artificial horizon, altimeter, turn and bank gyro, directional gyro, and vertical speed indicator (vertical velocity indicator if you learned in Air Force Undergraduate Pilot Training). However, these gauges would not be arranged in the “standard T" arrangement that you were used to, because that standard arrangement hadn’t been standardized yet.



1962 Piper Comanche Instrument Layout

The 1962 airspeed indicator in this book was marked primarily in miles per hour. This was very common in aircraft in the early days of aviation, even through World War II. My assumption has always been that airplanes started out this way because it was common in automobiles to measure speed in miles per hour. The problem was that airspeeds were being measured in statute miles per hour, but distances on aeronautical charts were measured in nautical miles, and wind speeds were reported in knots. Thus, a lot of navigational calculations were unnecessarily complicated with constant unit conversions. Military and commercial aviation would eventually mitigate this problem by switching to measuring airspeeds in knots. General aviation tended to be late to the simplification party. Kanard’s 1969 Cessna Skylane has an airspeed indicator with a primary scale in miles per hour, though it has a secondary scale in knots. Since the restart of production in 1996, Cessna has equipped its airplanes with airspeed indicators marked in knots. However, even in the present day many homebuilders are known to still install airspeed indicators marked in miles per hour, simply because their airplane sounds 15 percent faster. Some people think that saying they cruise at 205 miles per hour sounds so much better than 178 knots, simply because the first digit is a “2”. (What would those builders do if offered an airspeed indicator marked in kilometers per hour? That would be 330 km/hr!)

The subject airplane was equipped with an attitude indicator (artificial horizon), but it was simply a white line on a black background. Modern attitude indicators have a blue half and a brown half to identify up and down. Any ambiguity in the white line instrument would have to be worked out with the other instruments. The book goes on to explain how the attitude indicator shows pitch angle and not flight path angle. That is, in level flight, especially at low speed, the attitude indicator will show a nose high attitude in level flight. Lack of change in the altimeter and a zero reading on the vertical speed indicator indicate level flight. This is actually no different from modern attitude indicators.

As shown in the figure above, the Directional Gyro was one of those horrible barrel type indicators. I always found these to be exceptionally confusing, because you are looking at the back side of the barrel, not the front. A turn to the right will increase the heading value, but the higher numbers appear to the left on the indicator. Thus, to change from a heading of 270 to 280 requires a right turn, but a glance at the DG shows “28” to the left of the current heading, which seems to say a left turn is required. For turns of more than 25 degrees, mental math is required to figure out which way to turn. With a vertical card compass or a Horizontal Situation Indicator (HSI) it is easy to look at the compass rose and quickly see which way to turn.

The subject airplane was equipped with a Turn and Bank indicator (needle and ball). The needle measures yaw rate. When the needle is lined up with the doghouse, it indicates a standard rate turn of 3 degrees/second, or two minutes for a complete turn. The needle does not respond to roll rate, which means it does not respond until the turn has been established. This is different from the more modern turn coordinator, which replaces the needle with an airplane image. In a turn coordinator, the gyro axis is tilted, such that the instrument responds to roll rate and to yaw rate.

A panel mounted clock was much more important for instrument flight in 1962 than in 2024. This was also the days before digital clocks, so it was an analog clock with a sweep second hand.

Simple autopilots were available, but were mostly limited to keeping the wings level on a constant heading. They may have been able to hold altitude as well. Coupled approaches, something possible with the G-1000, were not a thing yet.

In 1962, even if an attitude indicator was installed, the practical test standards expected the pilot to demonstrate maintaining a wings level attitude using needle-ball-airspeed. That is, use the rudder and ailerons to center the needle and ball, then use the elevators and throttle to maintain a desired airspeed. If the turn rate is zero and the sideslip is zero, the aircraft must be in wings level flight. Depending on the airspeed and throttle combination, the airplane might be level, climbing, or descending. The altimeter and vertical speed indicator will indicate the vertical motion.

The practical test standards expected the pilot to fly turns to a heading by using a standard rate turn and timing the turn. The directional gyro was then used to fine tune the final heading. Again, more mental gymnastics than just watching the HSI, waiting for the heading bug to come to the top of the case.

Tracking a course required a coordinated use of the course deviation indicator and the directional gyro, which were two different instruments. It's not too challenging if your heading is close to that of the course. If not, it's more mental gymnastics that an HSI makes super easy.

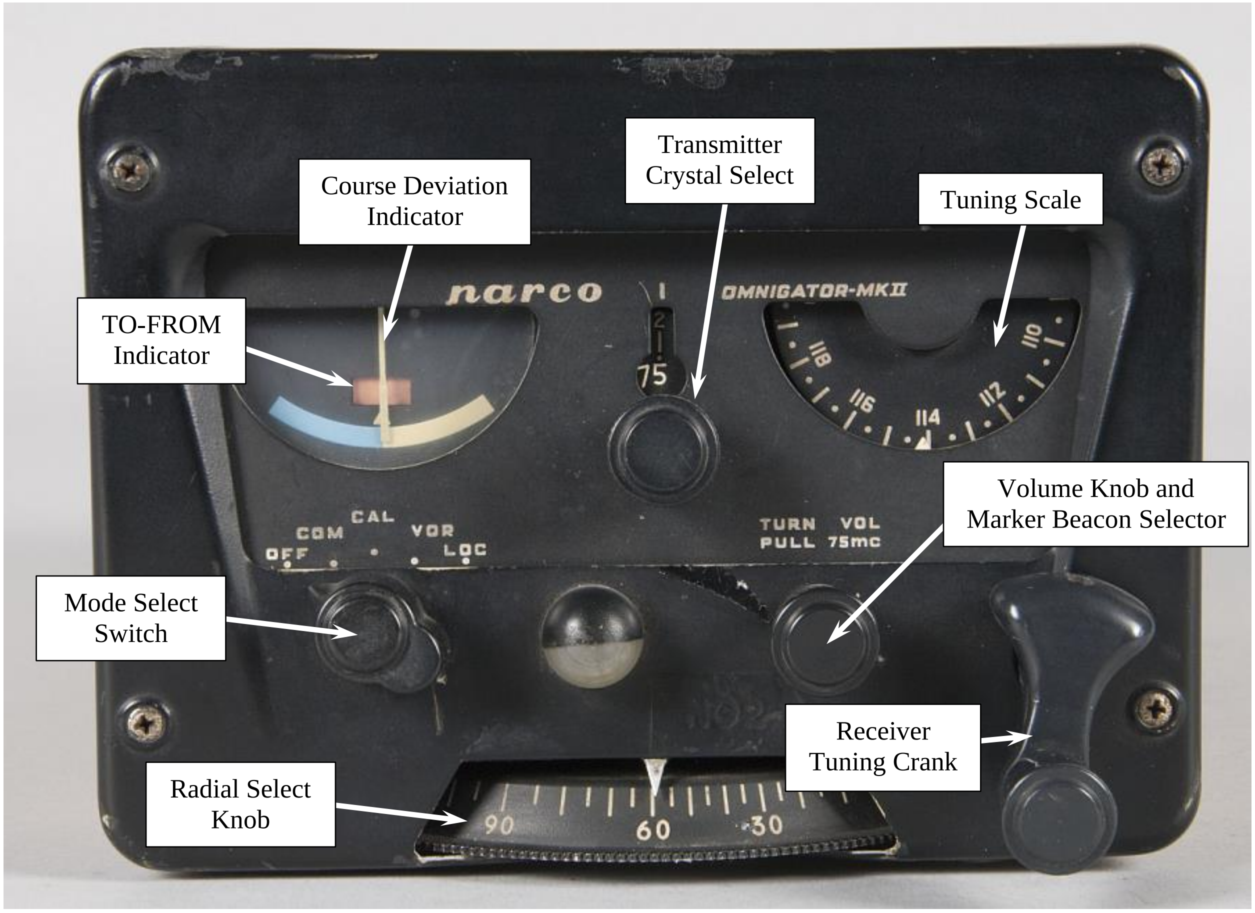
Avionics

A typical example of early VHF communication radios and VOR receivers was the Narco Omnigator Mk II. As can be seen in this table, the Omnigator Mk II was very similar in size to the Garmin GNS 530. In fact, the Omnigator was so popular at one time that instrument panels were designed with holes specifically to fit it. The modern day aircraft radio stacks are 6.25 inches wide, known as "Mark Width" after Narco's Mark series of radios that popularized that width (Ref 2).

Avionic	Width	Height	Length	Weight
Narco Omnigator Mk II	6.5 inch	4.75 inch	12 inch	18 pounds
Garmin GNS 530	6.25 inch	4.6 inch	11 inch	9.5 pounds

One major difference from the Garmin GNS 530 was that the Omnigator Mk II weighed twice as much at 18 pounds, compared to 9.5 pounds for the GNS 530. One reason for the extra weight was the vacuum tube circuitry. Built well before the transistor age, the Omnigator Mk II used 23 vacuum tubes. To provide the high voltage necessary for the vacuum tubes, the Omnigator Mk II had a 12v DC vibrator power supply. I could not resolve conflicting references as to whether this power supply was part of the 18 pound box or was a separate box with even more weight.

The Omnigator Mk II contained one VHF transmitter and one VHF receiver. The transmitter was crystal controlled, with a maximum of 27 frequencies available. Because individual crystal oscillators were expensive, many Omnigators were equipped with less crystals, and were thus limited on which frequencies they could transmit on. The VHF receiver was capable of continuous tuning, much like the continuous variable capacitor tuning of car and household AM radios of the day. To tune the receiver, a crank at the lower right corner was turned. This use of a crank led to these radios being derisively referred to as "coffee grinder radios".



Narco Omnigator Mk II

To set the VHF transmitter frequency, turn the outer Transmitter Crystal Select knob to set the MHz (big numbers), and turn the inner Transmitter Crystal Select knob to set the kHz (little numbers) in the window above the knob. This picture shows a frequency of 121.50. The "7" next to the "5" implies that crystal oscillators were available with 25 kHz spacing. Of course, the transmitter would only work for frequencies for which a crystal oscillator was installed.

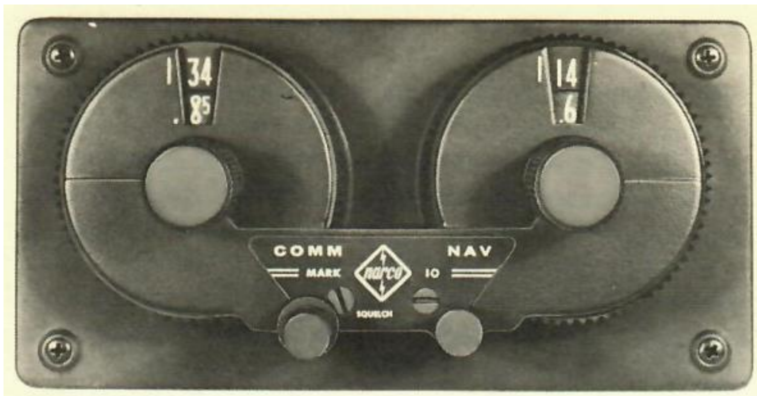
To set up to receive VHF communications, the Omnigator uses "whistle stop" tuning. Turn the Mode Select Switch from OFF to CAL (calibrate). With the transmitter set to the desired frequency, turn the Receiver Tuning Crank until the Tuning Scale in the upper right corner is pointing at approximately the desired frequency. Continue turning the crank until a whistle is heard in the speaker. When the whistle is heard, the receiver is tuned to the same frequency as the transmitter. You can imagine this would take a lot longer to accomplish than just pressing the flip-flop button. After tuning, move the Mode Select Switch back to COM.

To receive a VOR for navigation, move the Mode Select Switch to VOR. The VOR uses the same receiver as the COM radio. Turn the Receiver Tuning Crank until the Tuning Scale in the upper right corner is pointing at approximately the desired frequency. Continue turning the crank until the VOR Morse code identifier is heard in the speaker. To select the desired radial, turn the Radial Select Knob at the bottom of the unit to the desired radial. This is the equivalent of the Omni Bearing Selector (OBS) on an external indicator. The Course Deviation Indicator (CDI) is the needle in the upper left corner. A TO/FROM/OFF indicator is shown in a window behind the needle.

For an ILS approach, turn the Mode Select Switch to LOC. This will receive the localizer half of the ILS signal, providing course guidance. Reference 1 states "All 'localizer' frequencies are the same, therefore there need be no other tuning for purely navigational functions." I think this was a mistake, as the same book shows at least two approach plates with different localizer frequencies. Even the text mentions tuning in the localizer frequency, presumably using the same procedure as tuning a VOR, listening for the localizer Morse code identifier. I suspect the purpose of the LOC mode was to increase the sensitivity of the CDI as appropriate for a localizer signal. To receive and display the ILS glideslope, an additional glideslope receiver was required.

To receive marker beacons, pull out on the Volume Knob. This activates a 75 MHz receiver which will play the marker beacon audio through the speaker. The Outer Marker transmits a series of Morse code dashes at 400 Hz pitch (G4, G above Middle C). The Middle Marker transmits a series of Morse code dot-dash at 1300 Hz pitch (E6, E two octaves above Middle C). The rarely found Inner Marker transmits a series of Morse code dots at 3000 Hz pitch (G7, G three octaves above Middle C).

Also in Reference 1, Mr. Smith is introduced to an airplane with newer avionics than his Cherokee. This airplane had a Narco Mark 10 NAVCOM. This unit had a VHF transmitter and two VHF receivers. The COM receiver was tuned in concert with the COM transmitter. Thus, you could always receive on the same frequency you were transmitting on. The VOR receiver was tuned separately, independent of the COM receiver. To tune either side, the large knob around the circle changed the MHz (big numbers), and the small center knob changed the kHz (small numbers). I can't find any information to tell me if the unit as shipped could use all frequencies or if crystal oscillators had to be added. The Course Deviation Indicator and OBS were on a different remote unit.



Narco Mark 10 NAVCOM

Instead of using physical crystals that resonate at a particular frequency for each possible frequency, modern digitally tuned radios use "frequency synthesizers" to generate a specific frequency for the receiver (actually for the RF mixer). There are also "digital receivers" which digitize an entire "block" of bandwidth, and then extract the frequency from a specific channel using digital signal processing. (GPS uses digital receivers).

Effects of the Omnigator Mk II on Communications Infrastructure

In 2024, VHF aviation communications and VORs (and ILSs) all seem to make sense. You transmit and receive on the same communication frequency, and for a VOR you just dial up the frequency shown on the chart (or in the database). So, what's the big deal?

Remember how your instructor taught you at non-towered fields to start a transmission with the airport name and to end it with the airport name? That is because many airports are on the same frequency. Many times I have been at altitude over Tehachapi in a glider with the radio tuned to 123.000 MHz, which is the frequency for L94 and KTSP. It is reasonable that these two airports have the same frequency, since they are only 2.2 nm apart. Just 1000 to 2000 feet above ground level, I have heard transmissions very clearly from Fresno (KFCH, 119 nm). Why are frequencies reused? Because there aren't that many available. In the table below, notice that the Omnigator receiver had a maximum frequency of 126.900 MHz. Current VHF radios, such as the Garmin GNS 530, can go up to 136.975 MHz, giving a lot more frequencies to choose from.

Avionic	VHF Comm Transmit Frequencies	VHF Comm Receive Frequencies	VOR Receive Frequencies
Narco Omnigator Mk II	Up to 27 crystal controlled channels	118.0 to 126.9 MHz continuous	108.00 to 117.95 MHz continuous
Garmin GNS 530	118.000 to 136.975 MHz 25 kHz spacing 760 channels	118.000 to 136.975 MHz 25 kHz spacing 760 channels	108.00 to 117.95 MHz 50 kHz spacing

A bigger limitation was that the Omnigator Mk II could only have a maximum of 27 transmit frequencies, which was very limiting. Reference 1 indicates that many Omnigators had less than the full complement of 27 crystals installed. With the probability of only being able to transmit on a few frequencies, the frequency allocation to significant airports was very limited.

Even today, the Ground frequency at most towered airports is either 121.7, 121.8, or 121.9. This is further shown in the common shorthand of the tower telling an aircraft that just landed to “contact Ground point seven”. The “point seven” is to be interpreted as 121.7, since all ground frequences start with “121”. This system worked reasonably well with little interference between towered airports. Because the only expected time that airplanes would be on the Ground frequency was while they were on the ground at that airport, the VHF transmit and receive range was very short because of line of sight issues. Rosamond Skypark (L00) is only eight nautical miles from Fox Field (KWJF), but while on the ground at L00 it is impossible to receive anything on the KWJF ATIS, Tower, or Ground frequencies.

Frequencies for airport control towers tended to be clustered near 120 MHz. When I started flying, the tower frequency at KWJF was 120.3 MHz. The control tower frequency at Edwards Air Force Base (KEDW), 19 nautical miles away, was 120.7 MHz. With the frequency capability of aircraft radios greatly improved, about 10 years ago the tower frequency at KWJF was changed to 118.525 MHz to separate the two tower frequencies farther apart to reduce the chance of interference. A frequency of 118.525 MHz is easily tuned on today’s aircraft radios with 25 kHz spacing.

Finally, in those days any small airport not big enough to justify a unique frequency was assigned to the MULTICOM frequency of 122.9 MHz. Rosamond Skypark is still on 122.9 MHz. Many other small airports are assigned very closed to that, being on 122.8 MHz or 123.0 MHz. In airplanes with two radios, this can lead to some problems in radio management. Say I was flying from L00 (122.9 MHz) to L94 (123.0 MHz). It is a short flight, and you might think that it would be reasonable to tune one radio to 122.9 MHz and the other radio to 123.0 MHz. However, if listening to both radios at the same time, transmitting on one will bleed through into the other radio, creating a horrible mess in your headset. Because the frequencies are so close and the signal is so strong at the receiving antenna (only a few feet from the transmitting antenna), the signal will bleed through as a partial reception.

Thus, with fewer frequencies to choose from, as limited by the number of transmitter crystals in most radios, many of those frequencies were repeated at airports reasonably close to each other. Also, with limited transmitter crystals available, it was important that there be a guard frequency that you could go to that anybody could monitor. We are all familiar with our current guard frequency of 121.5 MHz for VHF and double that at 243.0 MHz for UHF. According to Reference 1, in the past all towers and approach controls could receive on 122.7 MHz, which is really close to the common frequencies of 122.8 MHz, 122.9 MHz, and 123.0 MHz, but they might not be able to transmit on 122.7 MHz.

Notice that the Omnigator could only receive on VHF frequencies up to 126.9 MHz. At 100 kHz spacing, this only provided for 90 useable frequencies. If we assume a modern 25 kHz spacing, that goes up to 356 useable frequencies. Modern radios, such as the Garmin GNS 530, are capable of transmitting and receiving up to 137.975 MHz, which at 25 kHz spacing allows for 760 useable frequencies. The military also uses VHF frequencies from 138 to 144 MHz, which are above the tuning capability of the Garmin GNS 530 or any other civilian VHF radio.

Split Frequencies

Reading Reference 1 finally answered a question that I had ever since my Private Pilot training days. The question was why would I ever talk to someone on one frequency and listen to them on a navaid frequency? Back in 1991, this was still a big part of the ground school training syllabus. Even today, the legend for the sectional chart shows a box that contains the information for a VOR station. Under it is the name of the Flight Service Station (FSS) serving that area. Above the box were some frequencies for the FSS. Some of those frequencies might be presented as “122.1R” with the “R” meaning “receive only”. The FSS could receive on this frequency, but could not transmit on it. To talk to the FSS, you would turn on the audio receiver for the VOR. That’s the button where you hear the morse code identifier for the VOR station that tells you it is working properly. You then transmit on 122.1 MHz to the FSS, telling them that you are listening on the VOR frequency. From an equipment standpoint, that means that the FAA only has to put one VHF transmitter at the VOR, which sends out the VOR signal as well as modulating the audio onto the same frequency. They install a receiver for the FSS (in this case on 122.1 MHz) at the VOR station, but don’t have to put in a second transmitter to cover the occasional radio call.

That has some reasoning to it, but it really becomes understandable when you consider that the Omnigator only had one VHF receiver, and it had to be used for both voice messages and receiving the VOR signal. If you are trying to talk to an FSS through a remote communication outlet at a VOR, it is reasonable to assume that you are navigating by that VOR. Your sole VHF receiver is tuned to the VOR. You can talk to the FSS through one of your transmit crystals, but since your receiver is listening to the VOR, that is the frequency you have to use to listen to the FSS.

Likewise, if you are using your sole VHF receiver to receive an ILS signal, you transmit to the tower on the tower frequency, but you listen to the tower on the ILS frequency.

This use of split frequencies is essentially obsolete today, as most NavCom radios use one receiver for voice communication and a separate receiver for VOR or ILS localizer signals. Essentially all voice communication now transmits and receives on the same frequency. It takes more equipment, but is much simpler to operate.

Flying the Approach, PMD 2024

Before looking at how complicated it was to fly under Instrument Flight Rules (IFR) in 1962, let us first look at how it is done today. One huge benefit today is that essentially all controlled airspace has ATC radar coverage. That means that with the help of ADS-B and your Mode-C transponder, the controller can look at a screen and see where you are. Prior to the widespread use of radar, the controllers had to depend on pilots giving position reports, and, instead of a glowing screen, they had to maintain a picture of what was going on either on paper or in their head. Since pilots didn't have GPS to tell them where they were, if the pilot gave an incorrect position report, the whole system could come crashing down.

Flying enroute airways is pretty straightforward, so let's look at flying an approach. This discussion is based on my experiences in instrument training around 2019. Consider the ILS or LOC RWY 25 approach at Palmdale (KPMD), shown below. Joshua Approach uses radar to provide separation, so multiple airplanes can simultaneously be on different parts of the approach. Communication with Joshua Approach is on 124.55 MHz for both transmit and receive. Likewise transmit and receive with Palmdale Tower is on 123.7 MHz.

My GNS-480 has a dedicated receiver for the ILS localizer on 110.7 MHz, and another dedicated receiver for the glideslope on 330.20 MHz. Don't waste your time looking around the approach plate trying to find 330.20 MHz, because it isn't there. Each localizer frequency has a specific glideslope frequency paired to it, and the GNS-480 knows that pairing. Thus, I just have to dial the localizer frequency into the VOR receiver. The GNS-480 recognizes it as a localizer frequency and automatically tunes and activates the glideslope receiver.

As for position along the approach path, the procedure is designed to use Distance Measuring Equipment (DME) from the Palmdale VOR (PMD), not from the localizer (I-PMD). I don't have a DME receiver, but WAAS GPS is a legal substitute for DME. When using the GPS for position, the display does not show the distance to PMD, but rather displays the distance to go to each of the significant waypoints (AMANE, FORDA, SKKEE), which accomplishes the same result. Even though I have a Marker Beacon receiver (it is part of the GMA 340 communications panel), there are no marker beacons on this approach, because they are redundant with DME or GPS.

To enter the approach, Joshua Approach will give you radar vectors that will have you intercept the localizer at a point outside of the Final Approach Fix (FAF) (FORDA) that will provide sufficient time to set up for the final descent. When doing multiple approaches, the initial radar vector will be for a downwind leg north of the localizer in approximately the reciprocal direction at 4500 feet, the altitude of the Final Approach Fix. At the appropriate point, a radar vector will be given to turn right 90 degrees toward the localizer, followed by a vector to turn right by 45 degrees, setting you up for a 45 degree intercept with the localizer. Upon receiving the localizer, you turn to a ground track of 254 degrees and center the localizer needle. Upon reaching FORDA, you start your descent down the final approach, keeping the localizer and glideslope needles centered. This will be considered "simple" compared to the alternatives.

This approach can be flown without radar vectors, but that is not the preferred method. Without radar vectors, much more time is spent on the approach, which reduces throughput. This is especially true if you are flying outbound on the localizer to do a procedure turn. To fly the "full approach" you have two options. You can navigate yourself to an Initial Approach Fix (IAF) at ETHER (ETHER is on Victor Airway V12), then fly at 4900 feet altitude and heading of 209 degrees until intercepting the localizer. Follow the localizer to AMANE, then descend to 4500 feet until reaching FORDA, then following the localizer and glideslope down the final approach path. The other option is to arrive at IAF FORDA at or above 5000 feet altitude. Fly outbound on the localizer (heading 074 degrees) past AMANE, then fly a procedure turn to the south. Once established inbound on the localizer, the remainder of the procedure is the same as starting from ETHER.

If you are not equipped with DME or GPS, but have two VOR receivers, the waypoints FORDA and AMANE can be identified by crossing radials from the EDW VOR.

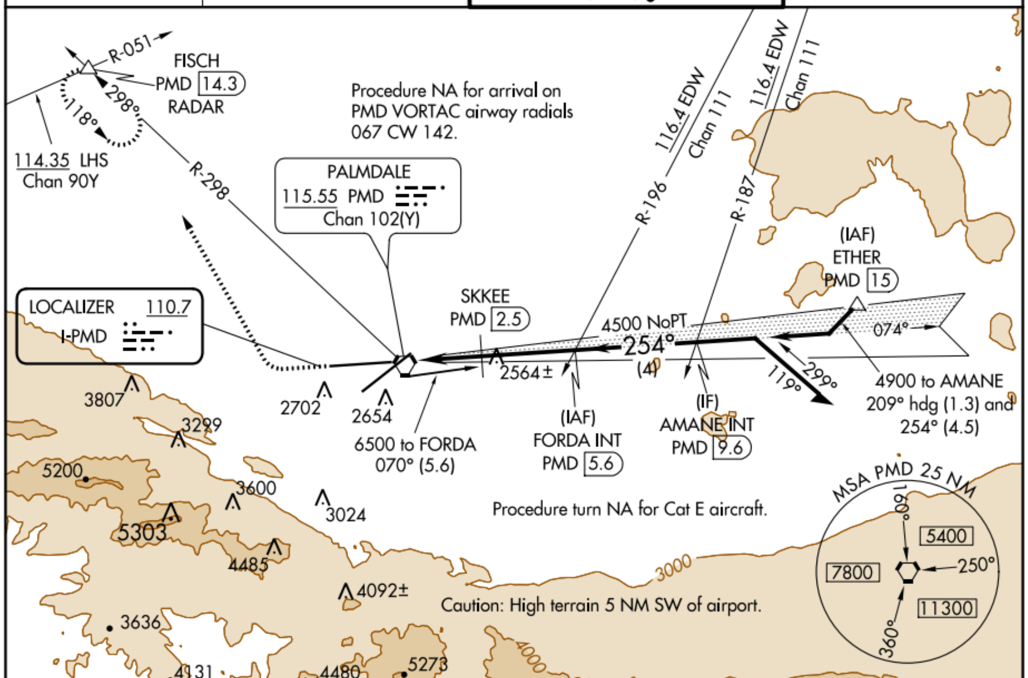
ILS or LOC RWY 25
PALMDALE USAF PLANT 42 (PMD)

LOC I-PMD	APP CRS	Rwy ldg	12002
110.7	254°	TDZE	2503
		Apt Elev	2543

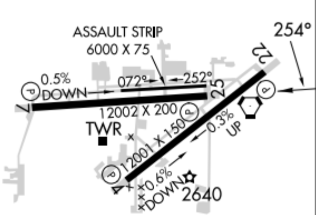
DME from PMD VORTAC.
Simultaneous reception of I-PMD and PMD DME required.
Circling NA for Cats C, D, and E south of Rwys 4 and 25.

MISSED APPROACH: Climb to 3000 then climbing right turn to 6700 on heading 318° and on PMD VORTAC R-298 to FISCH INT/PMD 14.3 DME/RADAR and hold, continue climb-in-hold to 6700.

ATIS	JOSHUA APP CON	PALMDALE TOWER *	GND CON
118.275	124.55 363.0	123.7 (CTAF) L 317.6	121.9 317.6

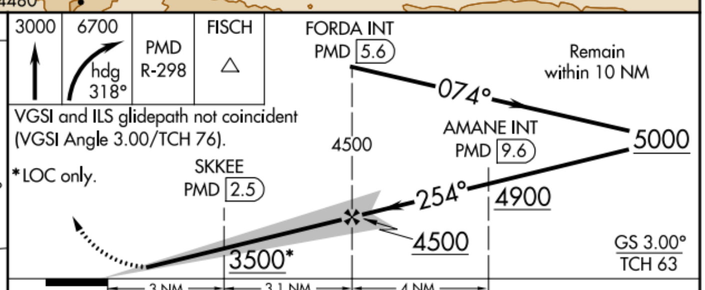


ELEV 2543 TDZE 2503



REIL Rwys 4, 7, 22 and 25 L
HIRL Rwys 4-22 and 7-25 L

FAF to MAP 6.1 NM					
Knots	60	90	120	150	180
Min:Sec	6:06	4:04	3:03	2:26	2:02



VGSI and ILS glidepath not coincident (VGSI Angle 3.00/TCH 76).

*LOC only.

CATEGORY	A	B	C	D	E
S-ILS 25	2703-¾ 200 (200-¾)				
S-LOC 25	3500-1¼ 997 (1000-1¼)	3500-1½ 997 (1000-1½)	3500-3 997 (1000-3)		
C CIRCLING	3500-1¼ 957 (1000-1¼)	3500-1½ 957 (1000-1½)	3500-3 957 (1000-3)	3740-3 1197 (1200-3)	3760-3 1217 (1300-3)
SKKEE FIX MINIMUMS (DME REQUIRED)					
S-LOC 25	2820-1 317 (300-1)		2820-⅞ 317 (300-⅞)		
C CIRCLING	3020-1 477 (500-1)	3060-1 517 (600-1)	3140-1½ 597 (600-1½)	3740-3 1197 (1200-3)	3760-3 1217 (1300-3)

Flying the Approach, ABE 1962

To see how flying IFR is much simpler today, let's look at flying the Localizer approach into Lehigh Valley International (KABE) in Allentown, Pennsylvania as described in Reference 1, shown below.

To fly the ILS approach, the airplane must be equipped with a VOR receiver to receive the localizer. This can be done with the VHF receiver on the Narco Omnigator. To receive the full ILS, a separate glideslope receiver would be required, and the pilot must tune the frequency on it manually—it is not automatically tuned when tuning the localizer. Since the subject airplane did not have a glideslope receiver, we will describe a localizer approach. For this approach, a low frequency receiver was required, generally in the form of an Automatic Direction Finder (ADF) receiver. Finally, a Marker Beacon receiver was required, which was part of the Narco Omnigator.

Since at that time radar tracking was not available, only one airplane could be on the approach at a time. Once cleared for the approach, the pilot would report starting the procedure turn and upon reaching the outer marker inbound (FAF). Once the airplane landed or went missed approach the controller could clear another airplane for the approach.

This approach used marker beacons. The Outer Marker served as the Final Approach Fix (FAF) and the Middle Marker served as the Missed Approach point. The Outer Marker was co-located with a Non-Directional Beacon (NDB). This combination is labeled as a Locater Outer Marker (LOM). In this case, the NDB has the identifier AB (the first two letters of the associated destination airport ABE) and a frequency of 224 kHz.

On this approach plate there is not identification of an Initial Approach Fix (IAF). Presumably, this terminology did not exist yet. From context, the IAF appears to be the ABE VOR or the AE low frequency range.

To start the approach from the ABE VOR, the pilot navigates to the ABE VOR at an altitude of 2400 feet. Transmit to Approach Control on 118.2 MHz and receive on the VOR frequency 117.5 MHz. Upon being cleared for the approach, the pilot turns to fly outbound on the 217 radial at 2400 feet. Fly 9.6 nm to the LOM AB.

Alternatively, you can enter the approach by navigating to the Low Frequency Radio Range AE on 321 kHz using the audio on your ADF receiver. If you are doing this, then you are probably making a non-precision NDB approach. Let's look at how this very early navigation system worked. Note that the identifier AE is the first and third letters of the associated destination airport ABE.

The low frequency radio range transmits four courses, which could be perpendicular but don't have to be. The transmitting antennas were arranged to create courses in desired directions toward other navaids. Between the courses are quadrants, transmitting either a morse code A (· -) or an N (- ·). The quadrants with the hashes into them transmit "A", and the quadrants bordered by hard lines transmit "N". To start with, you guess which quadrant you are in based on the morse code letter you hear and your dead reckoning. Based on where you think you are, turn to a heading to intercept the desired course leg. When you get to the course leg (the intersection between quadrants), the dash of the A overlaps the dot of the N, and the dash of the N overlaps the dot of the A, resulting in a continuous tone. Then fly the course heading toward the station. You should know the direction to the station based on your dead reckoning position. As you approach the station, the signal strength will increase. Station passage was marked by the loss of audio signal, since the antenna pattern did not propagate straight up. Signal reception was on an AM radio, similar to the AM radios that were in cars and homes, but on lower frequencies. Frequencies ranged from 190 to 535 kHz, just below commercial AM radio. This was the same frequency band as used by NDBs, so an ADF receiver could be used to fly a low frequency radio range. The Morse code was modulated at a pitch of 1020 Hz, which is approximately 2 octaves above middle C. This is the same pitch as used for the Morse code identifiers on VORs and localizers. To confirm that you were listening to the correct station, a Morse code identifier (AE in this case) was transmitted twice every 30 seconds, first on the N transmitter and then on the A transmitter. This ensured that the identifier was heard regardless of which quadrant you were in.

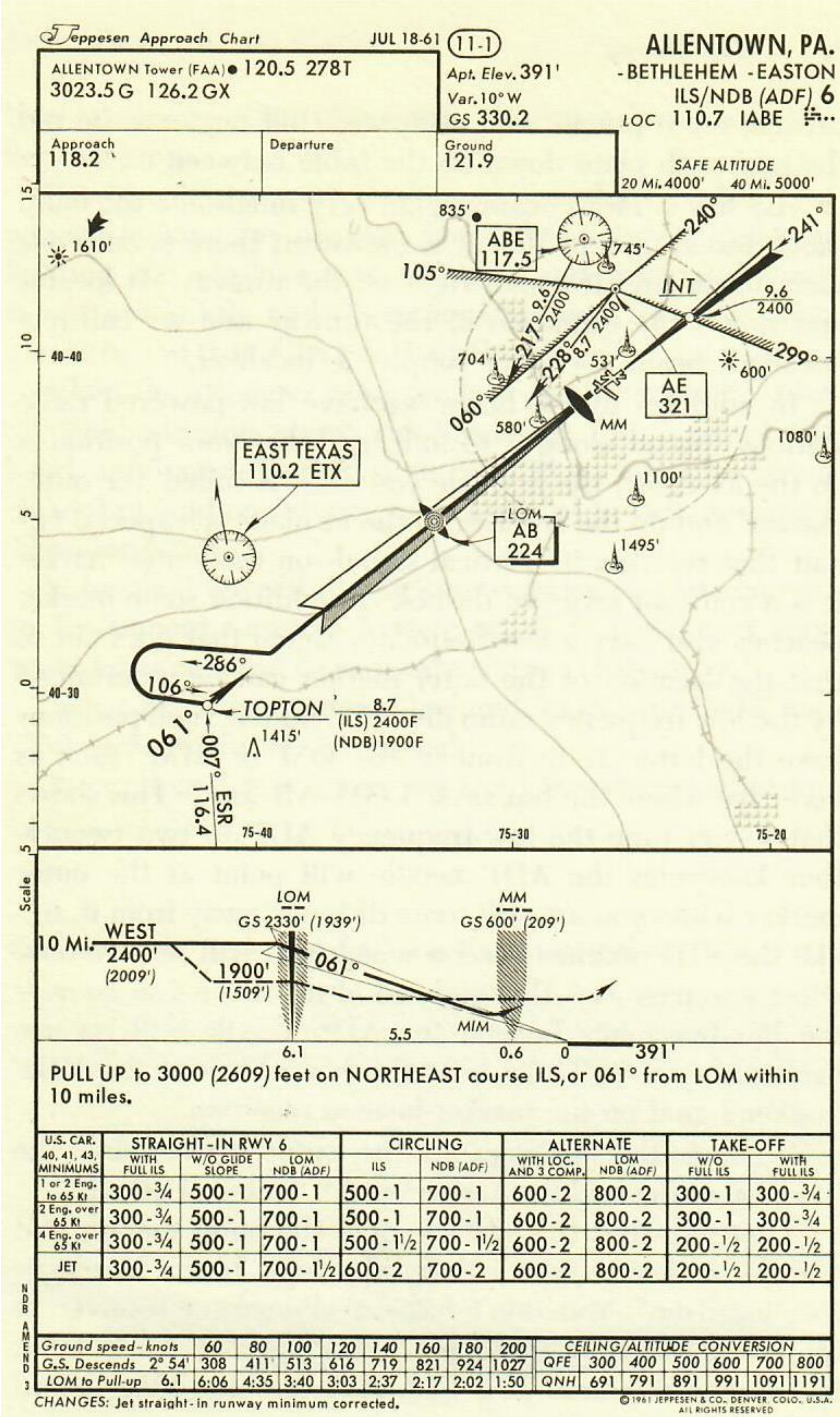
A third option for entering the approach was to navigate from the ESR VOR (116.4 MHz) on the 007 radial to TOPTON intersection. At TOPTON intersection, turn inbound on the localizer at 2400 feet altitude.

Back to our scenario, while flying inbound on the low frequency radio range, you can transmit and receive approach control on 118.2 MHz, since you are listening to the range on the ADF receiver. When you enter the cone of silence, identifying that you are over the station, turn to a heading of 228 degrees at an altitude of 2400 feet. Fly 8.7 nm to the LOM AB.

Regardless of which navaid you started at, you are now inbound to the LOM AB. Tune your ADF receiver to 224 kHz to receive the LOM AB. Switch the Narco Omnigator to LOC mode and tune the receiver to 110.7 MHz to receive the localizer. Notify approach control that you are now receiving voice communication on the localizer audio on 110.7 MHz.

Pull out the knob on the Narco Omnigator to be able to hear the beeps of the outer marker as you pass over. When you pass over the LOM, the ADF needle will swing wildly and you will hear the beeps of the outer marker. Turn outbound on the localizer (241 degrees). Sensing on the localizer will be reversed, just like flying a back course ILS.

Remaining within 10 nm of the LOM, fly your procedure turn to the west. Notify approach control that you have begun your procedure turn. Once established on the localizer, track inbound on a heading of 061 degrees and an altitude of 2400 feet. The ADF will also indicate the direction to the LOM. Configure for the final approach. Upon reaching the LOM (ADF needle swings, marker beacon beeps), begin your final approach descent. Notify approach control that you are outer marker inbound. Change transmitter to 120.5 MHz for tower when directed. If equipped with a glideslope receiver, track the glideslope and localizer inbound. If not, establish a descent rate based on your ground speed per the table at the bottom of the approach plate. Assuming an 80 knot ground speed, that would be a descent rate of 411 feet per minute. Upon reaching about 600 feet altitude you should hear the middle marker beacon. Don't proceed below 500 feet AGL without seeing the runway. The table at the bottom also tells you that it should take four minutes 35 seconds to get from the LOM to the missed approach point. That's a lot of knob twisting and button pushing, especially if you are by yourself.


Jeppesen Approach Chart
JUL 18-61 (11-1)
ALLENTOWN, PA.
-BETHLEHEM -EASTON
ILS/NDB (ADF) 6
LOC 110.7 IABE
ALLENTOWN Tower (FAA) 120.5 278T
3023.5G 126.2GX
Apt. Elev. 391'
Var. 10° W
GS 330.2
Approach 118.2
Departure
Ground 121.9
SAFE ALTITUDE
20 Mi. 4000' 40 Mi. 5000'
835'
ABE 117.5
105°
745'
240°
241°
INT
9.6 2400
217° 9.6 2400
228° 8.7 2400
299°
704'
531'
600'
AE 321
060°
580'
MM
1080'
EAST TEXAS 110.2 ETX
1100'
LOM AB 224
1495'
1610'
40-40
40-30
286°
106°
TOPTON
8.7 (ILS) 2400F (NDB) 1900F
061°
1415'
007° ESR 116.4
75-40
75-30
75-20
Scale
10 Mi.
WEST 2400' (2009')
LOM GS 2330' (1939')
MM GS 600' (209')
061°
1900' (1509')
MIM
5.5
6.1
0.6
0
391'
PULL UP to 3000 (2609) feet on NORTHEAST course ILS, or 061° from LOM within 10 miles.
U.S. CAR. 40, 41, 43, MINIMUMS
STRAIGHT-IN RWY 6: WITH FULL ILS | W/O GLIDE SLOPE | LOM NDB (ADF)
CIRCLING: ILS | NDB (ADF)
ALTERNATE: WITH LOC. AND 3 COMP. | LOM NDB (ADF)
TAKE-OFF: W/O FULL ILS | WITH FULL ILS
1 or 2 Eng. to 65 Kt: 300-3/4 | 500-1 | 700-1 | 500-1 | 700-1 | 600-2 | 800-2 | 300-1 | 300-3/4
2 Eng. over 65 Kt: 300-3/4 | 500-1 | 700-1 | 500-1 | 700-1 | 600-2 | 800-2 | 300-1 | 300-3/4
4 Eng. over 65 Kt: 300-3/4 | 500-1 | 700-1 | 500-1½ | 700-1½ | 600-2 | 800-2 | 200-½ | 200-½
JET: 300-3/4 | 500-1 | 700-1½ | 600-2 | 700-2 | 600-2 | 800-2 | 200-½ | 200-½
Ground speed-knots: 60 | 80 | 100 | 120 | 140 | 160 | 180 | 200
G.S. Descends 2° 54': 308 | 411 | 513 | 616 | 719 | 821 | 924 | 1027
LOM to Pull-up 6.1: 6:06 | 4:35 | 3:40 | 3:03 | 2:37 | 2:17 | 2:02 | 1:50
CEILING/ALTITUDE CONVERSION
QFE: 300 | 400 | 500 | 600 | 700 | 800
QNH: 691 | 791 | 891 | 991 | 1091 | 1191
NDB AMEND 3
CHANGES: Jet straight-in runway minimum corrected.
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Flying the Approach, ABE 2024

For comparison, let's look at flying the ABE ILS or LOC RWY 6, shown below, today. The first thing we notice is that the designation of the Allentown VOR has been changed from ABE to FJC. We also see that the approach plate shows us what the Morse code is, since most of us don't know it by heart. Apparently in 1962 they assumed you knew Morse code.

The Low Frequency Radio Range is gone, as those were all shut down by the 1970s. The marker beacons and NDB are gone. Location is now determined by cross radials from East Texas (ETX) VOR, radar, or GPS. ("East Texas" is a funny name for a VOR in Pennsylvania.) The procedure turn has been replaced with a holding pattern. This is increasingly common, as it provides an easy way for approach control to put an aircraft into holding, and it provides the same ability to reverse course in a controlled fashion. Communication with approach control and tower is done transmitting and receiving on the same frequency. With radar tracking available, multiple aircraft can be at various positions on the approach.

To fly the approach, load the approach in your IFR approved GPS. Tune your VOR receiver to 110.7 MHz. Contact approach control on 119.65 MHz or 124.45 MHz on your comm radio. Request radar vectors to the localizer outside of SHAGY, the final approach fix. At SHAGY, track the localizer and glideslope to the runway. Much simpler, huh?

If you insist on flying the full approach, you can enter at the IAF JISTO intersection, identified by the localizer and crossing radial 179 from ETX. Use the holding pattern for a course reversal if needed. SHAGY intersection is identified by the localizer and crossing radial 098 from ETX. Still a lot less button pushing and knob twisting than in 1962.

ALLENTOWN, PENNSYLVANIA AL-15 (FAA) 23278

ILS or LOC RWY 6
LEHIGH VALLEY INTL (ABE)

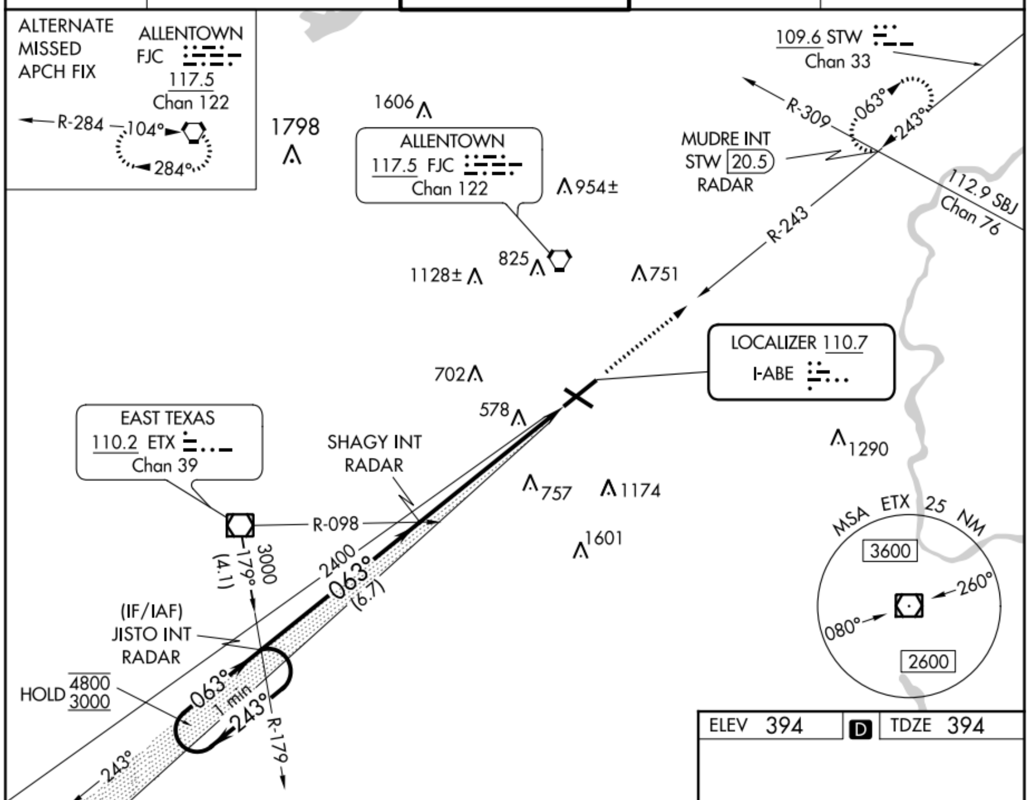
LOC I-ABE	APP CRS	Rwy ldg 7599
110.7	063°	TDZE 394 Apt Elev 394

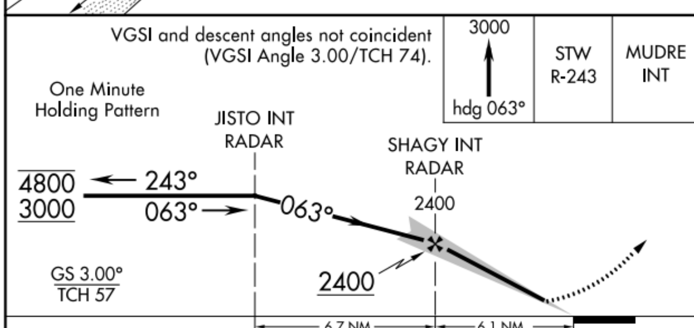
* RVR 1800 authorized with use of FD or AP or HUD to DA.

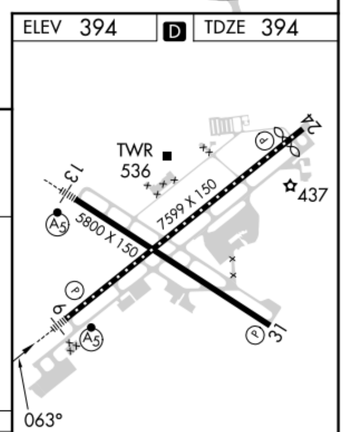
MALSR

MISSED APPROACH: Climb to 3000 on heading 063° and STW R-243 to MUDRE INT/STW 20.5 DME/RADAR and hold.

ATIS	ALLENTOWN APP CON	ALLENTOWN TOWER	GND CON	CLNC DEL
126.975	119.65 124.45 351.8	120.5 257.95	121.9 257.95	124.05 257.95







CATEGORY	A	B	C	D
S-ILS 6 *	594/24 200 (200-½)			
S-LOC 6	920/24 526 (600-½)		920/55 526 (600-1)	
C CIRCLING	920-1 526 (600-1)		1180-2¼ 786 (800-2¼)	1600-3 1206 (1300-3)

REIL Rwys 24 and 31
HIRL Rwys 6-24 and 13-31

FAF to MAP 6.1 NM

Knots	60	90	120	150	180
Min:Sec	6:06	4:04	3:03	2:26	2:02

ALLENTOWN, PENNSYLVANIA
Amdt 24 03JAN19

40°39′N-75°26′W

LEHIGH VALLEY INTL (ABE)
ILS or LOC RWY 6

NE-4, 31 OCT 2024 to 28 NOV 2024

NE-4, 31 OCT 2024 to 28 NOV 2024

The Future of IFR Flying

Hopefully by now you've realized that the complexity of IFR flying has been a function of what technology was available. Through the years, as the available technology has improved, the complexity of flying IFR has been reduced. Assuming this trend continues, what does the future hold?

The FAA is working on transitioning IFR flying to something they call "Performance Based Navigation". I'm sure someone at the FAA got an award for coming up with that name, plus an extra bonus for writing something that sounds impressive but obfuscates what it really is.

Regardless of the fancy bureaucratic name, Performance Based Navigation (PBN) will be based on area navigation capabilities, such as provided by GPS, INS, or DME/DME. The key point is the ability to navigate directly from any Point A to any Point B[1]. Thus, PBN does not require navigating directly to or from any ground based navaids. This will allow the FAA to reduce the number of VORs in operation. Most of the NDBs are already decommissioned. This will reduce the operations and maintenance costs to the FAA, as well as reducing the costs of flight checking all of the navaids on a regular basis.

Totally eliminating VORs would not be good, as it would leave no navigation backup in the case that GPS was unavailable. The FAA will be reducing VORs to what they are calling the Minimum Operational Network (MON). This will primarily decommission some VORs in the eastern and central US. All VORs in Alaska and the mountainous west will be retained, as they were already a minimalist network. For the VORs that remain, their service volume will increase from a 40 nm radius to a 70 nm radius. The intent is to have nearly full coverage at 5000 feet AGL everywhere. Strangely, with the increased service volumes, the FAA actually expects better coverage at 5000 feet AGL than was available previously with more VORs. In the MON, there will always be an airport within 100 nm with an ILS or VOR approach with no requirement for GPS, DME, ADF, or radar.

The intent of PBN is to use area navigation if available. VORs will only be used if GPS is not available. Even so, you can bet that aspiring student pilots will continue to be confused by how to read a VOR indication. Instrument approaches will be mostly GPS RNAV, though existing ILS approaches will be maintained to support the MON. Using GPS approaches allows building new approaches at airports without approaches without the expense and effort of building and maintaining new ground navaids.

As IFR procedures require less unique avionics, it means there are less antennas that need to be located on the aircraft. This is especially good for homebuilts. Avionics boxes that are not installed require zero panel space and have zero weight. Antennas that are not installed have zero weight, create zero drag, create zero interference, and require zero maintenance. No antennas are required for DME or ADF since they are not installed. The Bearhawk has two comm radio antennas, a GPS antenna, a transponder antenna, and an ELT antenna. There is a marker beacon antenna in the right wingtip, but it serves no significant useful purpose. The VOR antenna is installed in the left wingtip. There is no glideslope antenna. The GNS 480 takes the VOR antenna signal and filters the glideslope signal from it. The second overtone of the VOR antenna resonates at the glideslope frequency, since the glideslope frequency divided by 3 would be in the localizer frequency band.

Improving Safety

Talking about safety can be boring for some people, but following good safety procedures ensures that we are around and alive to be bored by someone talking about safety. As IFR procedures are simplified by better technology, the pilot workload is reduced. When pilot workload is reduced, the pilot performance should improve. With better pilot performance, safety should be improved, which is good for the pilot, the passengers, and all of us on the ground looking up, pointing, and saying in an excited voice "Airplane!". You know who you are.

- **Russ Erb**

References

1. Smith, Frank Kingston, *I'd Rather Be Flying! Instrument and Multi-Engine Flying for the Week-End Pilot*, Random House, New York, 1962.

2. Twombly, Ian J., *The 36-Pound Radio*, https://www.aopa.org/news-and-media/all-news/2008/march/01/the-36-pound-radio , Aircraft Owners and Pilots Association, 2008.

[1] If I didn't already have a cool name for my house ("Bearhawk Manor") I think I would call it "Point B". There must be something exciting at Point B, because everyone at Point A is desperately trying to get there.