Flying IFR

Author: Andrew Ayers
Embraer EMB-120 Brasilia First Officer

Published on:

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IFR Overview

IFR is an acronym for Instrument Flight Rules. As the name indicates, IFR is a system of rules for operating via instrument reference. Most people equate IFR with poor weather flying, but in reality, most IFR flying is done in perfectly good weather conditions. IFR is designed to allow safe operations in weather conditions that don't allow adequate visual reference, but if you are instrument rated, you're free to operate under IFR at any time, provided you're current and your aircraft is properly equipped. Because we're going to be flying a sim, there are a lot of things we can get away with in X-Plane. So, there is a lot of information which you would learn in a real instrument ground school which you won't need for our purposes. However, I know that many of you are interested beyond just what you need to know, so I'll make mention of references which will provide more information. My purpose in these lessons is just to give the necessary information to properly fly IFR procedures, not to make everyone IFR experts.

So what is this IFR `system" that we'll be talking about? What makes it up and where do we fit into it? IFR flying isn't as abstract as some think it is. It's principles are simple, your attitude instruments tell you how to keep the plane upright and flying, your navigation instruments tell you how to get where you're going, and ATC and timing keep you from running into everyone else. Until we get to the lesson about GPS procedures, we'll be discussing ground-based navigational aids, namely VORs and NDBs and when we get to approaches, the Localizer and Glideslope. So, an understanding of how to use these aids(tuning, tracking, etc.) will be fundamental to your ability to operate safely IFR. See below for references on this material. Now, getting back the system...The entire enroute IFR system is based on the VOR. We will be flying along imaginary highways called `airways" which are made up of radials to and from various VORs. Now, you can see how this could get restrictive and indirect when you can only fly VOR to VOR. However, you may fly direct from one navigational aid to another even if it's not a published airway, so there are ways to go as directly as possible. We'll discuss how to go about doing this when we get to flight planning. Your enroute chart is just like a `roadmap" of the skies and we'll be using it to figure out what airways to take to get from one place to another. At this point, it's probably still a little vague as to how it all fits together. As you can see by the syllabus, we'll be discussing each part of a flight separately and then putting it all together on a complete flight plan lesson in the end.

As I stated above, IFR is a system of rules, so if you want to operate under IFR, you need to be familiar with those rules. In X-Plane, we aren't bound by those rules, so we don't really need to know them all inside and out. For realism purposes, I will discuss some of the rules applicable to particular operations when we reach that part of the lessons, but if you're interested in more in-depth discussion, I'll just refer you to your copy of the F.A.R.s. Start with 91.167 and read through 91.187. Those rules discuss particular things you must do to be operating legally under IFR. Also review Chapters 3,4,5 of the A.I.M. Those discuss ATC and accepted methods of operation.
We should also be familiar with how the navigation aids we will use operate. It's not necessary to fully understand how an ILS works in order to properly fly one, but it is good practice to know what you're dealing with and what is actually happening to the instruments during your flights. Read Chapter 1 of the A.I.M. or Chapter VII of the Instrument Flying Handbook for detailed information on how these various types of equipment operate.

Another important facet on instrument operations is properly scanning and interpreting what the instruments are telling you. A good scan is key to safe IFR operations. In X-Plane, we can always pause the sim or turn on the autopilot, so it's not as big of a deal, but for those of you who like to hand fly most of the time, you should develop a proper scanning technique. For information on how to do this, please see Chapters IV and V of the Instrument Flying Handbook.

So, that will give you a good background on what we're going to discuss in the future lessons. Don't feel like this is necessary reading however. Each lesson will contain all the information necessary to fly what's covered in that particular lesson. If you feel lost or that information hasn't been properly covered, please let me know and I'll provide more support and information. Most of all, have fun and PLEASE, let me know what you want to see. I'm doing this to help out, so please let me know if you feel a different approach is necessary to better facilitate learning.
To your right, you'll see a section of a Jeppesen low altitude enroute chart. Low altitude enroute charts cover the IFR system below 18,000ft MSL. Above that, we have high altitude enroute charts. Both charts use the same symbology, so we'll just look at the low altitude chart... "A" indicates the box which tells us who the controlling agency is in that sector of airspace. In this case, it is Miami Air Route Traffic Control Center, better known as "Miami Center".

In this area, their freq. is 124.1. Below that you'll see another box which indicates that the freq. in that area is 132.25 or 135.7. "B" indicates a VOR, just like on an approach plate. At the top it says "Miami WX-2.0" which indicates you can reach Miami Flight Watch on 122.0 for weather updates. You'll then see a number of frequencies below which you'll see "St. Petersburg". This indicates that you can contact the St. Petersburg Flight Service Station on these frequencies. Below that you see the VOR ID and freq. As I said in the previous lesson, our enroute structure is based on VORs, so you'll see a lot of these. "C" indicates the Satellite NDB. NDBs will always be in green. Now look down to the bottom at "E". These two black lines that are being pointed to are airways, the imaginary highways we'll be flying on. Low altitude airways are called "Victor" airways. Take a look at the "V3". Along that airway, you'll see a black box that says "V3", meaning this is a segment of Victor 3. High altitude airways are called "Jet" routes. Though Jet routes are primarily found on high altitude enroute charts, they are also sometimes depicted on low altitude enroute charts. Take a look just to the left of "C" and you'll see a green line. Follow it down just below the Vero Beach VOR identifier and you'll see "J20-113". This indicates that this is a segment of both Jet
20 and Jet 113. Going back to "\*", you'll see that below the "\*V3", there is "2000". This is called your Minimum Enroute Altitude(MEA). This is the lowest you can fly to maintain obstruction clearance(1000ft in non-mountainous areas, 2000ft in mountainous) AND have adequate navaid reception. You'll notice they're all fairly low in Florida, but it's not the same everywhere. Keep in mind that flying on a magnetic course of zero degrees to 179, you must fly odd thousand foot altitudes(ie 5000ft, 11000ft) and on a magnetic course of 180 to 359, you must fly even thousand foot altitudes(ie 8000ft, 14000ft). So, if you were heading southeast-bound on V3, even though the MEA is 2000ft, you'd have to fly at least 3000ft. Now take a quick look at `D`. This triangle represents an `intersection`. Just like roads we drive on, airways cross over each other and create intersections. This intersection is called `SMERE`(because it's over the town of Fellsmere) and is defined by the intersection of V295 and the airway running north-south. Now, back to `\*`, you'll see an intersection just above it called `VALKA`. Above the V3, you'll see `\'15". This indicates the DME distance from the Vero Beach VOR to VALKA intersection. We know this because just below the airway near VALKA, we see a `\''D" with an arrow pointing north. On the other side of VALKA, you see `\''12" which indicates the DME distance from VALKA to the Melbourne VOR. Now, right at the tip of the arrow, you'll also see a six-sided shape with a `\'27" in it. This indicates the total distance between the two navais that make up that segment of the airway(VRB and MLB). But more to the point as far as using the airway, if you look at where the airway starts at VRB, you'll see that it's defined by the 347 radial FROM VRB and on the other side, it's defined by the 165 radial FROM MLB. Procedure says that you should switch from one to another half way in between unless otherwise specified. So, if you left VRB, you'd fly 357 FROM until about 15 miles DME away from VRB and then switch to flying 345 TO(the reciprocal of 165 FROM) MLB. Take a look on the south side of VRB and find V295 heading southeast. Below it's box, you'll see `\'2000", your MEA, but you'll also see `\'1500T". This is your Minimum Obstruction Clearance Altitude(MOCA). This altitude assures you of your proper obstruction clearance, but only guarantees navaid reception within 22NM of the navais. This is used in emergency situations where you're not able to maintain the MEA(ie twin engine aircraft with an engine out). Since we're down there, lets take a look at another thing. Just east of V295 near the edge of the image, you'll see `\'ANGEE" intersection and if you follow the airway back to VRB, you'll see that it's 22DME from VRB. But, if we didn't have DME, how would we know we were at ANGEE? Well, if you look at ANGEE, you'll see a small line extending southwest that has `\'035" printed on it and a little further along it says `\'PHK 115.4". This indicates that if you set the NAV you're not using to fly the airway to the PHK VOR and tune in the 035 radial, when it centers, you've reached ANGEE. Now, let's move to `\'F". This is an airport identifier, in this case identifying my home, Vero Beach Municipal Airport. It's ATIS freq. is at the top followed by the airport information. After it's identifier, you'll see the MSL altitude and length of the longest runway in thousands of feet. Now, below that, in green, you'll see the frequency and identifier of the Vero Beach NDB. Notice it doesn't look the same as the Satellite NDB we saw earlier. If you look back up at the Satellite NDB, you'll see a green line extending out southeast off the edge of the chart. Though you can't see it marked on the chart, this is BR1L, one of the Bahamas Routes. They are based on NDBs instead of VORs. So, if an NDB is used to make up a route, it will have a large identifier like the Satellite NDB does. Last, let's take a look at `\'G". This large number is your Grid Minimum Off-Route Altitude(Grid MORA). As I said in the Overview, it is possible to fly direct from some places to another without having to use the airways. If you're going to do this, you use your Grid MORA to determine the lowest altitude it is safe to fly at. In this case, in this grid on the chart, the lowest we could fly to maintain obstruction clearance would be 2700ft, but since we have set altitudes we must adhere to, we would have to be at least 3000ft eastbound and 4000ft westbound. Now, there's even a way to cheat this, but it's a technicality and complicated, so I'll save it for later.

So that's the basics of the enroute chart. Again, the main difference between low and high charts is the Victor airways vs. Jet routes. At higher altitudes, you can receive navais further away(generally), so Jet routes can be made up of VORs that are further apart. That's really the big difference. Now that we've got an idea of what the
two main charts are telling us, let's move on to actually doing some procedures...
To the right, you'll see a Jeppesen Approach plate for one of the approaches which serve Key West, Florida. Though each plate contains specific information for each approach, they are all laid out in the same format, so what you will see here will be the same things you will see on other plates. I'll be using Jeppesen for my examples since I have current charts. NOS are just as easy to use and use nearly all the same symbols, so if you've purchased some NOS charts, you won't have any problems transferring this information. This lesson is just to explain what the charts are telling you, not how to actually fly an approach with them. That will be covered in the "Approach" lessons. Let's start at the top and work our way down... The top section of the approach plate is called the header. "A" shows us the chart identifier. We see that is the chart for "Key West, FLA", the airport being served is "Key West INTL". This is important for cities with several airports, make sure you've got the right plate in front of you. Next, we see that this is the chart for the "VOR or GPS-B" approach. This tells us a number of things. First, we now know that this approach is based on the use of either the VOR or the GPS. Second, we see that instead of indicating what runway the approach serves (ie "VOR 9"), it just says "B". If an approach identifier ends in an alphabetical suffix, that means that the final approach course (the course we will fly
on the final part of the approach) is not aligned within 30 degrees of the runway centerline. Because of this, the approach doesn't serve one runway in particular. Below the identifier, we see the VOR frequency and identifier. Since the VOR is the primary navaid for this approach, it's information is printed in the header. It's the same for ILS, NDB, etc. Below that, you'll see the airport identifier and sea level altitude. "B" shows us our Minimum Safe Altitudes(MSA). Near the bottom, we see "MSA EYW VOR". This tells us the MSA circle is centered around the Key West VOR. The circle represents a 25NM radius area allowing 1,000ft of obstruction clearance. From this, we can see that anywhere from east through south and west to north, we can descend to 1500ft and still have assured obstruction clearance. In the northeast quadrant, we can't descend below 15,000ft. This is primarily used during missed approach procedures to maintain safety while preparing for another approach. "C" is our communications box, giving us all the pertinent frequencies. Since we don't really have to tune correct frequencies in X-Plane, we'll move on...

Next we come to what is called the "Plan View" which gives us an overhead look at our approach. "D" points to the ID box for the primary navaid, the Key West VOR. This tells us all the pertinent information about the VOR, its freq., its Morse code ID, the "D" indicates it has DME and the (H) indicates that it's a high VOR(read your AIM). Above the identifier, we see the letters "(IAF)". This stands for Initial Approach Fix. In other words, this is where the approach starts. If we were going to fly the full approach, this is where we would start. Some approaches have more than one IAF. For example, if you look just up above "D" slightly, you'll see a GPS fix called [D037H], which is also an IAF. "E" points to what is called a "DME Arc". An Arc is another procedure we can use to fly to an approach course, one we will discuss in detail in a later lesson. Not all approaches have Arcs. "F" indicates the inbound approach course. This indicates that we will be flying along the 127 degree radial TO the Key West VOR when we're inbound on the approach. "G" illustrates what is called the procedure turn. If we start the approach at the VOR, we have to fly out away from it and then come back in to complete the approach. To do this, we have to have a way to turn around safely. The procedure turn shows us headings to fly while making our course reversal. We'll talk in detail about how to fly them when we get into approaches. "H" shows us where the airport is located on the approach. The triangle represents the missed approach point, showing that it's at a DME distance of 2.6 or at the GPS waypoint [MA127]. The segmented line curving back towards the VOR represents the missed approach path. "I" points to the ID for the Fish Hook NDB. Since this is not an NDB approach, this navaid is not part of the approach procedure, however, it can give us information about how to orient ourselves with the approach. Below the ID, you will see where it says "to VOR 342 2.4 1500". This is telling us that from the NDB, we can fly a course of 342 for 2.4NM at 1500ft MSL to reach the IAF. These are called "feeder routes". This is useful for making transitions from enroute to an approach. "J" illustrates an obstruction in the area of the approach, with its MSL altitude printed near it.

The next section is called the "Profile View", which shows us a side view of our approach. You'll see that in the center of the section is a symbol representing the VOR. Since we found out that the approach starts at the VOR, you'll see the approach course starting from the top of the VOR symbol, reading the outbound course while descending to an altitude of 1500ft. "K" illustrates the procedure turn, telling us that we must not descend below 1500ft MSL(we may stay higher if we like) until we've completed it. At that point you see the inbound course as we head back to the VOR, not descending below 700ft MSL. As we pass the VOR again, you'll see what looks like an "x". It is a "Maltese Cross" and indicates the Final Approach Fix(FAF). This indicates that we're about to start the final segment of the approach. At this point, we'd descend to what is called out Minimum Descent Altitude(MDA) until we see the airport and land. "M" points to the "M" which represents the Missed Approach Point(MAP). This would be the place where we would initiate a missed approach if we weren't able to gain visual contact with the runway. We'll talk more about making that decision when we get to approaches.

So if we have to make a missed approach, what do we do? Well, "N" represents your
missed approach procedure. It's quite simple, just read and do. It's not uncommon however to get amended missed approach procedures from ATC, so be prepared.

``O'' will tell us what our MDA is as mentioned above. First, you'll notice that there is a lot of blank space to the left of ``O''. This space would normally contain the straight-in minimums for the approach, but since I said above that because this is the VOR or GPS ``B'' approach, it's not aligned to allow straight-in to a particular runway, so we only have ``circle-to-land'' minimums(see to the right of ``O''). The MDAs are listed by aircraft categories. You'll see ``A'', ``B'', etc. along the left-hand side. Aircraft categories are based on approach speed. As you can see, ``A'' is aircraft with approach speeds 90kts and below, ``B'' is aircraft with approach speeds 91kts-120kts, etc. So, if you're coming in at 80kts, your MDA is 500ft MSL. In parenthesis, you'll see that AGL altitude of 496ft. Also, you'll see a ``1'' after the MDA. This indicates the minimum visibility of 1 statute mile. So, what this is telling you is that you may NOT descend below 500ft until you have the runway in sight(it's more complicated than that, but we'll save that for approaches) and you may NOT land unless you have a flight visibility of at least 1SM.

Now, as I said above, the MAP is DME 2.6 or a GPS waypoint. But, let's say you don't have GPS and you don't have DME. So, how do you know when you're at the MAP? Take a look at ``P''. This table shows you how long it should take you to get to the MAP at various groundspeeds(NOT indicated!). So, if you've got a groundspeed of 90kts, start your timer passing the FAF and when it says ``1:44'', you're at the MAP. See how easy that is?

So there's a typical approach plate. As I said, each plate will have it's own information and may contain items which aren't covered on this plate. If you have any questions, consult your chart legend or e-mail me. Enjoy!

Goto Lesson 3
Departures (SIDS)

Let's talk a little about what we're going to need to do before departing. First, as always, would be a check of the weather. For the sake of simplicity, I'm going to use rules pertaining to FAR part 91 operations (private aircraft and operators). Airlines, charter, cargo, etc. have to follow specific guidelines, but we are allowed to takeoff in any weather we choose. So, if the ceiling is down to the ground and visibility is zero and all you can see is the runway centerline to maintain directional guidance during the takeoff role, that's fine, you can takeoff anyway. Not a really good idea however. What happens if you have an emergency after takeoff and need to come back? Uh-oh, now the weather is below minimums for the approach and you're on your way to somewhere with better weather (if you can keep the plane flying that long). So, the general rule is don't takeoff unless you've at least got the minimums for the approach back into the airport. At the bottom of your approach chart airport diagrams, you'll probably see takeoff minimums printed, but those don't apply to you. Also at the bottom of some approach plate airport diagrams you'll see "IFR Departure Procedure:" These aren't explicit instructions for how to get where you're going, they're instructions on how to maintain obstruction clearance at airports where there are obstacles nearby. For instance, the IFR Departure Procedure for Ft. Pierce, FLA says "Rwy 14 & 32 climb rwy heading to 600ft before turning right" This is just telling you not to make an early turn out so you don't run into something. Also, for every IFR flight, we're going to have to file a flight plan. We'll discuss how to file a flight plan in the final lesson when we work up to an entire flight. From our flight plan, we will receive our clearance. Our clearance, in part, will tell us how we are to depart. At large airports, there are frequently Standard Instrument Departures (SIDs) which provide explicit instructions on how to make the transition from takeoff into the enroute structure. Because of the high volume of traffic in or around these airports, a standard procedure is needed to keep traffic organized. At smaller airports, we may not receive explicit instructions on how to depart. Instead, ATC may instruct us however they best see fit in order to control traffic in the area. So, having said that, let's take a look at a segment of a sample flight and see how a departure would go...

Since we looked at enroute charts previously, you will remember our discussion of V3, a portion of which runs between the Vero Beach VOR (VRB) and the Melbourne VOR (MLB). So, let's say that we're going to depart Vero Beach on a flight to Melbourne and we've filed V3 as our route of flight at 3000ft. If you look on the enroute chart, you'll see that the airport is approximately 3.5nm east of the VOR. If the airway starts at the VOR, how are we going to get there from the airport? Well, first let's look at the clearance we'll get if we file V3. We would pick up our clearance while still on the ground, just like in X-Plane. The clearance you will get in this case would be exactly like this: "N9246F cleared to the Melbourne International airport as filed(V3). Climb and maintain 2000, expect 3000 ten minutes after departure. Departure will be on 132.25. Squawk 4352". What that means to you is that you have been CLEARED (read: you may proceed all the way to) the Melbourne International airport. This means that you are cleared all the way to touchdown at Melbourne. There are times when you will only be cleared to an intermediate fix, but we'll save
that for later. As filed means whatever you put on your flight plan (V3) is OK with ATC. Many times you will NOT get what you filed. You are then instructed to climb and maintain 2000ft and told that you may EXPECT 3000ft ten minutes after departure (read: if you lose communications, assume that you will have been cleared to 3000ft and then climb to it ten minutes after departing). You then get your departure frequency and squawk code. But we still haven't been told how to get to V3 right? Do not fear, let's taxi out and see what the tower has to say. When we're ready to takeoff (let's say we're using runway 11R), we'd contact the tower and they'd say to us `N9246F fly runway heading. Cleared for takeoff runway 11R". So, we taxi onto the runway and blast off into the soup, climbing to 2000ft and flying runway heading (110). We're climbing out and at about 500ft or so, the tower calls us up and says `9246F contact departure". Just like X-Plane right? Well, here's where things start changing.... Since we got the departure freq. in our clearance, we just flip to the proper frequency and say `Miami, 9246F is 500 for 2000 runway heading". Now they know where we're at and they know that we know we're supposed to stop at 2000ft. They would then come back and say `9246F Miami Center radar contact climb and maintain 3000". Now they've got us on radar and they've cleared us to climb to our cruise altitude of 3000ft. All this time, we've been flying along at runway heading and climbing towards 3000ft. Shortly after this, Center would come back and say something like `9246F turn left heading 300 vectors to join V3". Now we finally have something to work with. So, we turn left to a heading of 300 and if you look at the enroute chart, sure enough, a heading of 300 should cause us to intercept V3 somewhere between VRB and MLB. So, we cruise along at this heading, leveling off at 3000ft, and tuning our HSI to intercept V3 (This should really be done before takeoff). To do this, we'd tune in the freq. for VRB (117.3) and turning the needle until the head points to 347 degrees and the direction indicator is showing FROM (pointing away from the head). The needle should then be deflected to the left side of the head indicating that our course is to the left side of center (our airplane is always in the center of the HSI). So, we'd have to fly one of the headings on the left side of the head to reach our course and sure enough, 300 is to the left side.

We would then cruise along until the needle centers, which means we are on course and then turn to intercept it. The needle should remain centered and we should be flying close to the same heading (perhaps a couple of degrees off for wind correction).
So there it is, we've successfully departed Vero Beach and established ourselves on course!

OK, now that we've done that, let's now depart out of a busier area, Ft. Lauderdale-Hollywood International. Before we begin, let me say a few things about SIDs. First, you don't have to have the SID chart to use one. If there is one available and you would like to use it, you can tell ATC and they will read off to you the textual description which contains all of the instructions. The graphic is only for situational awareness, so you're not required to have it. Second, you are NOT required to file or use a SID just because one is available. If you choose not to use one, simply put "NO SID" in the remarks section of your flight plan. Having said that, guess what, if there's a SID available, you're going to fly it whether you like it or not. The only way you can get around it is if you can't climb at least 200ft per NM which is a standard requirement for SIDs or if you don't have the necessary equipment. Why is this? Well, SIDs were designs for a reason and ATC wants to make their job as easy as possible, so they're not going to let you just fly in and out of the airspace wherever you like. So, let's say that you tell ATC that you don't want to use a SID. They'll come back to you and say "No SID huh? OK, cleared to ... via a REVISED routing..." and then they'll proceed to read off exactly what it says on the SID chart. So, you thought you got away with it by filing your own routing, but ATC has the authority to change your routing to fit in with traffic flow, so they're going to make sure you go where they want you to. OK, let's get to the flying. Here you see the chart for the "Ft. Lauderdale Eight Departure".
A shows us the chart identifier, letting us know it's a chart for Ft. Lauderdale, FLA pertaining to Hollywood INTL. Like our Approach plates, B is the communications box showing us applicable frequencies. C tells us the identifier of the procedure. At the end, you'll see the ``(FLL8.FLL)''. This is the actual ID for ATC to program in their computer when you file your flight plan. Next to that, you see ``(PILOT NAV)''. This tells you that you will have to follow the instructions and you're responsible for the navigation. Some SIDs are ``(VECTOR)'' procedures where ATC just gives you a vector out to your course as filed. Notice below is says ``(DME Required)''. Make sure you read these or you won't be able to fly the SID and you'll have to notify ATC accordingly. D is the beginning of the textual instructions. Read it just like a book and follow the parts that apply to you. The first part says” Ft Lauderdale-Hollywood Intl Take-off” which means this section will tell us what to do on takeoff. Let's say we're departing Rwy 27L. The first section says ``Rwys 9L/R''. Since we're not using this runway, we skip down to where is says ``Rwys 27L/R'' and read that we're supposed to fly runway heading or as assigned ``Thence''. When you see ``Thence'', that means move on to the next section. Below that you'll see takeoff instructions for Ft. Lauderdale Executive and Pompano Bach, but since we're not operating from those airports, we skip those and move on to E. E tells us our departure procedure. It tells us to climb and maintain 3000ft or assigned lower and EXPECT a vector to the appropriate transition and EXPECT clearance to our filed altitude. Now we move on to F, which is ``Transitions''. Transitions are how we get from takeoff into the enroute part of our flight. Since you can't see the applicable enroute chart here, you have to work with me a little bit. Let's say that we were on our way to Tampa Intl, which is northwest of Ft. Lauderdale. So, we want to use the ``THNDR'' transition to take us up to V157 towards Tampa. So, under ``Transitions” we would go down until we reached ``THNDR'' and read what it says. It tells us that the THNDR transition goes from DHP VOR to THNDR intersection and to fly it, we would, from over DHP VOR, proceed via radial 335 until reaching THNDR. Now, above in E, it told us to expect a vector to our appropriate transition, so we shouldn't have to fly to the DHP VOR and then back track up radial 335. However, if we lost communications, we would have to
do that because ATC wouldn't be able to give us vectors. Now, let's move down to the pictorial overview for a better idea of what's going on. "G" illustrates a VOR, just like on enroute and approach plates. "H" is the airport identifier and you can see the dark black lines with arrows illustrating the takeoff instructions we saw in section "D". "I" points to a couple of transitions. You'll see that the one on the left is the THNDR transition. Below the transition ID, you'll see "2000" which, like our enroute chart, is our MEA. Below that, you see "57", which is the DME distance from DHP VOR to THNDR intersection. Once you reach THNDR, you would proceed on course as you filed. So, you can see how this saves everyone time. You know exactly what to expect and ATC knows what to give you, so communication and confusion is cut down. So, let's fly it. Our clearance would say "...Cleared Ft. Lauderdale Eight then as filed..." Like I said, we'll depart runway 27L on runway heading, climbing to 3000ft. After being switched to departure, we would receive our vector to intercept our course.

We would then fly along until we intercepted the 335 radial FROM DHP and then turn on course until we reach THNDR.

At that point, we've completed the SID and we would proceed along our route as
filed. There you go!
The enroute part of IFR flying isn't tremendously complicated. We'll be spending most of our time tracking airways and intercepting new ones. Occasionally we'll be handed off to a new Center controller and in rare circumstances, we'll be asked to hold. Let's first talk about airways tracking.

As we learned before, airways are simply imaginary paths which are based on radials to and from VORs. We try to fly as directly as possible, but VORs aren't always going to be in straight lines between where we're starting from and where we're going. So, we're going to have to piece together the airways which will take us to our destination. Along the way, we'll have to be diligent to maintain our course and be aware of when our next changeover I is coming. Now, airways are protected 4NM either side of the centerline, so we have a little room to play with before getting ourselves into danger of obstruction interference, but that doesn't mean we should get sloppy with our tracking skills. So, let's take a look at a sample flight from Vero Beach to West Palm Beach International(PBI) Near the top, you'll see Vero Beach.
West Palm Beach is off the chart to the southeast. If you look at "D", you'll see that it says "Palm Beach 115.7". This indicates that the airways which are going off the map at this point are based on the Palm Beach VOR (which is on the field at PBI). So, if you look back up at Vero Beach, you'll see that V3 runs in a straight line directly from the Vero Beach VOR to the Palm Beach VOR. This seems like the logical choice for us to use then right? Well, sure it is, but you're not getting it. Unless you're flying high, there's too much VFR traffic coming up and down the coast in that area, so ATC isn't going to want to keep and eye out for you the whole time. Instead they'll bring you out and then back in when you get near Palm Beach. So, let's assume that we were given this clearance: "9246F is cleared to the West Palm Beach International airport via Victor 159 TBIRD Victor 531..." So, looking on our chart at "A", we see that V159 extends south along the 182 radial FROM Vero Beach. At 31DME, it passes through TBIRD intersection ("B"). From there, we see that V531 ("C") extends southeast bound 35DME to the Palm Beach VOR via radial 327 FROM. Alright, now that we know how we're supposed to proceed to PBI, let's talk a bit about altitudes. You'll remember that going on a magnetic course of 180-359 degrees, we've got to fly even thousand feet intervals. VOR radials are magnetic, so along V159, we're going to be going on a magnetic course of 182 degrees. We see that the MEA along that segment of V159 is 2500ft, so we'll have to go at least 4000ft. That'll be fine for us, so we'll plan on that. However, once we cross TBIRD, we'll be proceeding along a magnetic course of 147 degrees (the reciprocal of 327 FROM). So, now we've got to fly an odd thousand foot altitude. The MEA along this segment of V531 is 3000ft, which will work fine for us, so we'll plan to make a descent to 3000ft after passing TBIRD. This brings me to an important point which applies more to climbs, but also to descents. If you are proceeding along an airway and you're about to cross into a section with an MEA higher than your present altitude, you are expected to start your climb to your new altitude UPON crossing into that segment. Some intersections have Minimum Crossing Altitudes (MCAs) which indicates that you should climb to the higher altitude BEFORE crossing into the new segment. You'll see an "X" with an altitude by it at those intersections, but they're not all that common. OK, let's go flying!

We'll assume that, like our "Departures" example, we've gotten radar vectors to join our assigned course. Now we're established on V159 and we're tuning our radios to intercept V531. We know that TBIRD is 31DME from VRB, so we don't actually need a second NAV radio to define TBIRD. We could simply fly until 31DME, switch to the Palm Beach VOR frequency, tune the new radial, and turn on course. But, for the sake of backup and practice, we'll also use dual NAVs to fly our courses. So, established on V159, we're proceeding along course with NAV2 set to VRB radial 182 FROM. We've set NAV1 to PBI radial 147 TO (reciprocal of 347 FROM).
Once the needle on NAV1 centers and the DE(set to NAV2) reads 31, we know that we've reached TBIRD. At that point, we'll turn to track NAV1 and continue inbound towards PBI. Also, at this point, we need to start our descent down to 3000ft. ATC expects that we know the rules and will be expecting us to make our descent. However, we still need clearance to vacate any assigned altitude. So, we could call Center and ask for clearance, something like "Miami 9246F would like a descent to 3000" to which they would reply "9246F descend and maintain 3000ft". We would then report leaving 4000 for 3000.

I should also note that any ATC clearance supercedes the course/altitude rule. If ATC tells us to maintain 4000ft, even though we're now on a magnetic course that dictates we fly odd thousands, we do it. Now that we're established on V531, I'd begin the arrival procedure which we will discuss in the next lesson. I'd set NAV2 to the ILS frequency in preparation for the approach and continue inbound.
So that's about all there is to enroute flying. I've decided not to discuss holding procedures at this point. The reasons for this are first because we aren't asked to hold in X-Plane. Second, understanding holds is very difficult without proper visual aids. Holding itself is quite simple, but visualizing how to enter and maintain a hold is difficult for the beginner and it's not at all uncommon for someone to bust an instrument ride due to poor holding. So, I will work on creating some better visual aids to facilitate understanding of my discussion and I will present holding at a later time. Thanks and enjoy!
Holdings

Even though we never get assigned holds in X-Plane (and rarely in real life), it's a good skill to understand and be able to apply. Holds are very difficult to teach in writing, but hopefully, with the use of illustrations, you'll gain an understanding of how to properly execute a hold. Holds are basically circular patterns which keep aircraft in a small space, allowing ATC to keep traffic orderly and separated. In IFR training, we commonly practice holding over a VOR. Holds can take place in many places however. We can hold over NDBs, we can hold at DME distances on a specific VOR radial, we can hold at airway intersections, we can even hold at GPS waypoints with real-life GPS'. You'll frequently see holds plotted on approach plates and STARs. We'll simplify our discussion by just holding over a VOR and we'll also use a no-wind situation to start. I'll discuss wind correction afterwards. Holds require that you be VERY familiar and comfortable with the operation of the VOR and interpretation of the NAV equipment. Because VORs have 360 radials, we can be assigned to hold on any of those. For our example, let's say that we have been told to hold east on the 090 radial of the Vero Beach VOR. So, we're going to head toward the VOR along the 090 radial, which means we'll be flying 270 TO. Standard holds are accomplished with right-hand turns, so when we pass over the VOR, we will make a 180 degree standard-rate turn to the right and head back away from the VOR for a specified time. We will then make another 180 degree standard-rate turn back towards the VOR. This will result in a racetrack pattern as depicted below. You'll notice that we have an

![Diagram of a racetrack pattern for a hold over a VOR.](image-url)

inbound (heading ding towards the VOR) leg and an outbound (away from the VOR) leg. I've noted that the inbound leg should be 1 minute long. Above 14,000 ft, the inbound leg should be 1 1/2 minutes long. So, how are we going to make sure our inbound leg is 1 minute long? Well, in a no-wind situation, our time outbound should equal our time inbound. So, let's start as we pass the VOR inbound. We start our right 180 degree turn. As we reach the abeam (the holding fix) point, the TO/FROM flag will flip and we will start our timer. We'll then fly along until the timer indicates 1 minute and then begin our right-hand turn back inbound. If we make sure the turns are standard rate, we would roll right out onto the 090 radial (270 TO). At that point, we will again start our timer and see how long it takes us to reach the VOR. We do whatever it takes to make our inbound leg 1 minute long. If we found out that it only took us 50 seconds to fly the inbound leg, we would have to modify the outbound leg by adding 10 seconds to it, flying outbound for 1 minute and 10 seconds. Now, let's talk a bit about how we navigate each leg. Since we're holding along the 090 radial, we will set 270 TO and TRACK the course inbound, keeping the needle centered. Now, as we
approach the VOR, the needle will become more sensitive and start to move off-center. Don't chase it! Just continue to fly your heading until the TO/FROM indicator changes and then begin your turn. Now, as we turn outbound, what are we turning to? Well, since we're not tracking a radial outbound, we just turn to the reciprocal heading. So, in this case, we would turn to a heading of 090. The outbound leg is a dead-reckoning leg, we just fly a heading for a specified time (1 minute). So, like I said, if it was a no-wind situation, it would look just about like above.

Now, let's talk about how we enter a hold. We don't just magically appear along the inbound leg to start the hold. There are three entries we can make, called "direct", "teardrop", and "parallel". The way we determine which entry to make is by our heading to the holding fix. Let's say that we have been given the holding instructions discussed above and we're southwest of the VOR. We would proceed direct to the VOR by turning our HSI needle or OBS until it centered. Let's say that it centers with an indication of 050 TO which would mean we're along the 230 radial. Our next step is to determine where we are in relation to the actual hold that we're going to fly. Take a look at the diagram below: You can see the various sectors for each entry. The sectors are determined by adding 110 degrees to the holding course on the non-holding side and subtracting 70 degrees from the holding course on the holding side. Our holding course is the 090 radial, so if we add 110 degrees, we get the 200 radial on the non-holding side and by subtracting, we get the 020 radial on the holding side. We said above that we were proceeding inbound along the 230 radial, so by looking at the diagram, we see that we should make a teardrop entry. If we were inbound on the 330 radial, we'd make a parallel entry and so on. Now, let's take a look at what it looks like in the plane and from above. I'll be flying the situation we discussed above. In the first turn, I didn't fly outbound long enough, so I overshot the inbound leg. After we've looked at it, I'll discuss how to fly each entry.
OK, so now you've seen a teardrop entry. But how did I do it? Well, it's pretty simple. When you pass the holding fix, turn to a heading of 30 degrees less than your outbound leg heading. Since the outbound leg heading is 090, I turned to 060 degrees.

You just fly outbound for 1 minute as usual and then turn inbound. A direct entry is even easier. You simply fly as depicted. Once you cross the holding fix, you just begin your turn to the outbound leg heading. The parallel entry is the most difficult. As you pass the fix, you turn to the outbound leg heading, but you're flying parallel to the holding course on the NON-HOLDING side. After you've gone out for 1 minute, you then make a LEFT-HAND turn all the way back until you're heading direct to the VOR. Once you cross it, you proceed with the hold as normal. A picture is shown below. OK, now let's talk briefly about flying in wind conditions and making crosswind
corrections.
On your first outbound leg in the hold, it's all going to be guess work since you haven't had a chance to establish a wind correction angle inbound yet. But, let's assume we're heading inbound along the 090 radial with a wind from the north at 20 knots. Because we have a crosswind, we're going to have to establish some crosswind correction to maintain course. I found that it was about 12 degrees to the right. So, since the outbound leg is a dead-reckoning leg, how are we going to compensate. Well, as we turn upwind, we're going to have a decreased groundspeed and as we make our turn back downwind, we're going to have an increased groundspeed. So, to account for that, we're actually going to have to fly AWAY from the course as we proceed outbound. To do this, we will DOUBLE our crosswind correction on the outbound leg. So, since I said it was 12 degrees, we will have a 24 degree correction outbound, or an outbound heading of 66 degrees. Below is a picture of what a properly executed hold with wind correction looks like. It appears odd, but it is the proper procedure. Well, I hope this has helped you to gain an understanding of holding procedures. I'll mention a few other things.

The maximum holding speed for all propeller-driven aircraft is 175KIAS. For civil turbojet aircraft, it is 200KIAS up to 6,000ft, 230KIAS up to 14,000ft, and 265KIAS above 14,000ft. For military turbojet aircraft, it's 230KIAS except for a few specific aircraft. Also, as I said above, normal holding take place with right-hand turns. You may be asked to hold with left-hand turns at times. In fact, the only time I was ever asked to hold outside of the training environment, I was asked to make left-hand turns. If they don't specify, you make right-hand turns. If you were instructed to hold east on the 090 radial of the VRB VOR at 7DME, you would follow the exact same procedure as above except that you would make your turns when you reach 7DME, not at the VOR. You should report to ATC when you enter the hold as well. You should be given an "expect further clearance" time so that you know about when you should be done holding or when to leave the hold in case of a loss of communications. As I said, holding can be complicated and a lot of people take a long time to pass this step in instrument training. Take your time, study the diagrams, and let me know if you have any questions. Good luck!
Arrivals (STARS)

So we've managed to get ourselves airborne and we've learned how to find our way around the airways systems, so now it's time to make our arrival into the airport area. Now, we're not talking about the actual approach to the airport, we're talking about arriving into the airport area in preparation for the approach. Normally the arrival process is simple, but before we get into the specifics, let's talk about what we want to do in preparation. Just like departure, one of the keys to a successful and efficient arrival is being prepared by getting the current information from the Automated Terminal Information Service (ATIS). By obtaining the current ATIS, we will know what the weather is at the airport and we will know which approach is in use. Having this done, we can contact Approach control when advised and let them know that we have the ATIS, avoiding having to switch frequencies later. In real life, you DO NOT want to leave Approach once you've contacted them. The other major consideration to think about is the descent. Once we establish a descent, it's preferable not to have to level off and then begin again. Now, once when you are at your cruising altitude, you're required to maintain it unless receiving a clearance to a new altitude. Normally when you're approaching the general area, ATC will issue you a clearance to descend just like in X-Plane. Once that clearance is received, you are expected to begin your descent immediately. You may also receive a clearance to descend "at pilot's discretion" meaning you are cleared to that lower altitude, but it's up to you to decide when to start the descent. Let's work with the usual "descend and maintain" clearance though. In order to plan your descent, you'll need to know how far you have to travel to where you're going and what your groundspeed is. Let's say that we're cruising at 10,000ft and doing 120kts over the ground. ATC comes on and says "9246F descend and maintain 2000". Our response to that would be "46F's out of 10 for 2". Now, let's say we're 20NM from the Initial Approach Fix (IAF) for the approach we plan to execute upon arrival. So, if we're doing 120kts, it's going to take us 10 minutes to reach the IAF. We have to descend 8000ft in that time, so we're going to need to make our descent at 800ft/min. Keep in mind that if you leave the power set at cruise and just lower the nose to descend, you're airspeed (and correspondingly groundspeed) will increase. So, make sure you take this into account when making a descent. Commercial operators are always concerned about time (which is equal to money of course), so you should plan to descend as fast as is feasible. Now, onto a little aside about that...We know that we cannot exceed 250kts indicated below 10,000ft. When I was getting my Private license back in Santa Barbara, CA, I used to visit the tower frequently because we had radar approach control. Aircraft arriving from the northwest would usually get a clearance to cross the Gaviota VOR (GVO) at some particular altitude and then descend into the Santa Barbara area after clearing the mountains. Almost always, we would be landing to the west, so aircraft would have to come around to the other side of the airport to land. Now, the airlines don't want to take any more time then they have to, so they'd come over the VOR still in excess of 300kts and just coast down to the airport area. You
could see them on the radar indicating like 310kts or so descending through 5000ft and Approach would say `United 463, what's your airspeed?" to which they would invariably reply `463's showing 250". Approach wouldn't make a big deal of it unless it was going to cause a traffic conflict. So, you can get away with it, but you didn't hear it from me. So, now that we've talked a little bit about descent planning, let's talk about procedures...

A normal arrival isn't too terribly exciting if you're going into an airport without a STAR. Let's go back to our enroute chart from the second lesson and pretend we've departed Vero Beach and we're cruising along on V3 at 4000ft heading for Melbourne. Now, the Melbourne VOR is located on the airport, so flying V3 to MLB will take us right to the airport. Now, let's look at a couple of options. First, let's say that we want to do the full(the entire procedure without radar vectors) VOR 9R approach at Melbourne. Now, the IAF for the full VOR approach is the MLB VOR, so just flying V3 right to the VOR will take us right into the approach. So, we're flying along V3 at 4000ft, we've been handed off to Patrick Approach(Patrick AFB handles radar coverage of MLB), and we've got the ATIS. At that point, we'd want to tell Approach of our intentions by saying `Patrick 9246F would like the full VOR 9R Melbourne". When we near the area, Patrick would come back and say `9246F descend and maintain 2000ft, cleared VOR 9R approach". Usually you'll be cleared down to whatever altitude is the entry altitude for the approach. So, now we're cleared down 2000ft and we're also cleared for the approach, meaning that once we reach the VOR, we may then execute the approach as charted, changing altitudes and headings as necessary without receiving clearance. So, that's really all there is to a typical approach. Just get ATIS, contact approach when instructed, let them know what you want to do, and make your descent as instructed. A note about full approaches: unless you ask for one, you'll almost never get it. You'll almost always get radar vectors because it's more efficient for you and for ATC and allows them more control of traffic.

Now, just like SIDs, the country's busier airports are normally served by one or more Standard Terminal Arrival Routes(STARs). Like SIDs, these are plotted procedures that you may file or may ask not to receive, but also like STARs, you will almost always be forced to comply to facilitate traffic control. STARs serve to `funnel" traffic through a particular area, freeing up other space for departures and other operations. Let's take a look below at a STAR...

``A" tells us that this STAR serves the Orlando, FLA area, the Orlando International airport being the primary airport. Keep in mind that, like SIDs, STARs frequently will serve all of the areas in a particular area, not just the primary airport, so if you're travelling to a small airport which is in the same vicinity as a large on, you may want to take a look at the STARs for that airport because you may end up being asked to fly it. ``B" is our communications box, telling us the ATIS frequency so that we can be prepared. ``C" is the procedure identifier, this one being the Goofy Two Arrival(yes, it's called Goofy because it's near DisneyWorld. This is the FAA's idea of a sense of humor). It's ATC computer identifier is (BAIRN.GOOFY2). BAIRN is included
in the ID because it is the intersection that serves as the "funnel" point, which you'll soon see. "D" is our textual description of how to proceed. Simply find which transition you will be using (ATC will usually say in your initial clearance (ie '9246F is cleared... Goof y Two Arrival, Vero Beach transition'). So, let's say we are going to be using the Vero Beach transition. We move down the instructions until we see "Vero Beach(VRB,G OOFY2)" and it tells us that this transition extends from VRB VOR to Bairn Int. In order to fly this, we would proceed via the VRB radial 300. Notice there is no mention of altitude here, it will be dictated by ATC's discretion at the time. Below that we see "Arrivals" which is our instructions on what to do once we've completed the transition. You'll see that the first part says "Executive, Kissimmee Mun, and Orlando Sanford". These are the instructions for the other airports in the area of Orlando. Let's say that we are going to land Rwy 18R at Orlando Intl. We would then move down and find the part which says "Orlando Intl Rwys 17,18" and it tells us that from over Bairn Int, we will fly via the ORL radial 162(make sure you tune 342 TO because you're flying to the VOR instead of away like from VRB to Bairn (see illustration below)) to Sabot Int. we will then depart Sabot Int on a heading of 360 for a vector to the final approach course. Now let's move down to the pictorial display. "E", just like SIDs, enroute, and approach charts, illustrates our VORs. "F" gives us a repeat of the instructions from above. This arrow points to BAIRN intersection and tell us if we're landing at an airport other than International, we'll be expecting a vector to the final approach course. Now let's move down to the pictorial display. "E", just like SIDs, enroute, and approach charts, illustrates our VORs. "F" gives us a repeat of the instructions from above. This arrow points to BAIRN intersection and tell us if we're landing at an airport other than International, we'll be expecting a vector to the final approach course. You'll notice that there is an oval "racetrack" pattern depicted at BAIRN Intersection. This indicates a hold. So, you can expect that, if it's a busy day in Orlando, you may find yourself stacked up over BAIRN Intersection waiting to be cleared for the approach. Also here, you'll see some special information for turbojet aircraft operating at high altitudes called "Vertical Navigation Planning". Since we're planning on landing south on Rwy 18R, it tells us that we should expect to cross BAIRN intersection at 11000ft. Knowing that, we can plan our descent from the Flight Levels better. On the right side of the chart, you'll see two more bracketed areas for other instructions. Also on the chart, you'll see other VORs which aren't part
of the actual procedure. However, they have radials which can be used to define the intersections. You can see that the Lakeland VOR radial 080 can be used to define ODDEL intersection in conjunction with the ORL radial 162. If you have DME, you don't need that intersecting radial because we can see that ODDEL is 28NM DME from ORL. Got all that? Good, let's go flying...

Let's depart Vero Beach and proceed directly to the VRB VOR, climbing to 6000ft. From there, we'll proceed via radial 300 along the Vero Beach transition. I've got NAV2 set to the VRB VOR r-300 FROM and I've got NAV1 set to the ORL VOR r-342 TO (reciprocal of r-162 TO). NAV2 is centered because we're tracking it and NAV1 is deflected to the left indicating that we would need to fly a heading left of 342 to intercept that course, which we're doing. I've got DME set to NAV2 to track my distance from VRB. At this point, we would have already been "...cleared Goofy Two Arrival, Vero Beach transition".

Now NAV1 centers as we pass over BARIN and I start my turn to fly inbound on the ORL r-162, continuing to use NAV1 to track to ORL.

Since I'm going to be landing south on Rwy 18R at Orlando International, I'm going to proceed to SABOT intersection, which is DME 18 from ORL. I've got NAV1 still tuned to ORL and I'm continuing to track towards SABOT. I've got the DME set to NAV1 now so I know when I've reached SABOT, which is 18DME. I'm also starting a descent to 2000ft, simulating that ATC had instructed me to do so. I've set NAV2 to the inbound course for the ILS 18R at Orlando International.
Upon crossing SABOT, I will proceed via heading 360 and wait for a vector to the final approach course. I've still got NAV2 set to the ILS course.

In this case, I've assumed that I've been given box vectors (90 degrees turns) to the final approach course to ILS 18R and landed safely ("Andrew Ayers, you just flew the ILS 18R at Orlando, what're you going to do now?" "I'm going to Disneyland!!!") So there you have it, a successful STAR! Next lesson, the stuff you've all been waiting for, it's time to fly some approaches!

Goto Lesson 6
Flying IFR, Lesson 6
Author: Andrew Ayers
Embraer EMB-120 Brasilia First Officer

Non-Precision Approaches

Well, we've navigated our way through the system and it's time for us to make our approach into the airport. There are many types of approaches we can execute into airports across the country and they're generally classified as Precision and Non-Precision approaches. The first set of lessons is "Non-Precision Approaches", so I'll first start by telling you what the difference between precision and non-precision approaches is. Quite simply, a precision approach is one that provides an electronic glideslope. Since we don't receive any glideslope information from a VOR, NDB, or localizer, they are categorized as non-precision approaches. Current GPS approaches are also non-precision, but we'll discuss those in their own lesson. There are also other types of approaches which we won't discuss such as Precision Approach Radar and Surveillance Radar approaches. These are completely ATC-controlled, so they're not applicable to X-Plane's technology.

There are some rules which we must follow when making approaches, so let's look at those now. As we discussed in the "Arrivals" section, ATC will give us descent clearances until we're cleared for the approach. So, we must maintain whatever altitude we've been cleared to until we actually here ATC say "...cleared for the approach...". Once we hear that, we are free to navigate and descend at our discretion per the approach chart procedure. Keep in mind that ATC may instruct you to proceed along a portion of the approach course before they actually "clear" you for the approach. So, in real life, it's very important to be sure of what ATC has asked you to do. ATC instructions take precedence over charted procedure. Now back into the FARs for a look at 91.175-Takeoff and landing under IFR, specifically (c)operation below DH or MDA. We know that we're going to be descending to a certain altitude at which we hope to make visual contact with the runway and land. Now, there are a few items we have to be aware of when making the decision to proceed below the MDA/DH and land. If you don't follow the rules, the FAA might be waiting for you on the ramp after your beautiful approach. The first rule says that we have to continually be in a position to make a normal landing. So, we can't pop out of the clouds right over the threshold at 400ft and decide we're going to chop and drop the airplane in. Second, the FLIGHT visibility must not be lower than the minimum visibility prescribed for the approach(located on the approach plate). Notice I say FLIGHT, not ground visibility. If the tower is reporting less than minimums and you've got at least the minimums from the air, you can go ahead and land. Just be prepared to justify it(I could see the threshold from the outer marker, etc...). Lastly, you must have one of the following in sight(distinctly visible and identifiable) for the runway of intended landing: the threshold, threshold markings, threshold lights, runway end identifier lights(REILs), visual approach slope indicator(VASI), touchdown zone or markings, touchdown zone lights, runway markings, runway lights. There's also one last thing.
If you have the approach lighting system in sight, you may descend to 100 above the touchdown zone elevation. However, if the approach lighting system is of the type ALSF-I/II (the kind with the red side row or terminating bars), you may descend to the runway if you have the red lights in sight. So, what all of this means if that, if you're making your approach and you pass over the McDonald's that you know is a mile from the runway, you still can't descend. Visual checkpoints don't count, only the items listed in the FARs. Believe me, it's tempting to do this. I flew the ILS 7 into Santa Barbara (SBA) once and the visibility was awful. I caught sight of the ground just as I was passing over K-Mart at about 350ft and I was thinking "Oh yeah, I'm almost there, no problem". But, I kept on cruising along and I didn't actually spot the runway area for about another 7-8 seconds right at the DH. So, the moral of the story is, keep it safe. Don't stop flying the approach just because you're starting to catch glimpses of the ground. Take short glances up and then come back and keep flying the instruments. Once you've established visual contact positively with one of the proper items, then make your transition. It's an interesting part of the flight. You go from airline pilot to fighter pilot in just a couple of hundred feet. You want to be frozen on the interments until it's time to make the landing and then you've got to fly the plane like it was meant to be flown to get it on the runway in a normal manner. Now, of course, I'm not saying to fly wildly because the FARs say we have to be able to make a normal approach at all times. I'm just saying, do what you have to do. Popping out of the clouds at minimums is no time to be light on the controls.

Finally, let's talk about the aircraft procedures we'll be following. The way we teach here at FlightSafety is to configure the first flap setting when on the initial approach segment. We don't normally fly approaches with full flaps because we want to be able to go around easily if we have to execute a missed approach. Since we're not using full flaps, we're also going to be flying at a faster speed. I'll use an approach speed of 90kts for the 172RG. Finally, the gear is brought down when passing the final approach fix. So, that's how we'll be operating the aircraft. For our demonstrations, we won't be doing arrivals, we'll just depart the local airport and start right into the approach. We'll be flying in weather that is pretty close to minimums so there won't be any cheating. OK, let's get started.

Goto Lesson 6A
The VOR Approach

Today we'll be talking about the most common non-precision approach, the VOR approach. As the name implies, VOR approaches are approach procedures which use VORs as the primary navigational aid. A lot of VORs are located at the airport, but there are many which are located away from the airport. Approach procedures can be based on either. So, now that we know what VOR approaches are, let's brief our chart and then go flying... Since we've already gone over chart symbology, I'll just touch lightly on most of these things. "A" tells us that we're going to be doing the VOR(or GPS) Rwy 11R approach at Vero Beach. Because the approach is categorized with a runway number(11R), we know that the final approach segment of this approach will bring us to within 30 degrees of the extended centerline of 11R. We also see that the primary navaid is the Vero Beach VOR(VRB), it's frequency being 117.3. "B" points to VRB and we see above the ID box that this is an Initial Approach Fix(IAF). This is where we will start the approach. You will see that there are two other IAFs, both located at the start of the DME ARCs. Since we'll be discussing DME ARCs in their own
Today's weather is ceiling 480ft overcast, visibility 2 miles. We'll be doing the full procedure, starting at VRB.
Now, ATC didn't give us any limitations on our procedure turn. In the profile view at "C", we see it says "10 NM". This means that the procedure turn must be completed within 10 NM of the VOR. Where in that 10 NM radius it doesn't say, so we can start it right after we pass over the VOR if we like or we can extend it out if we were descending from a higher altitude. I'll go out about 3NM from the VOR before I start my turn. Now, procedure turns are a bit tricky for some, so follow closely. The purpose of this is to turn us around, heading back to the VOR and the airport, without getting us totally off course. You can see at "C" that the first turn is to a heading of 255 degrees. This is a heading, NOT a radial from a VOR. So, when I get to 3NM DME from VRB, I'll make a turn to 255 degrees and start my timer. We want to fly the procedure turn outbound for 1 minute. When 1 minute is up on our timer, we'll start a 180 degree turn to a heading of 075 degrees and then fly inbound. MAKE SURE to make standard rate turns(wings set on the turn index line on the turn coordinator) or else the procedure turn won't work out. At this point, we're inbound on the procedure turn, so it's time to call the tower and report where we are. The tower will then say "9246F roger, report the VOR". As we're flying inbound, I'll now set the HSI/VOR needle to our inbound course of 120 degrees.

As we near our course, the needle will start to center and we'll start a turn to intercept our course. Once we're established inbound(on the inbound course), we may descend to 1000ft MSL and continue inbound to the VOR. Once we pass over the VOR, things get busy. It's the FAF, so let's drop the gear. As you can see on the plan view, the final approach course is 115 degrees FROM, so we need to turn the needle from 120 to 115. This is VERY important and easy to forget. In this approach, you won't hit anything. There is a similar approach in Concord, CA where, if you don't make the course change, you'll fly right into some tall antennas. Also, we need to start our descent down our MDA of 380ft MSL. As you can see, we've got 3.5 DME until the MAP, so we've got until then to get to our MDA, but the sooner the better.
since that will give us more time to look outside for the runway. We also need to start our timer. We'll be doing the approach at 90kts, so looking at "F", we can see that it should take us 2:20 to reach the MAP.

We can determine the MAP with DME alone, but if the DME fails after passing the VOR, we have no way to determine the MAP if we hadn't started the timer. Also, it's important to look at "F" for each approach to see where the timer should be started. In this case, it tells us "VOR to MAP", so we start it over the VOR like I said. Finally, the tower asked us to report the VOR, so we would call them and they would say "9246F runway 11R cleared to land." No we're done with communicating and configuring and all of our concentration is on flying. We going to level off NO LOWER than 380ft MSL and proceed along course until reaching the MAP, looking up every few seconds for the runway. Hopefully we would get the runway in sight before reaching the MAP. If not, we would immediately begin the missed approach upon reaching the MAP, calling the tower to let them know we're going missed. In this case however, we've got the runway just in sight, so we'll continue the approach and make a normal landing.
See how easy that was? Next time, NDB approaches. These will take a little more instrument savvy, so brush up on your ADF use. Have fun!!
The NDB Approach

Today we'll be talking about the least common ground-based non-precision approach, the NDB approach. As the name implies, NDB approaches are approach procedures which use NDBs as the primary navigational aid. Like VORs, NDBs can be located either on the airport or at a remote location. Approach procedures can be based on either. NDBs are very old and and their operation is very simple, yet flying them precisely is difficult. You will notice that approach minimums for NDB approaches are higher than those for a VOR or other. This is because NDB signals are less precise and they are subject to several types of interference. I won't discuss the use of the ADF in this lesson, so if you're not familiar with it's use, you may want to skip this lesson for now. The key to remember is that ADF needle always points to the station. Unfortunately, we only have a fixed-card ADF in X-Plane which makes it even harder. Many aircraft are now equipped with RMIs which have movable cards, which are much easier. Maybe we can push Austin to include this on X-Plane RMIs. One other thing to remember is that we don't get DME information from the NDB, so we have to be more aware of our position. So, now that we know a bit about NDB approach, let's brief our chart and then go flying...Since we've already gone over chart symbology, I'll just
touch lightly on most of these things. "A" tells us that we're going to be doing the NDB(or GPS) Rwy 11R approach at Vero Beach. Because the approach is categorized with a runway number(11R), we know that the final approach segment of this approach will bring us to within 30 degrees of the extended centerline of 11R. We also see that the primary navaid is the Vero Beach NDB(VEP), it's frequency being 392. "B" points to VEP and we see above the ID box that this is the Initial Approach Fix(IAF). There are no other IAFs for this approach. "C" shows us our outbound bearing of 265 degrees. "D" shows us our procedure turn, the course reversal we will fly to establish ourselves on course. "E" indicates our MAP. We see that the MAP is located at the NDB. "F" shows us our minimums, 760ft MSL/1 mile vis. for both straight-in and circle-to-land. Something you'll notice about this approach is the absence of a Final Approach Fix(FAF). Because we simply make our procedure turn and then descend to our MDA, the beginning of the Final Approach segment will depend on how far out we make our procedure turn. In this case, we have what is called a Final Approach Point(FAP) which is wherever you complete the procedure turn. "G" shows us our time to the Missed Approach Point(MAP), which in our case, isn't applicable. It simply says that the MAP is at the NDB. So, we don't need time to find our MAP, we will know because we'll pass over the NDB and then ADF needle will flip. OK, now that we've briefed our plate, let's do this...

Today’s weather is ceiling 850ft overcast, visibility 3 miles. We'll be practicing with no wind because wind makes NDB procedures really tough. We'll be doing the full procedure, starting at VEP. So, what we’re going to do is take off from Vero Beach, climbing to 3000ft, and request the full NDB 11R approach. At that point, Center will say "9246F proceed direct to the beacon, cleared full NDB 11R approach, contact tower 126.3 when procedure turn inbound". So, now we've tuned in VEP and turned so the head of the needle is pointing to 0 so we know we're headed directly to the NDB. We're level at 3000ft and proceeding to the NDB. We see that our outbound bearing for the initial approach segment is 265 degrees. So, as we pass over the NDB, we will turn to a heading of approximately 265 degrees, looking for the head of the needle to swing around so the tail is now pointing to 0. We're now actually on the approach, proceeding outbound. Since we don't have DME to give us our distance from the NDB, we will start our timer so that we have an idea of how far out we are. Since we're going 90kts, it will take us about 6.5 minutes to go 10NM from the NDB.
Another trick that we use in this particular case is to reference the DME readout from the VRB VOR. Since we know from yesterday's procedure that the VOR is 3.5DME from the MAP. Add another 0.5NM since the NDB is in the middle of the field and we've can say that we don't want to go out any further than about 6DME from the VOR and that should keep us within 10NM of the NDB. This is a very general backup and you wouldn't depend on it entirely, but it can be helpful. In the profile view, we see that we can also descend to 2000ft until the completion of the procedure turn. So, we'll start a descent to 2000ft.

I'm going out about 3 minutes from the NDB before I start my turn. You can see at "D" that the first turn is to a heading of 310 degrees. This is a heading, NOT a radial from a VOR. So, when the timer says 3 minutes, I'll make a turn to 310 degrees and start my timer again. We want to fly the procedure turn outbound for 1 minute. When 1 minute is up on our timer, we'll start a 180 degree turn to a heading of 130 degrees and then fly inbound. MAKE SURE to make standard rate turns(wings set on the turn index line on the turn coordinator) or else the procedure turn won't work out. At this point, we're inbound on the procedure turn, so it's time to call the tower and report where we are. The tower will then say "9246F roger, runway 11R cleared to land". Now, here's where it gets a bit tricky. Our needle is going to be deflected off to the left a bit. So, how do we know when we've intercepted our course? Well, we're now on a heading of 130 degrees and we want to fly inbound on a bearing to the NBD of 085 degrees. That's a 045 degree difference. So, when the needle swings to the left 045 degrees from 0(in this case it will be pointing to 315 degrees), we know we're on course.

Now we want to start a turn to a heading of 085. As we do this, the needle will swing slowly so that the head should line up on 0 when we roll out on a heading of 085 degrees. Once we're established inbound(on the inbound bearing), we may begin our
descent down to the MDA of 760ft MSL. We're now at the FAP, so let's drop the gear. Our time to descend to the MDA is dependant on how far we went out on the procedure turn, so we must plan our descent accordingly to give us time at the MDA to look outside for the runway. We don't need to start our timer since the MAP is at the NDB.

Now we're done with communicating and configuring and all of our concentration is on flying. We're going to level off NO LOWER than 760ft MSL and proceed along course until reaching the MAP, looking up every few seconds for the runway. Hopefully we would get the runway in sight before reaching the MAP. If not, we would immediately begin the missed approach upon reaching the MAP, calling the tower to let them know we're going missed. In this case however, we've got the runway just in sight, so we'll continue the approach and make a normal landing.
You can see that the approach course or bearing doesn't lead us directly to the runway threshold in every case. That's another drawback of non-precision approaches. You can also see from the overhead view that even though I flew the course as best as I could within the precision of the instrument, the inbound leg is not exactly lined up with the outbound leg. Such is the inaccuracy of the NDB. Even though we get less information from it, it is still perfectly usable and excellent practice. Have fun!
Precision Approaches

As I said in the last lesson, Precision Approaches have an electronic glideslope. We will be flying an ILS approach for our example which uses both a localizer and a glideslope. The localizer is just like a VOR except it only extends in one particular direction and it's four times as sensitive. So, you'll just have one radial extending out from the runway it serves which you'll be tracking inbound. The glideslope is also a single signal which extends upwards from the runway area at a preset angle (usually 3 degrees). It operates on a UHF frequency which is paired to the localizer frequency so we can receive both on a single frequency. The glideslope will provide us with precise descent guidance. Instead of the MDAs which non-precision approaches use, precision approaches have Decision Heights (DHs). Because we will receive descent guidance, we will arrive at the DH right at the point where we should be able to make normal landing. So, at that point, we immediately have to make a decision as to whether to land or whether to execute a missed approach. Hence the name Decision Height. In non-precision approaches, we leveled off at our MDA and continued on to the MAP. In the case of precision approaches however, we won't level off at the DH to make our decision, we will continue our normal descent all the way to the DH, make our decision, and then land or level off and start the missed approach. We may also fly ILS approaches without the glideslope. Some older aircraft do not have OBS instruments with glideslope indicators. Sometimes the glideslope may be out of service. In this case however, it become a non-precision approach since we no longer have the electronic glideslope. So, we would then follow the `loc only" or `gs out" procedure and minimums on the approach plate. The actual procedure for flying these approaches isn't so different from non-precision approaches except that we'll be following a needle down to the runway instead of descending to a minimum altitude at our discretion. Remember that our needles are going to be very sensitive, so you've got to have a steady hand and a lot of concentration. I flew the ILS into West Palm Beach for practice once at 160kts in a Seminole. That's faster than a lot of jets fly approaches. It was pretty hairy as I got down to the last 1000ft or so and I was totally focused on the needles. It was night time, but VFR, and I didn't see anything at all until I hit the DH and looked up. I was just practicing so I went missed and all I remember seeing was the tower as I zoomed by at 160kts. It's tough to keep your head in all the things you need to be aware of during an approach like this. Don't get tense and let it fall apart. A lot of people fixate on one needle and forget the other. There's a lot going on, don't get stuck on any one thing.

There are other types of precision approaches, though none we can do in X-Plane. Some large airports and other which are located in the vicinity of military bases offer Precision Approach Radar. The controller can give you precise heading vectors...
and altitudes in order to bring you right down to the DH. GPS can allow for precision approaches too, though the FAA is just getting into implementing and approving it. If your receiver can acquire enough satellites (four), you can get vertical positioning as well as lateral positioning. So, there we have it. The ILS will be the focus of our discussion here and then we will move on to DME arcs, which can apply to both precision and non-precision approaches. Enjoy!

Goto Lesson 7A
The ILS Approach

Today we'll be talking about the most common precision approach, the ILS approach. It uses both a localizer and a glideslope for guidance. Our nav radios can only tune the localizer frequency and we then receive the glideslope as well. So, when preparing to fly an ILS, we tune the localizer frequency in the nav radio. The ILS is located at the airport and they are runway-dependant, so large airports may have several ILS frequencies. So, now that we know what ILS approaches are, let's brief our chart and then go flying...Since we've already gone over chart symbology, I'll just touch lightly on most of these things. `A` tells us that we're going to be doing the ILS Rwy 9R approach at Melbourne, FLA. Because the ILS is going to take us directly to a particular runway, we will always see the runway number in the approach identifier. We also see that the primary navaid is the localizer(IMLB), it's frequency being 108.3. `B` points to a chart notification, telling us that we must have DME or radar(ATC, not onboard) in order to fly this approach. It also tells us that there is pilot-controlled lighting for this runway. The first question I always ask myself is `Why do I need DME or radar?`. The most common reason deals with being able to reach the IAF. If you look at `C` you'll see that the IAF is at MERCS, the outer marker. Well, since a marker just puts out a signal to our marker lights and aural
marker lights and aural system, we have no way to navigate to it directly. ``D'' shows us a feeder route from the VOR, which we CAN navigate to directly, which will take us to MERCS if we fly the 268 radial at 2100ft MSL until 7.8DME. So, you can see that we'll have to have DME to reach MERCS via the feeder route or get radar vectors from ATC. Otherwise, we have no way to start the procedure. The next question I ask myself is ``Why don't they just make the VOR the IAF then?'' Well, there's no good answer. You'll have to call the FAA and get their reason if you really want it. ``E'' shows us our localizer frequency and front course heading. You'll notice this ILS does NOT have DME(otherwise it would say ``ILS DME''), so if you use it in X-Plane (like I will for this example), you're cheating. ``F'' shows us our procedure turn. ``G'' tells us a few things. One, you see the maltese cross which represents the FAF. However, this is only if you were doing this approach as localizer-only. For an ILS approach, the FAF is wherever glideslope intercept occurs. You can see that at ``G'' it says ``GS 2025''. That means that if we are on glideslope, we should be at 2025ft MSL when we pass MERCS. You can see that glideslope intercept actually occurs a bit before MERCS. The line with the ``090 degrees'' through it represents the glideslope, the dashed line indicated the localizer-only approach procedure, the MAP being at 1.4DME from the VOR. ``H'' shows us our approach minimums. Our Decision Height(DH) for the ILS is 233ft MSL, the MDA is 480ft MSL for localizer-only. Our visibility minimums are RVR of 2400ft or 1/2 SM visibility. ``I'' shows us our times for the localizer-only MAP. It also shows us our proper descent rate to maintain the glideslope for several groundspeeds. So, if we're doing 90kts, we should descend at 455ft/min in order to maintain the glideslope. OK, now that we've briefed our plate, let's do this...

Today's weather is ceiling 350ft overcast, visibility 1 mile. We'll be doing the full procedure, starting at the VOR. So, what we're going to do is take off from Melbourne, climbing to 2100ft, and request the full ILS 9R approach. At that point, Center will say ``9246F proceed direct Melbourne VOR, cleared full ILS 9R approach, maintain 2100 until established, contact tower 118.2 when procedure turn inbound''. So, now we've tuned in MLB and turned the needle until it center TO the VOR. We're level at 2100ft and proceeding to the VOR. I'll use NAV1 to fly the feeder route and set NAV2 to the localizer. After the procedure turn, I'll tune NAV1 to the localizer as well so you can see the procedure on both instruments. Normally, I would leave it set to the VOR frequency so I could use its DME. We see that our course for the feeder route is 268 degrees FROM MLB, so as we pass over the VOR, we will turn the OBS to set 268 on top and turn to intercept the course. We'll continue on this course until we get to 7.8DME. This may not take us directly over the beacon since it is designed to be aligned with the localizer, not the VOR radial, so when we reach 7.8DME, hopefully we'll hear the beacon as well, but we might not. Also, let's get those flaps out.
Now, we've got 10NM from MERCS to do the procedure turn. Since we're already at 2100ft, I'm only going to go out 1NM from MERCS before I start my turn. Now, you can see at `C` that the first turn is to a heading of 225 degrees. So, when I get to 8.7DME from MLB, I'll make a turn to 255 degrees and start my timer. We want to fly the procedure turn outbound for 1 minute. When 1 minute is up on our timer, we'll start a 180 degree turn to a heading of 045 degrees and then fly inbound. **MAKE SURE** to make standard rate turns (wings set on the turn index line on the turn coordinator) or else the procedure turn won't work out. At this point, we're inbound on the procedure turn, so it's time to call the tower and report where we are. The tower will then say `9246F roger, report MERCS". As we're flying inbound, I'll now set both NAV instruments to the inbound course of 090 degrees.

As we near our course, the needle will start to center and we'll start a turn to intercept our course. We can see that we are below the glideslope at this point, which is good because we want to intercept from below. As we near MERCS, the glideslope needle will slowly move down until we're on glideslope. At this point, we're established on the glideslope, so we may begin descending (455ft/min approx. see `I`). We'll also be hitting MERCS, so you'll see and hear the marker beacon. We said that glideslope intercept is the FAF, so let's drop the gear. We should also start our timer. Even though we don't need time for an ILS approach, if we were to lose both the glideslope and the DME, we would need a way to identify the MAP. We'll be doing the approach at 90kts, so looking at `I", we can see that it should take us 4:16 to reach the MAP. Finally, we need to call the tower at which point they will clear us to land.
Now we're done with communicating and configuring and all of our concentration is on flying. We've got two needles to watch as well as the other instruments, so keep your eyes moving. Pitch for your glideslope and use power to hold your airspeed. Use very small changes, remember, the localizer and glideslope are very sensitive and get even more so as we get closer. Our DH is 233ft MSL. Once I hit 1000ft above the DH, I start calling out altitudes at every hundred feet to remind myself (800 for 233, etc.). Once we hit the DH, we take a quick look up for the runway environment. If it's there, we keep on going down, If not, we would immediately begin the missed approach upon reaching the MAP, calling the tower to let them know we're going missed. In this case however, we've got the runway just in sight, so we'll continue the approach and make a normal landing.

If you've got a good handle on your aircraft, ILS approaches aren't very difficult. It gets very touchy down near the runway, but if you've got the plane stabilized and you remember to make very small corrections, you'll be in good shape. Have fun!
DME Arcs

The DME arc is a procedure used to transition from the enroute environment to an instrument approach. It's not a particularly difficult procedure, but it's difficult to explain. As the name implies, we'll need DME, so if you're aircraft is not equipped with DME, this won't apply to you. An arc is simply a segment of a circle and you'll see on the chart that the plotted arc is exactly that, a segment of an imaginary circle who's radius is defined by a DME distance from the VOR. Arcs can come in all sizes and don't necessarily have to be based on the facility which is the navaid for the approach. The ILS to Fort Pierce, Fl also has a DME arc based on the Vero Beach VOR. In demonstrating this procedure, we'll be using a new piece of equipment, the Radio Magnetic Indicator(RMI). Since we can't have both the RMI and OBS on the same panel in X-Plane, you won't be able to see this demonstrated on the OBS. The interpretation of the RMI is simple, it's needle always points to the station. Most RMIs have two needles, one ADF and one VOR. In X-Plane, we just have the VOR needle. So, keep that in mind, the needle will always be pointing to the VOR we have tuned in. Because of the initial complexity in learning this maneuver, the FAA recommends that we use an RMI unless we are highly proficient with the use of the HSI/OBS. So, today we'll use both and you'll see first, how much easier it really is with an RMI and second, that it's not all that hard without it. Don't be intimidated by the arc. It seems like an odd and abstract procedure, but it can be useful in certain situations. We've seen this chart before,
so I'll only brief the parts pertinent to executing the arc. First, make sure you've got the DME set to receive the VOR, not a GPS point if you're using a GPS-equipped aircraft. At "A" and "B", we see two IAFs for the two arcs. "A" would be the IAF for the arc south, since we would be flying south to intercept course on the arc. This point lies at 7DME along the 345 radial, which also defines V3 between VRB and MLB. So, if we were coming southbound along V3, we could go directly from the airway onto the arc to begin the approach. "B" is the IAF for the arc north, lying at 7DME along the 147° radial, which defines V295 between VRB and STOOP intersection. Today we'll be coming north (from West Palm Beach or someplace down south) along V295 and we'll fly the arc from there. "C" tells us that this is a 7DME arc, which means that all along the arc, we'll be maintaining 7DME from the VOR. "C" also tells us that we'll be proceeding along the arc at 1500ft MSL. Next to that, you'll see "NoPT", which means "No Procedure Turn". Since we'll be using the arc to intercept the course inbound, there's no need for us to make a course reversal. Once we intercept the course, we'll just proceed straight in. "D" shows us our approximate turning point to intercept our course. You see that both arcs "funnel" into the approach course. Somewhere along the arc, we'll have to stop flying the arc and start intercepting our course. Some charts actually depict "lead" radials which tell you when you should begin your turn. In the absence of them, we will use 5 degrees prior to course, so, in this case, when we're crossing the 295 radial FROM VRB, we'll start a turn to intercept the 300 radial inbound (120 TO). OK, so I've gone backwards here a little bit. I've told you how to get off the arc, but how do we get on and stay on? Well, let's go flying and find out...

The weather today will be 500ft overcast, visibility 4 miles. You'll do best to practice arcs with no wind first. Well, we'll be proceeding directly to the VOR as we fly northbound. We would have already gotten the ATIS and contacted Miami Center with our request to make the VOR 11R approach, arc north transition. Center will then tell us to "descend and maintain 1500ft, report established on the arc." In order to establish ourselves at 7DME from the VOR and not get any closer, we'd have to be flying exactly parallel to it at that moment. In other words, we'll have to turn 90 degrees from our course. If you look at "B", you'll see that the arc starts exactly 90 degrees from the course to the VOR. We can't turn on a
dime though, so we'll have to lead our turn. The suggested distance is to begin our 0.5DME before the arc at speeds below 150kts, so, since we're intercepting from the outside, we should begin our turn at 7.5DME from the VOR.

So, when we reach about 7.5DME, we'll begin a standard rate turn to the left 90 degrees and start our descent to 1500ft. Since we're flying inbound to the VOR on a heading of 327 degrees, we're going to turn to a heading of 237(327-90) degrees. At this point, since we're now 90 degrees to the VOR, the RMI needle should be just about directly off our right wing and we should be just about 7DME from the VOR. Right there, you can see that the RMI gives us an instant picture of where we are in relation to the VOR and the arc. You get 0.5DME on either side of the arc before ATC will start warning you. OK, so what do we do with the HSI/OBS? Well, first, let's think about what we're trying to do. This is the meat of the maneuver and it gets a little tricky here. We want to fly a constant radius around the VOR. We could do that by flying a continuous shallow bank all the way around, but holding in a small bank angle while trying to maintain 7DME would take a lot of attention, attention we'll need for other things. Instead, what we're going to do is fly small straight-line segments around the arc of about 20 degrees each. In this case, we're going to be flying across increasingly greater radials until we reach our turn radial of 295 degrees. For our first segment though, we'll only fly a 10 degree straight segment so we can see if we're properly established on the arc quickly. Since we just turned off the 147 radial, we'll fly a straight line on our heading of 237 until we cross the 157 radial. So, what we need to do is turn the HSI needle/OBS card until we've got the head set on 157. As we fly along, the needle will start to center as we begin to cross the 157 radial.

Now we're going to turn our heading 20 degrees north along the arc to a heading of 257(100 degrees past the radial we just crossed) degrees and twist the needle 20 degrees to the 177 radial. Now we're established on the arc and it's time to
report to Center. Miami would come back saying "9246F cleared VOR 11R approach. Contact tower VOR inbound." We would then continue on until the needle centers and then turn to a heading of 277 and turning the needle to 197 (then turn 297 twist 217, etc.). You can see that this is continually turning us north along the arc in twenty degree segments. So, this is how we fly the arc using the HSI/OBS. We follow the rule of "turn twenty, twist twenty" all the way around. Some people prefer to follow a "turn ten, twist ten" procedure instead to maintain a greater degree of accuracy, but the twenty rule should work fine to keep you within a half mile either side. Now, that's the hard way. The easy way is with the RMI (refer to 2 above). We said that when we made our first turn of 90 degrees that the needle should be 90 degrees off the right wing. Well, we've got a card on the RMI that shows us bearings in degrees. So, if we just fly in a straight line until the RMI needle swings to 10 degrees behind the right wing (pointing to 337), we must be on the 157 radial now. All we have to do at that point is turn twenty degrees right to put the needle ten degrees before the wing tip. No twisting using the RMI, just let it fall back ten degrees behind the wing and then turn to put it back in front of the wingtip ten degrees (ten behind plus ten ahead = twenty total degrees of turn). Now, if you follow either of these procedures in a no-wind situation, you should maintain 7DME all the way around the arc. But what happens when the wind blows (365 days/year)? Well, as we travel around the arc, the wind will be coming from various directions trying to blow us either to the inside or the outside of the arc. You may find yourself following the procedure but drifting slowly further so that your reach 7.1DME and then 7.2DME. So, you've got to make a correction. If you're drifting to the outside of the arc, you're going to have turn MORE to get back to it. The general rule is to turn an extra ten to twenty degrees to get you back into the arc. In relation to the RMI, this addition will place the needle twenty degrees BEFORE the wing now. As you can see below, we were starting to drift outside the arc (7.2DME), so we want to get back to the arc. We've added an extra ten degrees to my turn to make it thirty degrees. You can see that the RMI is now about twenty degrees ahead of the wing.

Once I get back to the arc, I'll go back to my normal procedure, adding in a few degrees wind correction as appropriate to maintain the arc. Remember, as you proceed along the arc, you will continually be changing your heading in relation to the wind, so your wind correction will always be different. Don't get bogged down in wind correction angles, just fly the procedure and make small changes when you see that your current track isn't keeping the arc. OK, so we're continuing along the arc and we're closing in on the 295 radial. Once you see that your next twist of the needle will take you to or past the 295 radial, turn it to the 295 radial and wait for the needle to center. Your RMI should now be pointing to 115.
Now we're at our turning point, so, instead of turning twenty and twisting twenty, continue your turn in order to intercept the 300 radial inbound (120 course) and turn the needle around so the head points to 120 TO the VOR. Your standard rate turn should take you right onto the 300 radial. The HSI/OBS should now be centered with 120 TO selected and the RMI needle should be pointed directly off the nose (120 heading). And there you are, off the arc and onto the inbound course. Now you can just proceed inbound on the approach just like we did in the `VOR Approach" lesson. So that's the arc. Like I said, it's not tough if you're really familiar with the OBS/HSI use and you're able to make yourself a good mental picture of where you are and what you're doing. The greater the radius of the arc, the easier it is to fly because your time between radials is greater. Try it first with no wind and just use the RMI. That way you don't have to think about where you're supposed to twist to. Just fly ten back, ten ahead and get an idea of what it looks like. Once you do that, try it with the HSI/OBS and use the RMI for backup. If you're feeling confident, just try it with the HSI/OBS and leave the RMI out. I know this is a difficult procedure to learn just from reading and looking, so don't hesitate to ask if you have any questions. Good luck!
Flying IFR, Lesson 9
Author: Andrew Ayers
Embraer EMB-120 Brasilia First Officer

GPS Procedures

First, we should note that our GPS in X-Plane is not a true GPS. For our example, I'll be using an image from the new Elite system. I thought that this lesson would be appropriate since there are often questions regarding the use of GPS in X-Plane as opposed to real-world operations. Unfortunately, we won't be able to apply any of this in X-Plane currently. Through acquisition of satellites in geo-stationary position 11,000 miles above the Earth (OK, I'm showing off here), a GPS receiver can pinpoint our position over the ground. There are currently 24 satellites which allow accurate coverage for most of the Earth. Because GPS can determine position via latitude and longitude, we can specify "waypoints" which are fixes defined by a latitude and longitude position. They don't exist, they are simply position fixes which are given names. All of these waypoints are then put into an electronic database which is in the GPS receiver. Most GPS' have removable cards which can just be pulled out and replaced when new data is added. Because the GPS can tell where we are and it knows where the waypoints are supposed to be, it can tell us which way to fly to get to it. Again, since it uses our position over the ground, it can tell us our groundspeed. It can also tell us the course we are actually flying compared to the course we are supposed to fly. Sound familiar? Yes, it's just like a CDI needle in an OBS or HSI. Most GPS' have their own CDI display on them and many can be slaved to the aircraft's HSI or OBS. You can see how useful this piece of equipment can be for us. Because it doesn't use ground-based signals, we aren't limited to flying from one station to another like using VORs or NDBs. We can also navigate between points that don't actually exist just as if we were navigating from one VOR to another. For our example, I'm going to give you an overview on my favorite piece of equipment, the Trimble 2000 approach GPS. "1" shows us our selected waypoint. In this case, we're flying to ORD, or Chicago-O'Hare airport. You can see the small "A" which tells us the waypoint is an airport. If we were navigating to the Vero Beach VOR, it would say "VRBv". A MAP would be appended by "ma" and so on. "2" tells us our course to fly to reach the point, in this case "156 °". "3" tells us our nautical mile distance from the waypoint and "4" tells us our time to reach it based on our current groundspeed, "5". Our ground track is displayed at "6". Matching up the ground track with the course will take you directly to the waypoint. This way, you don't have to figure out your wind correction angle. You can just turn to match up your ground track and then read your heading from the HSI to see what your wind correction is. "7" is the CDI display. On course would be with the needle in the middle of the "O" in the center. There is also a smaller needle below it which shows how your track compares to the course you're trying to fly (whether your correction is bringing you
back on course or not). `8" is the dial which we use to select our waypoint. `9" is the `direct" button. Once we choose a waypoint (ie. ORD), we could push the `direct" button and the GPS would immediately show us our course, speed, and time to that point. `10" is the `message" button which is used to read messages the GPS is sending. You usually enter your fuel when you depart, so the GPS will tell you when you don't have enough fuel to reach the selected waypoint. It can also tell you when it loses signal from another satellite, when you're nearing an approach, etc. `11" in the `enter" button, used to enter the selected waypoint once it's dialed in with the knob(8). `12" is the `airport/VOR" button which will display the closest 30 airports or VORs. This is especially useful in emergency situations when you need to find the closest airport. Simply hit `APT/VOR" and then hit `direct" and you're on your way. This is how I handled my `lost" procedure on my commercial checkride, much easier that getting out the charts, plotter, and flight computer. The grey line indicated the database card. `13" are the function buttons. `AUX" is used for monitoring system status and checklists. `CALC" is used to flight computations such as true airspeed, range, winds aloft. You must enter in the necessary data (temperature, pressure altitude, etc.). `FPL" is the flight planning button. By pushing this, you can enter a set of waypoints to make up a flight plan. You can then just fly along and each time you pass one of the waypoints, the GPS will tell you that you have and inform you of your new course to fly. `WPT" is how you select waypoints to fly to if you're not flying a flight plan. `NAV" is used to set up a certain course to fly to a waypoint. If you want to go directly to a waypoint, you can simply choose `direct", but if you wanted to fly to a waypoint on a course of 320, you would use `NAV" to set in the course and then the CDI would indicate accordingly. This is used for holding and also on some approaches. We should note that at this time, all GPS approaches are non-precision. GPS vertical navigation is being studied and surveyed for later implementation. So, now let's take a look at a GPS approach...`A" tell us this is the GPS Rwy 7 approach to Orlando Executive. This is a `stand-alone" GPS approach since it only says `GPS" in the approach identifier. If you look back at the VOR lesson, you'll see that it says `VOR or GPS Rwy 11R" which means it's a Phase III approach. Looking back to the NDB lesson, you'll see that it says `NDB Rwy 11R" with `(GPS)" below it. This is a Phase II approach. I'll explain what this means in the end. You'll see that there is no primary navaid
here since this is a GPS-only approach and we won't be using any ground based facilities. ` ´B" indicates the Orlando VOR which is ORL, but again it doesn't give frequency or ID since we use GPS latitude-longitude coordinates. This is just a reference point. "C" shows us our IAF as the GPS waypoint called "ESRAQ". It also depicts our procedure turn. You'll notice that this doesn't look like the procedure turns we're used to seeing. This "racetrack" pattern depicts a traditional holding pattern and must be flown as such. "D" depicts a feeder route from ORL. "E" illustrates our MAP, a GPS waypoint called "RW07". "F" depicts another waypoint which is simply 2.8NM to RW07. This is not a GPS waypoint you'll notice as it's depicted by a triangle instead of a star. We only have to look at the GPS to determine when we are 2.8 from RW07. "G" is the FAF at the GPS waypoint "HERNY". "H" is a fairly unique situation for an approach. You see that it says "MAXIMUM 1160ft". On normal altitudes, like 2000ft to HERNY, we can fly any altitude at or above 2000ft. In this case however, we must be right at 1160ft, no higher. This is because this approach crosses the approach path to Orlando International. "I" tells us that our MAP is at RW07. So let's just briefly run through the procedure we would follow...

Assume that we were proceeding to Orlando directly and we decide we're going to execute this approach. We would ask ATC for it and, since we can proceed directly to a waypoint, we would ask to proceed direct to ESRAQ(Why go to ORL first when we can go direct ESRAQ?) Now, using the "WPT" button, we would choose the approach we are going to fly and the point we are going to begin the approach at. In this case, we're going to go directly to ESRAQ, but if we chose to get radar vectors onto the approach course, we may get turned in somewhere between ESRAQ and HERNY, the FAF(we'll never get vectored onto the approach after the FAF). So, if that were the case, we would choose HERNY as the IAF so the GPS knew when to move on to the next part of the approach. At this point, you're done setting up and all you have to do is fly. When we hit ESRAQ, we'd enter the hold using the GPS' CDI to track our course. Once we passed ESRAQ inbound, the GPS would switch automatically to HERNY and tell us to fly a course of 070. Once we passed HERNY, it would switch to RW07, the MAP. We would then see the DME readout off the GPS to identify 2.8DME.

So, that's really all there is to it. You choose the approach you want to fly, select the waypoint that you will begin the approach at, and then follow the GPS directions. It can also do SIDs and STARs. It's a very handy tool to have on board and it can open up a whole new, more efficient way to fly. If you ever get a chance to use on in real-life, make sure you get your hands on it and really see what it can do.

Goto Lesson 10
Well, we've gone through all of our individual procedures and now it's time to make a whole trip from takeoff to touchdown. Today we'll be departing out of West Palm Beach International (PBI) for a short flight up to Vero Beach Municipal (VRB). For this lesson, I've used an NOS enroute chart instead of my Jeppesen chart since the Jepp chart has a fold in between PBI and VRB. It's fairly similar though, we'll go through it and see what we're looking at... Looking at "A", we see the airport symbol for PBI and at "E", we see the symbol for VRB. So how are we going to get from one place to another? Well, if you look in a straight line between the two VORs, you see V3. But, as I said in my previous lessons, you never get V3 in your clearance unless you're high and out of other traffic's way. Plus, it's too easy to just fly one radial the whole time. We need some practice. Instead, we'll fly the most common route depicted by the arrows. "B" shows V492 which is the 359 degree radial FROM the PBI VOR. As we proceed along, we come to "C", which is STOOP intersection. There, we can make a turn onto V295 and proceed to VRB along the 147 degree radial FROM VRB("D"). It seems pretty simple so far, the only question is how are we going to know when we reach STOOP? Well, if you follow V492 north, you can see that it's 19DME to WHELM and then 15DME to STOOP, so it's a total of 34DME, which is also shown in the box right at STOOP. So, we can fly along V492 until we're 34DME away and we know we're at STOOP. Also, we know that we're going to be crossing the 147 radial FROM VRB, so if we've got that set in our second NAV instrument, when the needle centers, we know when we're at STOOP. OK, since we've decided on our route, let's look a bit at altitudes. 3000ft is the MEA for V492, 2000ft is the MEA for V295. Since we're going to be on a magnetic course of 359 degrees and then 327 degrees (147 FROM), we know that we're going to have to fly even thousand feet intervals. Since it's relatively short, we'll just fly 4000ft to keep it simple. Alright, let's take a look at our flight plan.
Keep in mind that I’ve entered my own information here to illustrate how a flight plan is filled out in the real world. In X-Plane, of course, we have limited options. In box 1, we’ve checked IFR. In box 2, we have the aircraft identification number. In box 3, we have the aircraft type, in this case, I’m flying my Piper Seminole. Taking a look at our performance charts, we find our true airspeed at cruise altitude and enter it in box 4. In this case, I get 160kts. In box 5, we have our departure point, PBI. Box 6 has entries for both proposed and actual departure times. You enter your proposed time, ATC will enter in your actual time when you contact them for takeoff. Box 7 has our cruising altitude of 4000ft. Box 8 contains our route of flight. We have boxes for our departure and destination points, so we just enter the fixes we use to determine our route. If you were filing this plan, you would say it just like it is “Route of flight: Victor 492, STOOP, V295”. Box 8 has our destination of VRB. In box 9, we enter our estimated time enroute. It’s a total of 66NM along the route of flight which, at 160kts, should take about 40 minutes. Add another 10 for the approach. You want to give yourself enough time to cover everything that happens in the flight, but you don’t want too much extra because that just delays rescue efforts in case you have a problem. Box 11 is a space for remarks. If you were on a flight to just practice approaches, you could enter “practice approaches”. That way, ATC would know what you were up to and wouldn’t get irritated when you keep going missed and asking for vectors around for another approach on a perfectly clear day. Anything you feel like you want ATC to know you should enter here. Based again on our performance charts, we enter our fuel on board in terms of time in box 12. The Seminole can fly for nearly five hours. Box 13 is for alternate airports. If you want to know if you’re required to file an alternate, take a look at your FARs. I just entered one for the heck of it. Box 14 is for personal information so ATC knows who’s flying so they know who to bust if you screw up. In my case, I just give them my name and tell them my info is on file with FlightSafety because they know us down here. Box 15 is for entering the number of people on board the aircraft. Box 16 is for entering the color of the aircraft for rescue efforts. Box 17 is for entering a destination contact in case ATC needs to know if you made it in or if you didn’t close your flight plan going into an uncontrolled airport. It’s not necessary. OK, lets go flying...
I'm not going to fly along with you on this one, I'll just talk you through it. You can set the weather as you feel comfortable. Having filed our flight plan, let's get our clearance from Palm Beach Clearance Delivery. It will probably be something like this: ```Seminole 2227G is cleared to the Vero Beach Municipal Airport as filed. Climb and maintain 2000ft, expect 4000ft ten minutes after departure. Departure will be on 128.3 Squawk 3462```. Alright, we're ready to go. We should have our NAV equipment set up and ready to go before we takeoff. We contact the tower and let them know we're ready and they come back and say ```27G fly runway heading, cleared for takeoff```.

Now, open up that throttle and let's go. Get established in the climb, fly the plane first. Don't worry about the weather outside, just keep the plane flying. Since the VOR is on the field at PBI, we'll actually cross the 359 radial during our takeoff roll. Don't worry, ATC will give us a vector back on course. So, we're climbing out and tower says ```27G contact departure``` and over we go. Departure says ```27G radar contact, climb and maintain 4000ft, turn left heading 330 vectors to join V492```. As we close in on V492, the needle should start centering and you should turn to track it. OK, get settled in and level off at 4000ft and hold your course. Set your other NAV radio to the VRB 147 radial and make sure the DME is set to PBI so you can identify STOOP. Somewhere in here, Palm Beach Departure will hand you off to Miami Center. They won't have much to say, they already know that you know where you're going and how to get there. As you come up on STOOP, smoothly make the turn off of V492 and onto V295. As we near VRB, we should be getting the ATIS and finding out what approach is in use. We can then call Miami Center and let them know which approach we'd like. Center will then clear you as necessary to the appropriate fix or navaid to begin the approach. You have plates for both the VOR 11R and NDB 11R approaches, so fly whichever you like.

Congratulations, you just made your first IFR trip with actual procedures! See, once you've got the fundamentals down, it's not so hard. In real life IFR flying, it's not difficult either, though the pressures of actual weather and the idea that you can't see outside and you ```pause``` to get your bearings addes anxiety. The most important traits of a good IFR pilot is a cool head and a sharp sense of situational awareness. Once you can look at the chart and say ```I am here right now```, it will make much more comfortable. I've been in the plane before with people that really had no idea at all where they were and it's frightening. But, enough about that, have fun!
Flying IFR, Lesson 11
Author: Andrew Ayers
Embraer EMB-120 Brasilia First Officer

IFR Summary

So, we've learned how the IFR system is constructed, we've learned the various components that we can operate with, and we've learned how to put it all together to get from A to B. So, what's left? Practice, practice, practice. The only way to remember everything is to keep yourself immersed in the system as much as possible. Now that you understand the basics, it's time to turn you loose and let you really learn what it's all about. Every approach you fly will be different, procedures and conditions vary by the minute. Don't think that you know an approach just because you've flown it once. Fly it until the approach chart is burned into your mind and you can pinpoint your position every second. As I said in the last lesson, the most important quality of a good IFR pilot is situational awareness. You need to have a picture of what's happening even though you can't see outside the aircraft. You'll find that after a good dose of IFR conditions, you won't even want to look out the window anymore.

Before you go though, it's time for your checkride. There's no getting out of this easy. So, here's your assignment. You're to make an IFR flight from Tampa International(TPA) to Fort Pierce-St. Lucie County International(FPR). Upon arriving at FPR, you will execute the VOR Rwy 14 Approach, circling to land on runway 9. This is an early morning flight, weather is ceiling 600ft, moderate rain. You can choose IMC the entire way enroute or you can fly VFR above the overcast. I need you to file a flight plan with me and give me a screenshot if able of you at minimums on the approach. Have fun and keep reading AVSIM!

EDITOR'S NOTE

In behalf of AVSIM Online! we would like to thank First Officer Andrew Ayers for his great contribution to the AVSIM Community and wish him the best in his aviation career... Thanks Andrew!

Mr. Maury Pratt - AVSIM Managing Editor
Mr. Jorge Landauro - AVSIM Tutorial Editor

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