

# IFR Cross-Country

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## Introduction

In the chapter „[VFR Cross Country](#)“ you learned how to prepare and fly under VFR-rules from KRRV to KLVK. You also learned to read and understand the instrument-readings by visualizing them against the actual, outside environment. Now we will learn to trust those instrument-readings -- without being able to verify those against the actual outside environment! That should introduce you to some very different (personal) feelings:

- when flying above the clouds, where you still have a horizon for reference - but where you already have no idea where you are or how the landscape is below you. There even will be no hole in the clouds to enable you seeing the ground when going down -- while knowing that there are invisible mountains around you!
- or even flying inside the clouds, where you see nothing at all from the outside - but the cloud-layers will perform a fantastic shadow-theatre for you - all that just with one goal: Trying to enforce a mismatch between your feelings and the reality of the instruments! Can you really trust those instruments??

Do not underestimate especially the second item: Even experienced pilots always have to fight against the "inner feeling" and the "outer instruments". For you it will be even worse: Real Pilots still "feel with there butt" what is going on - you cannot! ... It is getting really difficult when you cannot trust yourself any more!

We will make it relatively easy by following pretty much the same flight as we did in the „[VFR Cross Country](#)“. So you know at least the environment, the airports, etc. If not: Please do the „[VFR Cross Country](#)“ first!

But in addition we will play "Petrus" and cook ourself a real nice weather - the recipe being:

- A closed layer of clouds from above 750 ft up to 4000 ft (for *cruising altitude of 5000 ft*)
- Below the 750 ft we will create a wonderful view - limited to 1 mile distance (1.6 km)
- Above the 4000 ft we will reward ourself with beautiful sunshine and unlimited view (except to the ground!)
- and during climb and descent we will test how it is to see nothing at all from the outside!

To me that sounds very interesting, especially when you discover that the airport KLVK has a field-altitude of 400 ft, that means: You will come

out of the clouds just 350 ft above the runway with a visibility of 1 mi! I hope you know by now how to control your glide-slope and direction - you will not have much time/room to correct anything after being able to see the runway (or not!)

If that did not frighten you, let us discover this new world, with lots of nice abbreviations, procedures - and fun:

## Pre-Flight

I am very sure that most beginners will consider the following complex preparation for such a short flight as absolutely excessive. Even real pilots do that - but they do want to get/keep their pilot-licence, their life, etc., and thus they have no choice! And yes: Also I heard about (and use) GPS and also I use "Route Manger" and alike: Just defining where you are and where you want to go - and let the autopilot do it! But then there comes the time when an ATC asks you to "report in over VOR ..." and then "?????" - what is a VOR (or NDB or ...)? And for sure there will come the time when you get bored of always flying under blue skys without any challenges! In addition it will become boring just leaving all the fun to the autopilot - some time you will like to konw what that is - and that we will try to tell you now!

This very short flight actually needs all the pre-flight preparations that also a long flight needs - so let us cut out the (boring) pure flying time and concentrate onto the "unusual" things! After you then understand the principle, you can always test it on e.g. a Transatlantic-Flight (*even if that may not be with a C172!*)

(If you want to get more detaisl to that: See <http://en.wikipedia.org/wiki/IFR>

## Altitudes

To help avoid crashes in mid-air there is a general agreement that airplans do fly on different altitudes, when going east- or west-bound: Those rules are:

|   |  |  |
|---|--|--|
|   | <b><i>cruise Heading</i></b><br><b><i>0°-179°</i></b><br><i>East-bound</i> | <b><i>cruise Heading</i></b><br><b><i>180°-359°</i></b><br><i>West-bound</i> |
| <i>if on <a href="#"><u>IFR</u></a></i> | Odd numbers<br>(3000, 5000, ... ft)  | Even Numbers<br>(4000, 6000, ...ft)  |

|  |                                  |                                  |
|--|----------------------------------|----------------------------------|
| if on <a href="#">VFR</a><br>(or above clouds) | + 500 ft<br>(3500, 5500, ... ft) | + 500 ft<br>(4500, 6500, ... ft) |
|--|----------------------------------|----------------------------------|

This "VFR above clouds" may sound a little funny - it means: If you are on VFR you are not allowed to fly through clouds and/or cloud-layers. On the other hand you may fly "VFR above Clouds" -- but then you need to find a hole in the cloud-layer when going down!).

- For this very short flight we stay as low as possible:
  - The general direction is East-bound (009°, *thus we need odd numbers!*)
  - There are some mountains alongside the course reaching up to 3800 ft

So the lowest possible altitude is **5000 ft** for IFR!

## Weather

Especially in the newer versions of FlightGear the [GUIs](#) to set the weather are very different, but the basic commands are still valid. So we will play "Weather-God" by entering some options when starting up FlightGear. If you are not sure how to do that see the chapter [Starting Manual](#):

**--ceiling=750:3250**      that will define a cloud-layer between 750 to 4000 ft

**--visibility-miles=1**      that will set the visibility to 1 mile (above and below the cloud-layer!)

**--wind=270@5**      that wind will assure that the runway KLVK 25R is the active one (*if we fly as "[Multiplayer](#)" we should make sure that no other pilots are flying in that area with "real weather", which may give them another active runway!*)

These settings result in:



*Ready to Start at KRVH with the weather we like!!*

Now that looks somehow depressive - so let us get a little reward in between: let us add the option:

***--prop:/environment/config/aloft/entry/visibility-m=30000***

That will give us *"a very uplifting moment when rising above the clouds into a bright sunny world, with blue skies above and a carpet of white below"* -- after getting there we might need that "uplift" desperately!

## Needed Options

You may define the needed options inside a "Options-file" or within a complete "Command-File":

## ***Options-file:***

If you are used to "[start with an options-file](#)", e.g. located at:

**Linux:** „~/fgfsrc“

**Windows:** „\$FG\_ROOT/system.fgfsrc“

then you might just add the following options to it:

```
--lon=-121.816320
--lat=37.334047
--heading=234
--disable-real-weather-fetch
--ceiling=750:2500
--visibility-miles=1
--wind=270@5
---
prop:/environment/config/aloft/entry/visibi
lity-m=30000
```

*The first 3 options define the Parking-position, as we used it already for the [VFR-Cross-Country](#).*

*In addition you have to set all the Radios - but that we can do easier when sitting in the cockpit!*

## **Command-file:**

A "[Command-File](#)" contains ALL commands you will need, and you can place it anywhere you want, e.g. also onto the desktop.

See the description for it and the complete "Command-file" I used for this flight in "Start with a "[Command-File](#)" in the Part "[Briefing](#)".

## Flightplan





Kurs: 1) Runway heading bis V334  
 2) V334 bis "SUHO"  
 3) SUHO nach ADF "REIGA"  
 4) "P procedure Turn": 2 Min 075°, 2 Min 075°, U-Turn to 210, Intercept ILS 25R

VOR: 5) San Jose (SJC) 114.1, Radial = 009 --> V334  
 6) Oakland (OAK) 116.8, Radial = 114 --> V107  
 7) Manteca (ECA) 116.0, Radial = 228 --> V195  
 NDB: 8) REIGA 374

Because we really wanted this "nice" weather we now need to find a route from Reid-Hillview (KRHV) to Livermore (KLVK). From our [VFR-Cross-Country](#) we know already that we cannot do that below the clouds - so we fly in or above the clouds and find other means to navigate: So now we speak about using [Radio-Navigation](#)!

And that Radio-Navigation means, that we cannot not take the direct route as before, but now we choose some routes that we can define by radio-signals - which also gives us a chance to get to know all the radios in our beloved c172p. (Well: You may take another airplane - but then I am not sure what Radio-Equipment you have!)

I again used the „<http://www.runwayfinder.com/>“ to define the IFR-route - if you want to revisit the general description of such a chart again: See the chapter „[The Sectional](#)“ in the book [VFR-Cross-Country](#).

In the picture on the left you see a part of that Sectional with

- the route to fly in green (the numbers will also be referenced in the following chapters)
- and the radio-signals used in blue (3 VORs (5-7) and 1 NDB (8))
- see also the marked "V334" alongside the radial 009 FROM SJC, as an example for an [airway](#)!

If you are not sure how to use the radios, revisit

- The Radios in general in the part [Radio-NAV](#)
- The details about the ADF/NDB in the sub-chapter [ADF / NDB](#)
- The details about the VORs in the sub-chapter [COM/NAV-Radios](#)

Remember that we had a picture that shows how all those radio-frequencies are set: See [Easy-Setup](#)



But first we need to analyse one more piece of this puzzle: The IAP

## **IAP: The "IFR-Approach-Procedure"**

As you recall from the previous tutorial when flying VFR, you don't just point your airplane to the nearest runway to land. You need to fly a pattern. This helps you line up, and helps prevent planes from crashing into one another, which is a Good Thing.

Similarly with IFR landings: There's a procedure to follow. In fact, there are procedures to follow! Because of the complexity of landing in IFR conditions, there's no single procedure for all airports. You need to check for your particular airport. In fact, you usually need to check for your particular airport, runway, and navigation equipment.

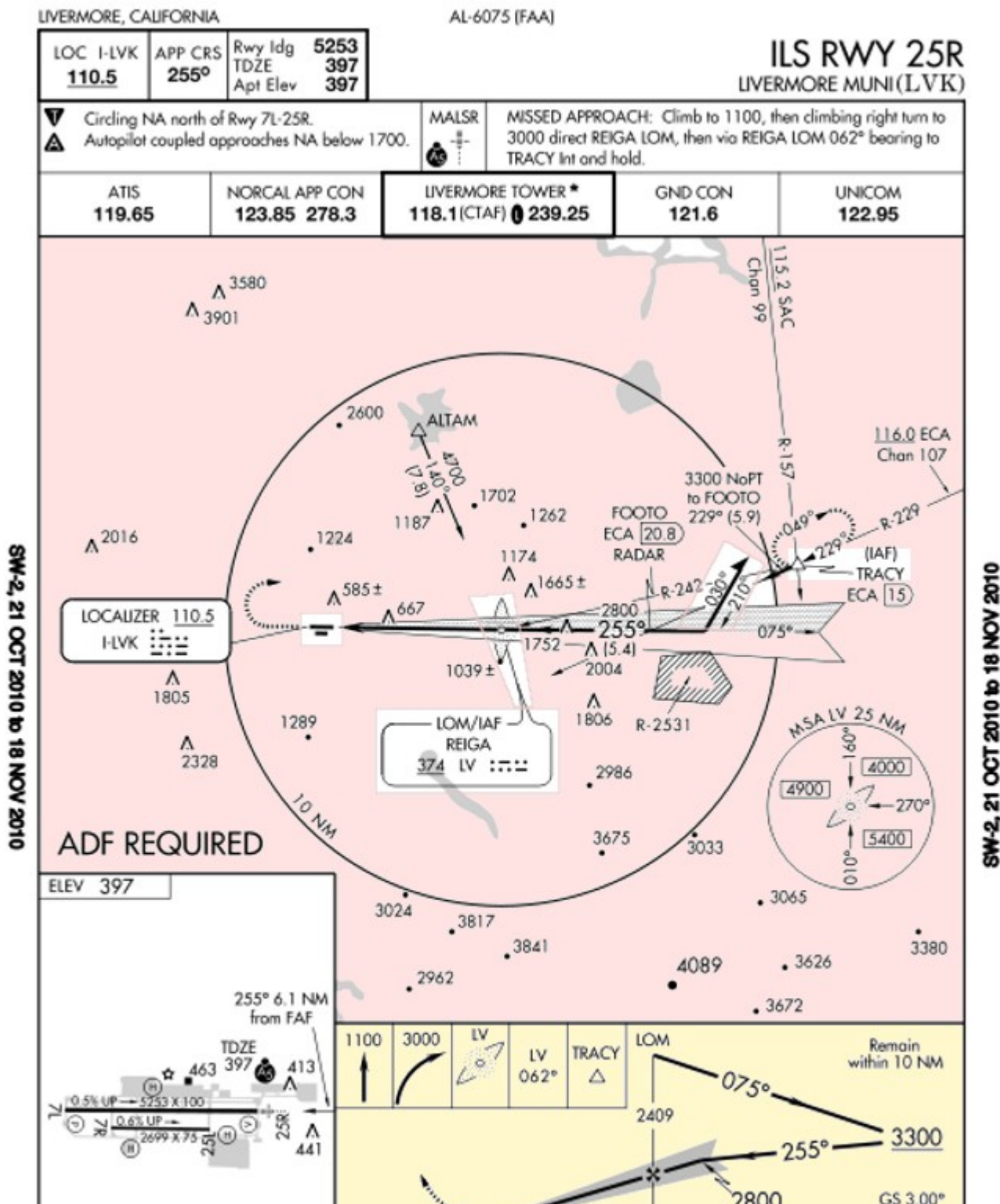
We covered the following in detail in part "RNAV", chapter "[IAP](#)", so you might have a look there for details about how to find a IAP, analysing it, and deciding what to do. Here just the analysis-extract of that, as we need it for our approach:

First let us find the beginning of the procedure, lucky enough there is a special mark for it: The [IAF](#) (*Initial Approach Fix*). Looking into the pink area we find 2 of those:

1. In the center of the pink area you find the **LOM/IAF REIGA**: This is a [NDB](#) with 2 functions:

- As [LOM](#) (*Local Outer Marker*) it defines a unique point on the final-approach (we will see/use that later. It is located 6.1 nm before the Touchdown Area of the runway at an altitude of 1039 ft)
- As [IAF](#) it is the starting point for the **IAP**. Based on the NDB it is easy to find: Just set the frequency 374 into the ADF and follow the needle. Defining the altitude is a little more complicated, because of the dual function of this point! As defined here that amounts to
  - gives us a minimum altitude of **1039** (LOM, in the pink area)
  - **plus 2409** (IAF, in the yellow part) added to that
  - == **3448 ft**

2. At the right centre of that pink area you see the second **IAF**, that one is named **TRACY**. There is a "[Procedure Turn](#)" attached to that



## Flying the IFR Cross-Count

|                       |      |      |      |      |      |           |  |                   |  |   |  |                      |  |                      |  |
|-----------------------|------|------|------|------|------|-----------|--|-------------------|--|---|--|----------------------|--|----------------------|--|
| MIRL Rwy 7L-25R       |      |      |      |      |      | 6.1 NM    |  |                   |  |   |  |                      |  |                      |  |
|                       |      |      |      |      |      | CATEGORY  |  | A                 |  | B |  | C                    |  | D                    |  |
| FAF to MAP 6.1 NM     |      |      |      |      |      | S-ILS 25R |  | 597-½             |  |   |  | 200 (200-½)          |  |                      |  |
|                       |      |      |      |      |      | S-LOC 25R |  | 940-½ 543 (600-½) |  |   |  | 940-1 543 (600-1)    |  |                      |  |
| Knots                 | 60   | 90   | 120  | 150  | 180  | CIRCLING  |  | 940-1 543 (600-1) |  |   |  | 940-1½ 543 (600-1½)  |  | 1100-2¼ 703 (800-2¼) |  |
| Min:Sec               | 6:06 | 4:04 | 3:03 | 2:26 | 2:02 |           |  |                   |  |   |  |                      |  |                      |  |
| LIVERMORE, CALIFORNIA |      |      |      |      |      |           |  |                   |  |   |  | LIVERMORE MUNI (LVK) |  |                      |  |
| Amdt 7A 10266         |      |      |      |      |      |           |  |                   |  |   |  | 37°42'N · 121°49'W   |  |                      |  |
|                       |      |      |      |      |      |           |  |                   |  |   |  | ILS RWY 25R          |  |                      |  |

value is your vertical speed at the moment the autopilot is turned on. See the vertical speed indicating **300 FPM** (feet per minute).

When you engage the autopilot first time, **CHECK THE FOLLOWING CAREFULLY:**

Sometimes the autopilot gets a very funny idea about what your current rate of climb is, like 1800 feet per minute. Our little Cessna cannot sustain this, and if the autopilot tries to maintain this (and it will), you will stall before you can say “Icarus”. This is a bug, to be sure, and a bit annoying, but it is also a useful cautionary lesson — don’t put blind faith in your equipment. Things fail. You have to monitor and cross-check your equipment, and be prepared to deal with problems. **You are "Pilot in Command" - not George!**

We want a vertical speed of around 500 to 700 feet per minute. Hit the up and down (UP and DN) buttons to adjust the vertical speed to a nice value. We want a sustainable rate of climb while the airspid remains at about 75 kn. More "UP" will reduce that speed - more "DN" will increase it!

Finally, once you’re climbing nicely, hit the heading (HDG) button. On the display, “ROL” will change to “HDG”, and the autopilot will turn the airplane to track the heading bug. Since you had set the heading bug to the runway heading, and you took off straight ahead (didn’t you?), it shouldn’t turn much.

In case you get to the 5000 ft prior to our next chapter, push "ALT" again at that 5000 ft, that will lock in that altitude to hold!

### **Otherwise:**

You should use the trimming excessively, vertically (*Num-Keys 0/*) and horizontally (*Num-Keys 8-2*) - that will become a big help in taming that wild beast (named "c172p")!

And now you really have to prove that you learned to watch the instruments, remember the "golden T": keep the eyes moving all the time, reading

- **Airspeed:** during the climb 70-80 kn
- **Gyro-Horizon:** horizontally straight but vertically indicating the climb

This Instrument now is the most important one right now! Because it shows you very fast your actual attitude - while all other instruments have very noticeable time-lag!

- Locate and watch especially that little dot directly in the center (*looks like a crosshair for aiming*) -- keep it where you want it!
  - exactly on the artificial horizon when cruising leveled, above the horizon when climbing and below it when descending
  - the first short line indicates ~500 FPM and the long one 1000 FPM
- --> So for now it should be between the first short and long line above the horizon
- and of course you see here very fast how your banking

After the real horizon (*which we do not have inside the clouds!*) this is now our most important guidance for our flight attitude!

- **Altitude:** steady climbing

- **Heading:** 310° - means according to your flight-plan or departing procedure - set the red bug for a fast reference - that will help a lot!
- Once in a while we also will check the other instruments

Especially do try not to overreact! Use only minimum corrective actions and give those instruments time to collect the changing data prior to displaying the changes - and even then: Do not chase the needle! Try small corrective actions - and increase those step by step when needed!

As soon as we are on a stable climb we will have to start watching the NAV1 CDI: We wait for that needle to start moving from the left to the centre, so that we can intercept the radial "SJC FROM 009°" to enter the [airway](#) "V334"!

## 2) Following the V334 to SUNO, passing MISON

As soon as the [NAV1-CDI](#) (set to VOR SJC 114.1 MHz, Radial 009) starts to move towards the centre, we will turn right to a heading of "009°". We time our turn such, that the CDI is centred when we see the heading "009°" on our Gyro-Compass. Do not be alarmed if we do not really get the CDI and Compass aligned first time - we just start to use our usual VOR procedure to get and keep the CDI centred: Just turn a little (10 to 20°) into the direction the CDI points until the CDI is centred. Continue trying to keep the CDI centred - the actually heading of the Gyro-Compass then is needed only as a reference - we now follow the CDI! Thus we hold our course - with whatever heading is needed for that!

Those who delegated the work must wake up and tell George with the "red bug" inside the Directional Gyro how to turn (or, if they are absolutely lazy, they just push ["NAV" on the AP.](#))

If you look along our route, just after we intercept the 009 radial and turn north, we pass by a point labelled MISON (see in our [flightplan](#) the crossing of the blue lines 5 and 6, and enlarged in the RNAV-part chapter ["The NAV-Radio"](#)). MISON is an intersection. We're actually going to pass east of MISON, but the radial passing roughly from north-west to south east through MISON (and our route) is of interest to us. We're going to use it to monitor our progress for 3 reasons:

First, it's nice to know exactly where we are.

Second, it confirms we are where we think we are.

Third: To exercise "How to find a FIX"

For that exercise we had set all radios already according to the chapter ["Easy -SetUP"](#), so:

- Make sure you are on radial "SJC FROM 009°" and fly the CDI centred
- Make sure the NAV2 is on frequency **116.8** and the OBS2 is set to "**OAK FROM 114°**"
- and then we wait that also the CDI of NAV2 moves into the centre
  - While waiting: See if you can guess whether the flag should read TO or FROM when we cross the 114 radial. And see if you can guess whether the needle will move from left to right or right to left as we cross the radial.

(This same procedure is described in more detail in the part RNAV, chapter "[Finding a FIX-point](#)")

We are now some time above the clouds and should take some time to recover from this "wonderful scary experience", and thus we **involve George**: ([ref.: AP](#))

As we continue on the 009 radial, let's look a bit more closely at the autopilot. First of all, if you aren't in the habit of trimming the airplane, you'll probably notice a flashing "PT" with an arrow on the autopilot. The autopilot is telling you to adjust the pitch trim. I tend to ignore it because, flying with a mouse, trimming is more trouble than it's worth. Those of you lucky people with yokes and joysticks and who find flashing lights annoying might want to trim to get rid of it. Doing that will minimize your problems when you need to trim the plane - if George returns a badly trimmed airplane to you! And that then may be just close before TouchDown!

Also, on the right there's a big knob, the altitude select knob, which we can use to dial in a target altitude. We're going to use it. Turn it until you see our desired cruising altitude, 5000 feet, displayed on the right. When you started turning it, "ALT ARM" should have appeared in the autopilot display. This indicates that you've selected a target altitude. The autopilot will maintain the current rate of climb until reaching that altitude, at which point it will level off and change from vertical speed (VS) mode to altitude hold (ALT) mode. In altitude hold mode it maintains an altitude (in this case our target altitude of 5000 feet).

Don't forget that the autopilot won't adjust the throttle, so when it levels out, the airplane (and engine) will speed up. You'll need to adjust the throttle to get a proper cruise.

Continue to watch your needles and displays closely: Remember that there are mountains close by that raise over 3500 ft altitude!

- By now we should be closing in onto the FIX SUNO, so let us prepare for things we will need there:
  - Make sure you are on radial "SJC FROM 009°" and fly the CDI centred ([see the blue line "5"!](#))
  - Make sure the NAV2 is on frequency **116.0** and the **OBS** is set to "**ECA FROM 228**" ([see the blue line "7"!](#))
    - The frequency 116.00 should already be in the right (standby) display of the NAV2 - so we just have to push the white button below it to set it into the "selected" window and then tune the NAV2-OBS to 228
    - OR we go to the GUI "[Easy -SetUP](#)" again and switch those frequencies there and overwrite the radial (now 114, from Oakland!) with the new 228.
  - And we verify that the ADF is on, because that one will guide us afterwards to the NDB REIGA ([see the green line "3" leading to the blue "8"](#)).
    - The [ADF-display](#) must display "ADF" (if it displays "ANT" push the "ADF"-button in)
    - and the selected frequency must be 374! (if not: Make sure that the display shows both, the "selected" and the "standby" frequency (maybe push "FRQ"), then rotate the big dial to set the 374 into the right display and promote it to the "selected" by pushing "FRQ". For details see the [ADF-display](#)).

Very soon now that ADF will start pointing towards the NDB. But we do not follow that yet - we wait till we cross SUNO.

Remember: There are still mountains in the area (and ATCs that may be watching us!) - so we exercise our flight-plan WITHOUT short-cuts!



And then we wait that the CDI of the NAV2 moves to the centre (*while of course the CDI in NAV1 remains centred!*).

And while waiting let's introduce another piece of gear on the panel that will cross-check the SUNOL passage. Some VOR stations have a distance capability, called [DME](#) (Distance Measuring Equipment). For example, San Jose does (remember it's a VOR-DME station), as do Oakland and Manteca (*VORTACs always have DME capabilities*).

Using DME, you can find out how far you are, in straight-line distance, from the VOR station. In our scenario, the DME isn't necessary, but we'll use it anyway, just to see how it works, and to reconfirm our position. Have a look to the chapter [DME](#) in the part RNAV!

The DME shows you 3 things: the distance in nautical miles to the station, your speed towards or away from the station, and the estimated time to the station at the current speed. Note that the distance is the direct distance from your plane to the station (called the "slant distance"), not the ground distance. Note as well that the speed is relative to the station, so unless you're flying directly to or from the station, it will probably be lower than your true ground-speed. For example, the speed from San Jose, which is directly behind us, should be greater than the speed towards Manteca, which is off to the right. You may tset it with at little knob in the lower left corner:

Position 1 is NAV-1 = VOR SJC (San Jose)

Position 2 is NAV-2 = VOR ECA (Manteca)

Let us look up the informations about SUNOL, e.g.: <http://www.airnav.com/airspace/fix/SUNOL>

#### Information on fix SUNOL

**Identifier:** SUNOL

**Name:** SUNOL

**Location:** 37-36-19.910N 121-48-37.010W

**Navaid radial/DME:** [OAKr093.00/20.97](#)  
[ECAr229.00/33.35](#)  
[SAUr096.60/37.07](#)  
[SACr176.80/51.71](#)

**Fix use:** Reporting point

**Published:** yes

**Charts:** IAP

AREA  
ENROUTE LOW  
SID  
STAR

**Nearest city:** Scotts Corner (Alameda county), CA, USA

**Nearest landing site:** [KLVK](#) - Livermore Municipal Airport (5.3 nm away)

**Nearest airport:** [KLVK](#) - Livermore Municipal Airport (5.3 nm away)

**Nearest public use**[KLVK](#) - Livermore Municipal Airport (5.3 nm away)  
**airport:**

- We know already from the Sectional that SUNOL is a major crossing point for many Airways and/or VOR-radials, see the above 4: OAK, ECA, SAU, SAC
  - we are especially interested in the ["ECAr229.00/33.35"](#), telling us that it is "33.35 nm from VOR ECA on the 229.00 radial"
- And also important for us is the line: **"Fix use: Reporting Point"** -- so latest here we will contact Livermore and tell them we are coming! On a real IFR flight we would have been all the way under ATC-control - so that would not be a surprise to them!
- And also nice to know: ["KLVK - Livermore Municipal Airport \(5.3 nm away\)"](#)

So let us sit and wait, until we arrive at SUNOL - if you still have time!

### 3) SUNO to NDB REIGA

As defined and preset before, we now know we are at SUNOL, when

1. the two radials cross, i.e. both CDI's are entered:
  1. We are still following the "SJC FROM 009" with a cantered CDI-1
  2. We have set "ECA radial 229" into NAV-2 and are waiting for that VOR-2 CDI to centre
2. When the CDI-2 centres we should see on our DME (*set before to "N2" (or "HLD") as you might remember!*) the distance of about 33 nm - do not look for inches, but if the distance is less than 30 nm or above 35, then it is time to recheck what you did!

When over **FIX "SUNO"** we turn right to follow the ADF-pointer towards the **NDB REIGA**, because we know: That is where our [IAP](#) begins! If you need a refresh on how to fly to a NDB see the chapter "[ADF/NDB](#)" in the part "RNAV". In case you cannot watch that ADF-instrument very good, remember: There is the possibility to hide the yoke: Menü → Cessna C172P → Showhide yoke!

If you did not yet report into KRVH-Approach then it is high time to do so now !

So we now follow that "ADF-pointer", keeping it always pointing straight upward - independent of what heading is shown in the "heading Indicator"! As we learned in the chapter "[ADF/NDB](#)" we probably will be flying a little a bow - but on that short distance we do not really mind!

While on the way to REIGA we will already set the "windrose-scale" inside the ADF-Display to 75 - just in preparation for the upcoming, more busy timeframe!

And then we continue that ADF-needle, until it starts swinging around 180° - that is when we know we arrived at REIGA (i.e. crossed it!).

#### 4) The „Procedure Turn“

So, once we hit REIGA, do we just turn left and head down to the runway? Ah, if only life were so simple. No, we turn right, away from the airport, and do a [procedure turn](#). We know there's a procedure turn because of the barbed arrow in the plan view ([compare the IAP at the beginning](#)). As you can see if you follow the arrow, we need to fly away, on a heading of 075°, then turn left 45° to a heading of 030°. We do a U-turn (*to the right, away from the airport — that's one of the rules about procedure turns*) to come back at 210°, then a 45° right turn to 255°, heading straight towards the runway. All of this turning gives us time to set ourselves correctly on course, at the right altitude, to land on 25R.

One thing the instrument approach procedure does not tell you is the length of the procedure turn. The only constraint is that you must not fly more than 10 nm away from the NDB. You'll notice there's a 10 nm circle drawn around it in the plan view, and a note in the profile (*yellow*) view saying "Remain within 10 NM". They're not kidding. So, since we fly at around 110 knots, two minutes on each leg is reasonable — two minutes at 075°, and two minutes at 030°. On the way back we don't care about times — we just want to intercept the localizer for runway 25R (255°).

So, after we pass REIGA, turn right to 075°. And now we have the problem of all very rich people: We have to decide what timer to take to time our two-minute legs! We have at least 3 to choose from:

1. Our ADF receiver has a built-in timer - you would start it by clicking the "FLT/ET" (flight time/elapsed time) button. The "FRQ" in the middle of the display will disappear, and "FLT" will appear on the right, and the standby frequency will be replaced by the timer. This "**FLT**" is the total **flight time**, and cannot be changed, except by cycling the power. Hit "FLT/ET" again. Now you'll see "**ET**", the **elapsed time** will appear. To restart the elapsed time, hit the switch, labelled "SET/RST". Each time you hit "SET/RST", the timer will restart at "0" - independent of the mode the ADF is working in! If you want to see the standby frequency again, hit "FRQ" once. (*The timer will continue to run in the background*).

2. We have a standard Stopwatch in the "menu -> Equipment -> Stopwatch", also that one nice and easy to use!
3. or you can use any outside "private" clock

## Outbound, 2min on 75°

When we approached REIGA, we weren't particularly concerned about our course — we just aimed for REIGA. Now, however, our course and altitude is important, remember: We are now flying opposite to the "traffic on final" - and that may be just about 1000 ft below us, and of course there may be more traffic just on approach with us! So we should not deviate from the procedure, that everybody expects us to follow!

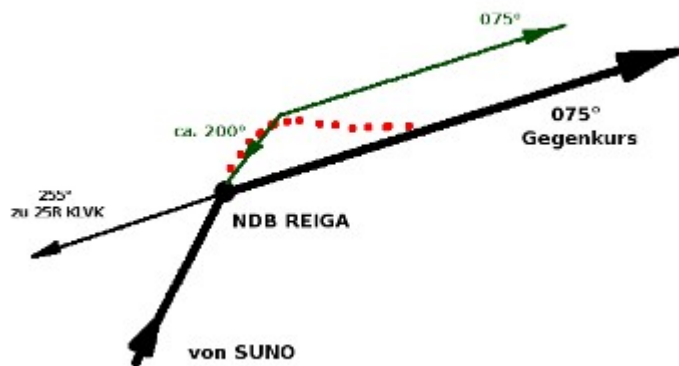


We want to fly directly away from REIGA on a course of 075°. You noticed: "course" - not "heading"! That means "leaving" KLVK on a straight line from the runway 25R (=255°!) via the NDB REIGA to the outside.

*(I just hope you did not notice, that this is what we usually call the "ILS-Backward" or reverse! (See e.g. the [Autopilot "REV"](#) setting.) So in this unique case we could just follow the 25R ILS-Radial "From" -- But please do not! We proved already that you can follow a "From" radial, that is getting boring - let us try something new:)*

We will use something like a **NDB-radial**: Before crossing the NDB we **set the "ADF display"-wind-rose to 075°** (see the picture at the left) - and then, when we cross the NDB, we turn right to the new heading of 075° (*on the Heading indicator!*). After that turn:

- The "heading indicator" defines we are on heading 075°
- But the ADF is stubborn and continues to point to the NDB at somewhat around 230° - but looking onto the following sketch we want to have the NDB behind us at 255°!



Actually we follow a course like the green line in the left picture - because even the little Cessan cannot fly corners! But definitely we have to follow the big fat arrow pointing to "075° Gegenkurs" (*reverse course*) - otherwise our instructor and/or ATC may not be satisfied!

That means we have to do something like what the red line proposes! But how do we know when we are on that "NDB-radial"? (*remember: we do not want to use the ILS at this point!*)

Well - by inventing the name "ADF-radial" I suggested you do the same as what we learned when following a VOR-CDI indication: In this case turn a little to the right until the ADF-needle centres and then fly keeping that ADF-needle centred (i.e. vertically pointing 075/255°). That way we should be on course! And on the

sideline you now learned why there is a "movable wind-rose" inside the "ADF display"!

***That way we can use the ADF like a VOR radial! BUT we keep in mind that this NDB-radial by far is not as exact nor as long reaching as an ILS! Actually: If you would use this NDB-method later on for our final approach (those last 6.1 nm from the LOM to Touchdown), you could get a deviation of about 1/3 of a mile! And that is just the mathematical part! You will find out that even when following the ILS-Localizer (manually) you will have some deviation, add that 1/3 nm to that and you really will have problems getting onto the runway! (At least with the weather-conditions we have set!)***

We now learned and never forget the 2 basic **characteristics of an ADF/NDB navigation:**

### **The ADF-needle always points to the station.**

We can just follow it to the station, but it may not always be the shortest, straight course!

### **If the ADF-compass card is set to our current heading, then the needle also gives us the bearing to the station.**

That way we have some kind of a radial like with the VOR-navigation, but by far not that exact!

(*And not usable by the Autopilot!*)

While you're flying outbound, take an occasional look at VOR2 and the DME, both still tuned to Manteca. Assuming the OBS is still at 229° then at some point the needle should center, meaning you've crossed the 229 radial: At that same time the DME should read 20.8. How do I know that? If you look at the [IAP-picture](#), you'll notice an intersection, named FOOTO. FOOTO is on the approach, and is defined to be 20.8 DME from ECA. Although this intersection is not strictly necessary for us, it comes for free, and provides good confirmation of our position both outbound

and, later, inbound.

- Depending on how fast you're flying, you'll probably pass FOOTO close to the time your two minutes at 075° are up.
- At the end of two minutes, turn left 45° to the new heading of 030°. (*You noticed: This time there are no special actions to hold the course - but do your best!*)
  - Reset the timer and fly again for 2 Min on that heading 030°
  - and now **it is time to start our descent**. Remember: We should be on 3300 ft when intercepting the localizer (see the yellow area in the IAP!)
- At the end of those two minutes, turn right to 210°

### Get George to work (or not):

This whole "Procedure Turn" is relatively uneventful, so now you might take advantage of the lull in the action to descend to 3300:

**With George:** you will need to do a few things:

1. If you're in altitude hold (**ALT**) mode, you need to get back into vertical speed (VS) mode. Press the ALT button — the "ALT" in the middle of the display should change to "VS", and your current vertical speed (probably 0) should be displayed momentarily on the right.
2. Click the **DN** button until you get a vertical speed of -500 feet per minute.
3. If you want to set the target altitude, rotate the big knob on the right until "3300" shows up on the right side of the display. "ALT ARM" should appear on the bottom.
4. You also could tell George to do the turns for you:
  - just set the red bug in the "Heading indicator" to the current heading
  - then push "**HDG**" on the autopilot
  - and for the next turns just move the "red bug" to the new heading!

Note: If you're using the autopilot to descend, it will just push the nose down, like a bad pilot, so the airplane will speed up. We want to go down, but we don't want to speed up, so we need to reduce the engine RPMs to keep the speed at 110 knots. Later, when you level off at 3300 feet, you'll have to increase power again.

### **Without George:**

If you're flying manually, then you just need to adjust the engine power to get the descent rate of descent you want — the plane should stay magically at the speed you have trimmed it for! e.g. a reduction by ~200 RPM will give you a descent of ~500 fpm, [ref. part "First Solo"](#)



[chapter "Cruise"](#). When at that wanted 3300 ft

we just increase the RPM again to what it was before and continue with the same speed

or we just retrim and continue with a reduced speed!

I personally prefer to reduce the speed already at this moment - that gives me more time to have a well trimmed plane prior to final approach!

## The ILS Landing

While descending, we need to start considering how we're going to intercept the 255° on the way back and follow it down to the runway. You might think we're going to use the NDB like we did on the outbound leg, but at this point, the NDB is not good enough. This will be an ILS landing, a so-called "precision" landing, and an NDB is just not precise enough! It can get us close to the runway, but not close enough under IFR-conditions.

So, we're going to switch over to our [ILS](#) system. That is much more accurate horizontally. And in addition it offers vertical guidance, something which the NDB does not give at all. And hey, it also gives you something else to learn in our few remaining minutes, so that you don't get bored! (If you did not yet study the "[VOR/ILS](#)" chapter in "RNAV", you might want to do that now!)

By now we do not need the SJC radial 009° any more - so we switch our **NAV1** to the ILS, see above [IAP](#):

- At the very top we see the major data for the "**ILS RWY 25R**":
  - LOC I-LVK 110.5 (*Localizer-frequency for ILS Livermore is 110.5 MHz*)
  - APP CRS 255 (*Localiser Approach Course is 255°*)
  - Apt Elev 397 (*also nice to know: The elevation is 397 ft*)

Set those data now manual at the device or in the "[Easy -SetUP](#)", as we have done before! And also as done before: Do not forget to check the "**Morse-code**" (.. -.- ..- -.-)!

If you look at the "NAV-1 display" while setting the above localizer, you should notice:

- the red "GS" flag should disappear, when we are inside of the radius of the 10nm (*remember: The GS-signal does only reach out for about 10 nm!*).
- the ILS needle will move to the side -- can you guess to which one? Well we are in that big U-Turn, which is to the right of the localizer 255° - thus we should correct to the left and that is where the needle points to! Always remember:
  - **The CDI does NOT point to the transmitter, but to the direction to which you have to correct to!**
- And the OBS? Well, it's useless. Try moving it. No matter how you turn it, the needles don't move in response. That's by design. A localizer is basically a VOR with only one radial: The approach heading. We don't care about any others, so we don't need an OBS to

declare interest in any others. However, it does serve as a useful reminder, so move the OBS to 255, our desired heading.

Looking at the [IAP](#) you should have noticed that the last leg of that U-Turn (210°) is considerable shorter than the opposite 030° was! So now we will not wait for 2 min, but watch the CDI/localizer needle: As soon as it starts to move to the centre we turn to intercept that 255° ILS-localizer back to the airfield - now really for landing!

And remember and check: ***We wanted to be on an altitude of 3300 ft at that intersection!*** (Otherwise the other traffic, now on that famous outbound heading 075° from REIGA, may hit us front to front!)

***As said for the start: You should also do the following at least once WITHOUT AUTOPILOT, so that you can enjoy the full pleasure of an IFR-approach!!***

But for the first try we will describe it as when using the Autopilot!

When using the autopilot (and missing the fun!), you should be aware of one additional button on the AP:

**APR:** For tracking the "Localizer" use the "APR" button instead of the "NAV" that we used for tracking a Radial. That "APR" will track both: the localizer and the glide-slope.

## Intercepting the Localizer

We're now ready to intercept the ILS localizer. Relatively soon after having turned to the last leg of the "Procedure Turn" (the 210° heading) the vertical (localizer) needle on the ILS will begin to move. And it will move fast, much faster than the ADF and/or VOR needles did. A localizer is 4 times as sensitive as a VOR, so relatively small movements of the aircraft make big changes in the needles. You'll probably overshoot, but don't worry, because we have around 5 to 10 minutes now, we will get things straightened out before touch-down.

Just remember: don't chase the needles. That mantra is now more important than ever. Those needles are sensitive — if you just turn left when the localizer needle is to the left and right when it's to the right, you'll be flying like a drunken sailor. If you're lucky, the runway will be passing underneath you as you swing across the track for the umpteenth time. Luck, though, is something we should not be relying on. Determine on how the needles are moving before making your move.

Now that you're heading back inbound at 255° , slow to 75 knots, drop a notch of flaps, and descend to 2800 feet (but no lower). And check for the inbound passage of FOOTO to confirm your position. And pat your head and rub your stomach.

## Intercepting the Glide Slope

As we fly drunkenly towards the runway, cursing localizers and needles and resolving never, ever to fly in such crappy conditions ever again, don't forget to look at the horizontal needle: The ***glide-slope needle***.

- At the start it was pointing **straight down**, indicating that it was not (yet) active (i.e. we were still outside a 10 mi range!)
- then it jumped way up **high above** us, because we were actually under the glide slope.
- But as we levelled out at 2800, the glide slope **starts coming “down”** to us - thus the needle starts to move down.
- When the needle **is horizontal**, that means you’re on the glide slope. You won’t be for long, though, unless you start descending.

So what’s a good rate for the descent? That depends on our ground-speed. In our case, we’re going at 75 knots (there’s almost no wind, so our airspeed and ground-speed are the same), and it turns out that we need to descend at around 400 feet per minute:

- **With the autopilot**, that’s pretty easy — just dial in -400, and you’re set (but remember to reduce power to keep our speed at 75 knots, or you’ll hit the runway going pretty fast)
- **Without the autopilot**, it’s also pretty easy — just reduce power. How much? In this case, with our plane, to around 1700 RPM. Again, it depends on many things, like plane, elevation, winds, weight etc.

So now you’ll have to adjust things if you see the glide-slope needle start to move up or down. Like the localizer needle though **DON’T CHASE IT**. Watch how it’s moving, then make your adjustments.

Since we’re now on final approach, you might want to drop a second notch of flaps. This will affect your trim, and you’ll have to adjust power a bit as well.

Soon after we intercept the glide slope, we should pass over the outer marker, and several things will happen more or less simultaneously, all of which confirm your position:

- You’ll hear a continuous series of dashes.
- The blue light labelled “O” above COMM1 will flash.
- The ADF needle will swing around (*That is still tuned to the ADF REIGA, which we used as the [IAF \(Initial Approach Fix\) and now acts as LOM \(Localizer Outer Marker\)](#)*)

## On Final

After all the excitement of the procedure turn, it will seem like a long way down to the runway from the outer marker. There’s not much to do but stare at those needles. In fact, you’ll probably stare at them like you’ve never stared at them before (especially when the autopilot is OFF!). But do not forget to take a look around at the other gauges too, though - they have useful things to tell you:

- **Airspeed ~75 kn:** We don’t want to stall!

- **RPM ~1800:** About at the start of the green marking
- **Trimming OK:** Try to take your hands off the Yoke from time to time - if the plane does not rapidly change heading and/or altitude then the trimming is ok - and it relaxes your muscles, at least the first few times they are probably very tense!
- **FPM ~400:** I hope that you do not rapidly try to get back onto the GS, when you deviated from it. Rather look onto the "Vertical Speed" first and then adjust FPM by adding/reducing RPM so that you gradually get back to the GS. Any wild actions on the yoke will get you into deep trouble, because that changes all attitudes (*speed, pitch, vertical/horizontal direction, etc. see the chapter ["Advanced Know How"](#)*). Gradually/slowly are the important words here - not fast!
- **Heading-Indicator ~255:** I hope you did set already your "red bug" to 255°, the heading for the GS and runway! Thus you have a chance to notice soon that you reacted appropriate or overdid it! For sure some day you will find out, that you may have turned off course by 90° or even 180° prior noticing it - and prior that the CDI indicated significant changes. But please: That day must not be today, when I am with you in that plane!
- You also should look to the altimeter from time to time - just make sure you still are on an appropriate altitude. You do know the altitude of the ground below you, do you?!?!
- This being a simulator, we don't really have to worry about **oil pressure and engine temperature**, but you might want to glance over there anyway, just to get into the habit.
- And I hope you've done things like
  - pulling out the "**Carburetor Heat**" (mausclick onto the black knob to the right of the light-switches)
  - setting the **mixture to full rich** (pushing it full in - you did lean it out while cruising, didn't you?).
  - **Landing light** is already on since the Start
  - **Flaps** are on stage 2 ("I")
  - etc.

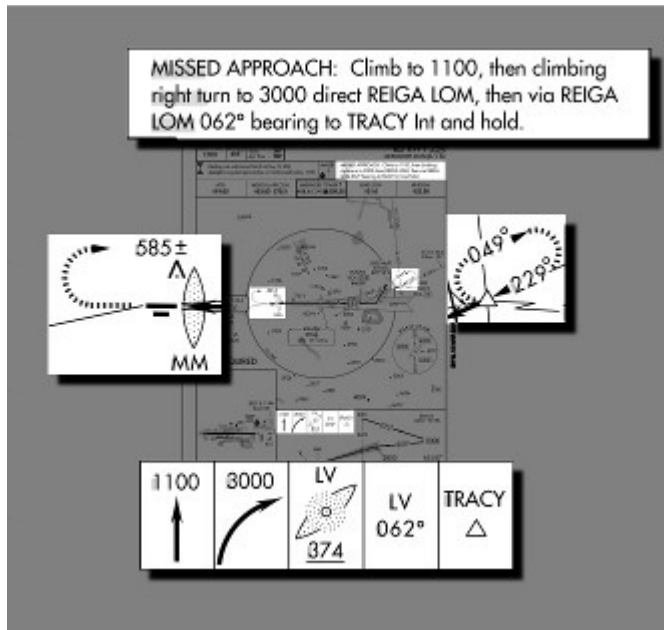
## Decision Height 597

Although ILS approaches can get us close to the runway, closer than VFR, NDB, or VOR approaches can, we still need some visibility to land, so we need a way to decide if landing is possible or not. That's what the landing minimums section in the [green part in the procedure plate](#) is for: In the category labelled "**S-ILS 25R**" (that's us), you'll see "597-½ 200(200-½)". This tells us that we can track the glide slope down to an altitude of **597 feet = 200 feet above the runway!** Thus: If we cannot see the runway at that altitude, then we have to execute a missed approach. 597 feet is our decision height (**DH**).

In addition to the altimeter, this particular approach also has another indication that we're close — a middle marker (**MM**). This marker will sound — in this case, a dot dash series — and the yellow light labelled "M" above COMM1 will flash. Passage over the middle marker should coincide with reaching decision height. So, what if you can't see the runway at decision height? As you might have expected:

Just as you can't land willy-nilly, you can't just go around willy-nilly. There's a Procedure:

### **The Missed Approach Procedure:**



Parts of that procedure are shown in several places on the [approach plate](#):

- At the top, where it says “MISSED APPROACH”
- in the plan view, where you can see a dashed arrow coming off the end of the runway
- and a dashed oval on the right
- and a series of boxes below summarizing graphically what to do.

In our case, these all tell us to:

1. Climb straight ahead to 1100 feet
2. Make a climbing right turn to 3000 feet
3. Fly to REIGA (compare the frequency and Morse-code!) and be sure to be there on 3000 ft, remember: Incoming traffic is on 1039 ft at REIGA!
4. Fly outbound from REIGA at 062°
5. Fly a holding pattern at the TRACY intersection

The holding pattern, as you might have guessed, is a place where you can “park” while sorting things out, and has its own set of procedures and techniques which we won’t go

into here, because . . . (but have a look into the chapter ["Procedure-Turns"](#) in the part ["KnowHow"](#).)

## Touchdown

In our ideal simulator world, you probably won’t have to execute a missed approach. Assuming you stayed on the glide slope, you should have popped out of the murk at 750 feet, a whole 153 feet above the decision height, and with 1 mile visibility. The runway should have been in view soon after. With the runway in sight, you could turn wildly to get on course (it’s very hard to be lined up perfectly) and land “normally” (which for me involves a lot of bouncing around and cursing). Park the plane, then stagger out of the cockpit and have another hamburger!

Exit the runway, Park the plane, then stagger out of the cockpit and have another hamburger!

**Congratulations:** You did it! If you don't have to fly back yourself you might even have a drink!

We hope you liked that it und exercises this flight many times, also for refreshing yor knowledge from time to time. Enjoy it!

## Epilogue

That was a lot of information in a short time, a rather brutal introduction to ILS flying. Hopefully, instead of turning you off, it has whetted your appetite for more, because there is more. Some of the major issues I've ignored are:

- **Wind:** This is a big one. Flying IFR in a crosswind affects everything you do, and you need to be aware of it or your navigation will suffer.
- **Flying without the autopilot:** George tries his best, but he's not completely trust worthy. You have to be prepared to go it alone.
- **DG precession:** The directional gyro in the c172p is not perfect. Over time, the values it gives you are less and less reliable — it precesses. It needs to be periodically calibrated against the compass (using the OBS knob on the DG to adjust it).
- **IFR charts:** We used sectionals, which are really intended for VFR flight. There are a whole set of charts devoted exclusively to IFR flights.
  - You also should have a look into the newly released "[Chart](#)"-feature!
- **ATC:** The other people out there, that need to know what you're doing. As well, they'll probably tell you what to do, including to ignore the approach plate you so fastidiously studied.
- **SIDs/DPs, Airways, and STARs:** This tutorial introduced IAPs, which are standard ways to make approaches. In IFR flight you need additional standard ways
  - to leave airports (Standard Instrument Departures, **SIDs**, or Departure Procedures, **DPs**),
  - to travel between airports (**airways**),
  - and to go from airways to IAPs (Standard Terminal Arrival Routes, **STARs**).
- **Holding Patterns:** Most missed approaches end in a holding pattern somewhere, so you'd better know how to fly them.
  - See also the chapter "[Holding-Patterns](#)" in the part "KowHow"
- **GPS:** Our Cessna doesn't have a GPS, but nowadays most small planes do, and GPS is rapidly replacing radio-based nav aids.

*If you want to learn more, try the following resources:*

- [Flight Simulator Navigation](#), written by Charles Wood. It covers everything from basic navigation to ILS approaches, with lots of examples and practice-flights to improve your skills. Everything is linked together by an entertaining storyline in which you are the pilot for a fictional charter service. Two caveats, though. First, it is Microsoft Flight Simulator-based, so you'll have to translate into "FlightGear-ese" as appropriate. Second, it is a bit out of date, and things in the real world have changed since it was written. NDB beacons have been decommissioned, new approaches have replaced old ones — even an airport has disappeared (!). Treat this as a learning opportunity.



You'll get better at finding more up to date information, and learn not to blindly trust your charts, just as you have learned not to blindly trust your instruments!

- If you're really keen and want to hear it straight from the horse's mouth, there's the official [FAA Instrument Flying Handbook](#). It's big and detailed, and there's no interesting storyline in which you're a pilot for a fictional charter service. It can be downloaded as multiple PDF files.
- If you'd like practice deciphering what the instruments are telling you, without the bother flying (or even virtual flying), you can try [luizmonteiro.com](#), which has Flash tutorials of various instruments, including a VOR and an ADF.
- Another simulated instrument site is [Tim's Air Navigation Simulator](#). It has a Java applet that simulates a plane flying in the vicinity of two navaids. The simulation allows you to use different kinds of instruments and navaids, so you can see their behaviour, and the advantages and disadvantages of each.
- If it's navigation information you're after, an excellent site is [AirNav.Com](#), which I've used extensively in the course of this tutorial. It has detailed airport, navaid, and fix information, and links to IAPs. Unfortunately, the information is only for the USA.
  - Another source of airport and navaid information is World Aero Data. Its information isn't as detailed as AirNav's, but it is international.
- FlightSim.Com has a very informative series of articles entitled "[How To . . . Use Approach Plates](#)". It starts with a very, very dense tutorial on how to read an approach plate, then follows with a set of approaches at Kodiak, Alaska. These are an excellent supplement to the approaches given in Charles Wood's Flight Simulator Navigation (see above). Most interesting, though, is section two — "Dangerous Approaches." Approaches at six airports around the world, from Penticton, BC to Kathmandu, Nepal, are described. Fly them if you dare!
  - Warning — the series is even more Microsoft Flight Simulator-centric than Charles Wood's, and some of it is out of date (some outside links are broken, and some of the approaches have changed).
- Also from FlightSim.Com is "[Golden Argosy](#)", a description of a flight from New York to Rome by Tony Vallillo, an American Airlines 767 captain. It gives some interesting information about navigation that doesn't appear in the other sites mentioned here, such as the North Atlantic Tracks. However, its main appeal is that it gives a good answer to the question "What's it really like to be a pilot?" The author's love of flying is evident throughout the article.
- For those who are interested in the ATC side of things, and want information from an authoritative source, check out Michael Oxner's "[Aviation Topic of the Week](#)", a series of articles about flying "in many types of airspaces in many situations." Michael Oxner is a professional controller and private pilot who obviously can't get enough of airplanes, because in his spare time he's also an on-line controller with VatSim. Particularly interesting are a set of articles describing a complete IFR flight and a complete VFR flight.
- Freeworld Airways is a virtual airline. Their "[flight school](#)" has lots of useful information about navigation (including holding patterns, SIDs, and STARs), ATC and communication, and weather. Also interesting are two example flights, one in Europe and one in North America, showing the interaction between pilot and ATC.

