
# X-plane 11 – MD 82

# Engine starting Tutorial

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# 1 Summary

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# 2 Why this tutorial

I always wanted to fly, but life broke my wings. I was too short-sighted to get the glider licence, and I had to give up and switch to flight simulators.

I started with Sublogic or Microsoft (can't remember) flight simulator on PC (DOS, of course!). We're talking about year 1990. The available airplane was a Cessna 172, just like now on x-plane. Sceneries were so poor, just a little bit better than basic wire frame. But it was already a real emotion to push the throttle and get aloft!, flying between the twin towers!


My hardware was really basic, i.e. a brand new Amstrad 1640. Airplane reactions to commands were so slow that a real pilot told me that flying a real Cessna was much easier that flying the Simulated one.

I read a few books about how to fly, VFR, IFR and gliders. Just to understand how to use the simulator, even thought my real dream was to fly for real, and not just in the passenger seat of some airliner.

To make a long story short, I built my own yoke, pedals and throttle and I spent so many hours reading maps and learning how to fly VFR and IFR from Kennedy to La Guardia airport, and more.
Everything was quite easy, and then I started playing with clouds and wind, to make it harder.

Here I am, with my x-plane-11 demo copy. I want to play with it on my lap-top. Yes, I know that this computer is too weak to support a real-time simulation. The frame rate is never above 11, and should be at last 20. My plan is to learn the basics, then I'll buy a complete x-plane-11 (xp11) licence and a computer

with good muscles, three monitors and some driving gadget like yoke, throttle and pedals at least. Then, if passion won't drop, some more instrument.

I already made my training with the default Cessna 172 plane. Easy to fly, easy to learn. In a couple of days I learned by myself how to take off, fly and land in VFR mode using just the basic six gauges pack and VFR maps.
Then I switched to IFR, learning how to use ADF, VOR, ILS and IFR maps.

Due to the fact that I'm using the demo version of the flight simulator program, my usual path is from Tacoma KSEA airport to Olympia KOLM destination.

Feeling "expert" with the Cessna 172, I decided to switch to something more complicated, and the MD82 caught my attention.

# 3 The Mad Dog Family

The MD80 family got the “Mad Dog” nickname. There are many versions of the reason why the MD-80 family got this nickname. Someone says:
“*It comes from the prefix M-D and it's easier to say than MD-80 on the radio. It sounds juvenile, but for example, if Ground asks you to hold short of a taxiway to let an MD-80 pass, it's easier and quicker to respond, "Ok, we'll give way to the mad dog," than to say, "Ok, we'll give way to the MD-80." That's the only reason, and most pilots who commonly refer to MD-80s as mad dogs with any regularity are Atlantic Southeast pilots in ATL who must yield to Delta's MD-88 fleet, and also the ASA pilots in DFW who must work with both AA and DL MD-80s daily. Other than on the radio, I've never, ever heard an MD-80 aircraft referred to as a "mad dog". It's just a playful use of the MD prefix.*”

## 3.1 Panic

When first time I sat on the virtual left seat of the MD 82, I felt lost. Engines were already running, the runway in front of me, flaps already at 15% ready for take-off. I pushed the throttle handle and heard engines roaring, but nothing else happened. Panic. “Ok, ok, there is something missing. Brakes, of course! Let’s find where is the handle”. But I didn’t find it, no leverage on the pedestal, where usually cars have it. No handle under the cockpit, where the good old Cessna 172 has it. Believe it or not, I had to google for “MD 82 parking brake”, so I discovered that it was there, near my left arm!
“Why didn’t you use the B key to toggle the parking brakes?”. Well, the thing is that I always want to play with “real things”, as far as possible. There is no “B key” on a real MD 82, you’ve to know where the handle is!
When I found the handle, I succeeded with my first MD 82 take-off. But then I thought “What if I want to start from the scratch, with engines and everything else off? “. And this is the subject of this tutorial.

## 3.2 Absolute beginner

Please keep in mind that I’m not a professional pilot, nor an MD 82 expert. I’m just an absolute beginner, and this is the spirit of this tutorial: to help other absolute beginners. Expert MD 82 pilots possibly will find lot of errors, and I’ll be glad to receive their critics and to modify this pages according to their suggestions. If you think that this tutorial could be useful, let me know (leave a comment on my website www.salrandazzo.it/fd). Other tutorials are on the way to come.

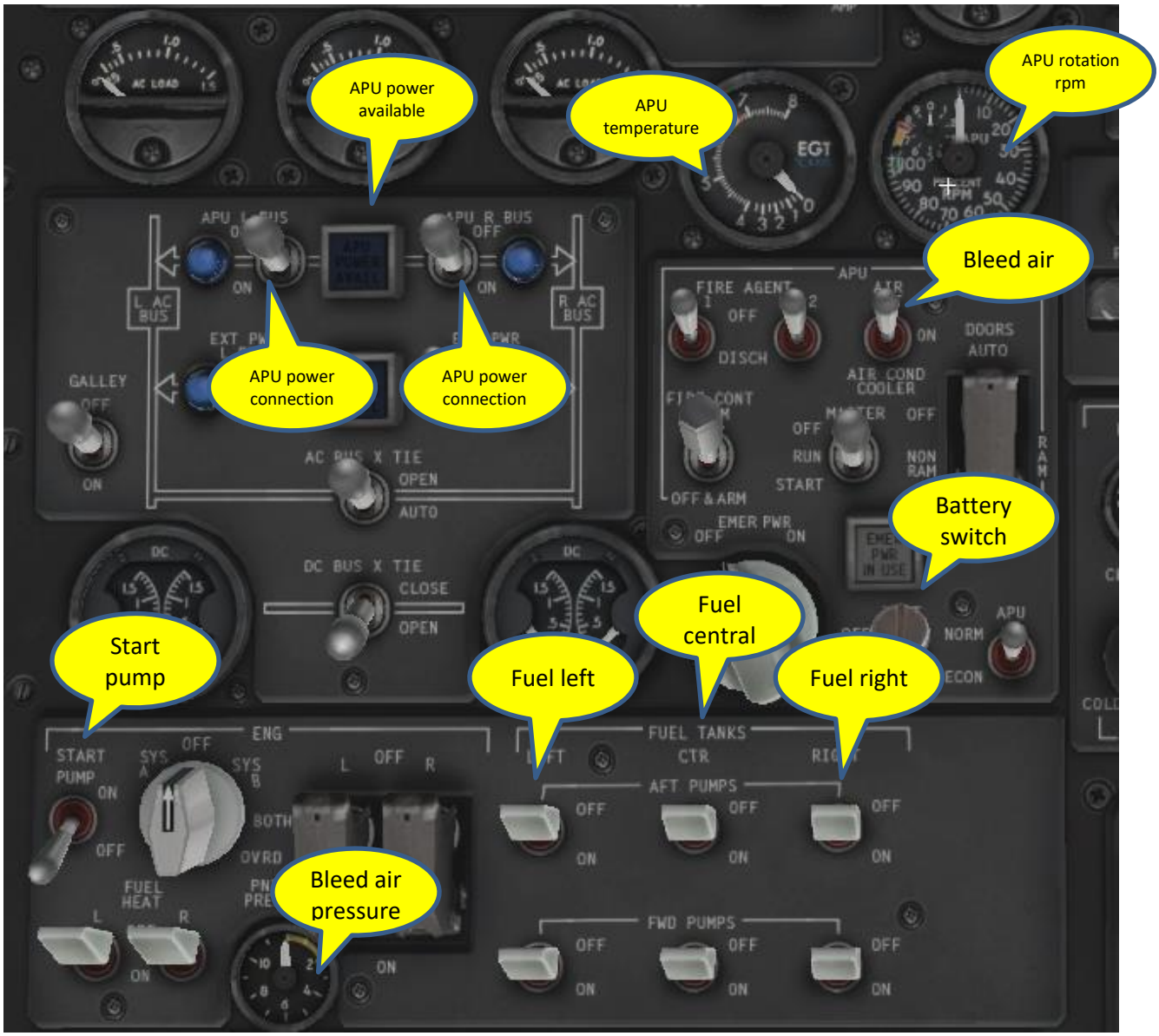
Here I will try to explain how to start MD-82 engines using the APU and, more, I’ll try to explain how a jet engine works.

# 4 Engine start procedure

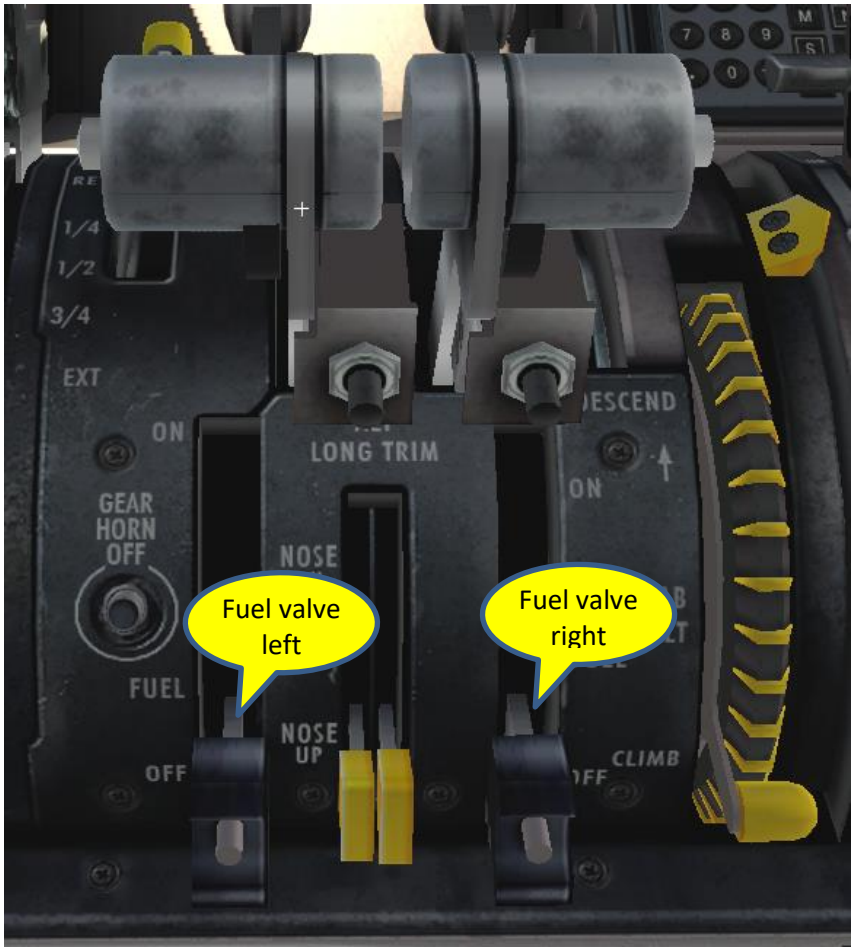
Our procedure will start with all the engines off, electrical power off, and all valves closed, so that we'll have to describe the whole procedure step by step.
There will be no external power or compressed air, so that we'll make use of the APU.

## 4.1 Instruments that we'll be using

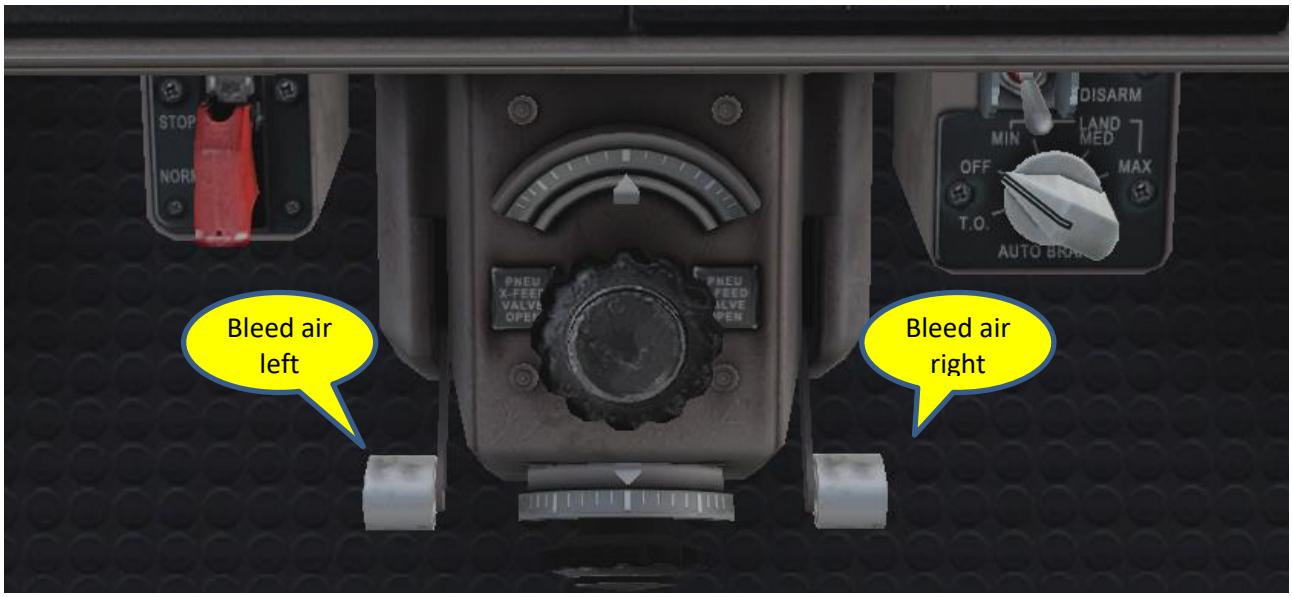
There is a set of instrument and commands that we'll use to start the engines. They are mainly on the overhead panel, then on the pedestal drum and in the space between the seats.




Over head panel, engine and APU.




Pedestal drum




Aft end of the pedestal, between the seats

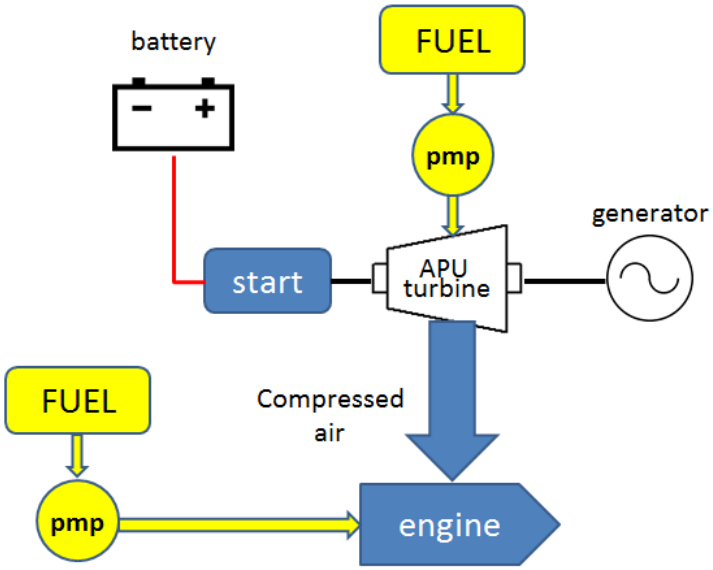
## 4.2 Pre-start situation.

I f you want to make a complete engine start simulation, verify that each command is in its inactive state:

1. Battery switch off.
2. Start pump switch off
3. Bleed air swtich off.
4. APU main switch off
5. Start pump off
6. L & R APU AC BUS switches off
7. All six fuel tanks AFT and FWD switches off
8. L & R fuel handle at minimum position (fuel valve closed, no fuel)
9. L & R engine bleed air closed (no bleed air to/from engines

## 4.3 APU

The Auxiliary Power Unit is a turbine powered generator that supplies electrical power and compressed (bleed) air when there is no ground assistance and engines are still off. When engines will be on, the APU can be turned off because engines will provide both AC/DC power supply and compressed air.
When APU is on, it generates AC/DC energy to power all the instrument and bleed air to start the engines. The APU is started using the airplane batteries.



## 4.4 Sequence

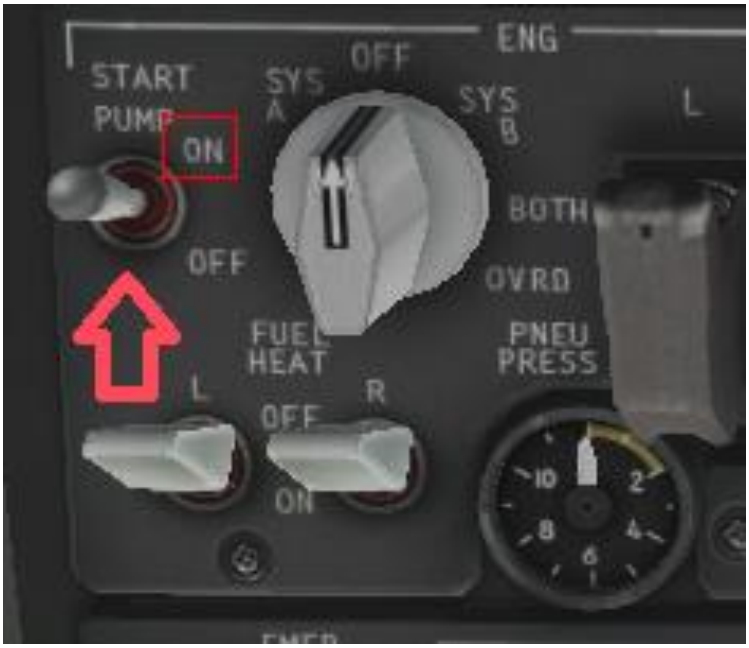
1. First we've to turn on the batteries, so that we'll have energy enough to start the APU. Click on the battery switch to put it in the ON position, then click again to secure the switch, just to avoid in-flight unintentional power-off. With the battery switch ON all the


battery switch ON


battery switch secured

2. With the battery switch ON some of the instrument will be powered, like the annunciator on the overhead panel


3. Turn the start pump on

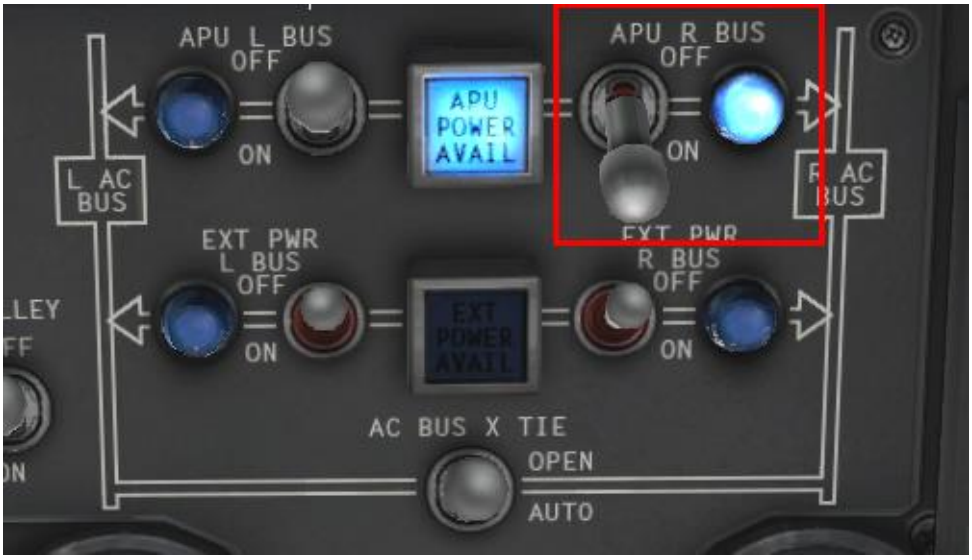


4. Switch the APU on


5. Wait for the APU full (100%) rotation speed and EGT (Exhaust Gas Temperature) to be stable around 500°C


6. Wait for the APU Power Available blue lamp on

7. When the APU power is available, move the left or right APU connection switch to the ON position to connect the APU generator to the AC BUS. The blue light will be ON

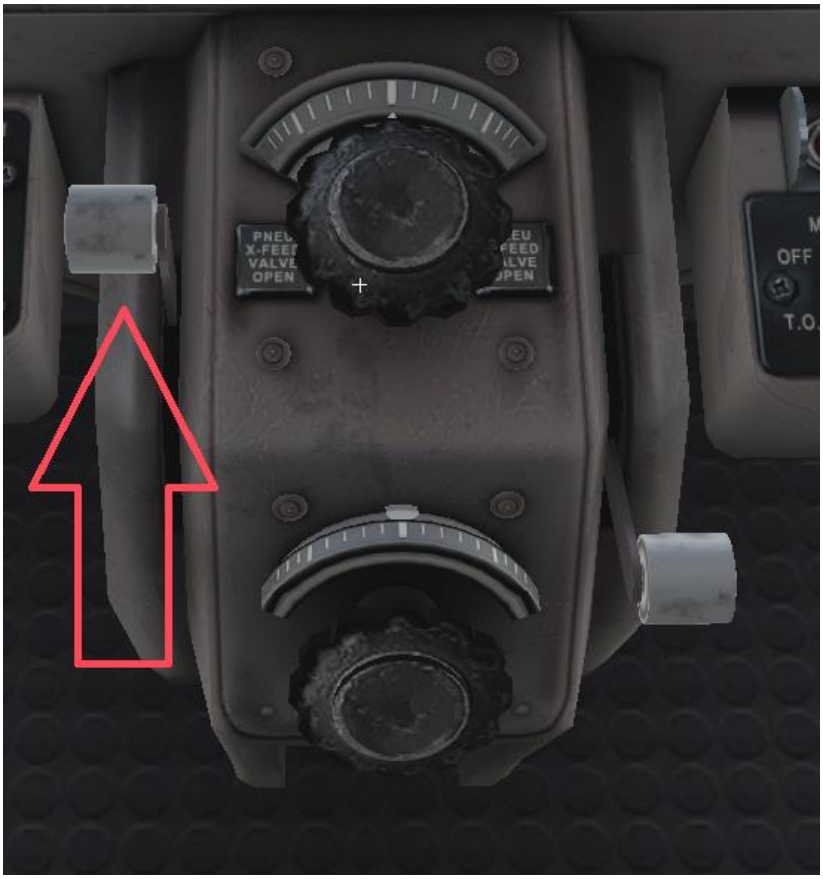



8. Move the start pump switch to the OFF position

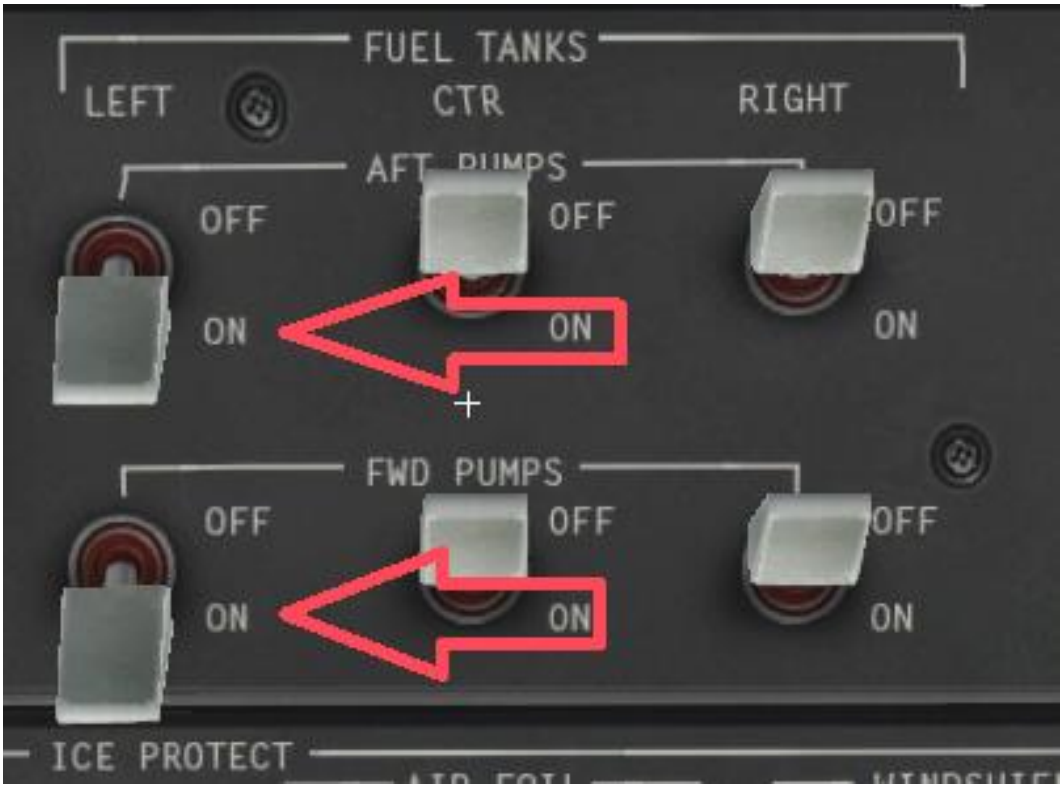
9. Move the APU air switch to the central ON position, so that APU bleed air will be available to the pneumatic system.


10. Wait for the air pressure indicator to go above 2

11. Toggle the left beed air command to feed bleed air from the APU to the left engine




12. Toggle the left fuel pumps (AFT and FWD) to the ON position

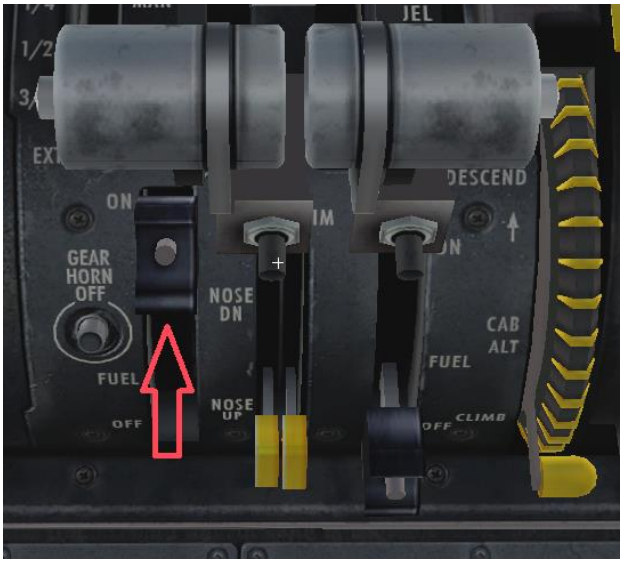


13. Open the engine ON/OFF switch safeguard


14. Move and keep the switch to the ON position

15. Keep the switch to the ON position and look at the N2 rotation speed gauge. Wait for the indication to reach 20% or more.

16. Pull up the left fuel handle to open the left fuel valve. The engine will be fed with fuel and will start.




Why do we have to wait for N2 to be above 20%? This is because we want to avoid the "hot start" problems. When the fuel burns inside the engine, the correct airflow keeps the engine temperature below the "damage limit". If N2 spinning speed is too low, let's say below 20%, and we open the fuel valve, there will be poor airflow that will be insufficient to keep the fuel burning temperature inside operational limits. That could damage the engine. That's why we've to monitor the N2 speed before to open the fuel valve, AND the EGT temperature, to be sure that it doesn't exceed 500°C during engine start.

17. To be sure that the engine is started verify the EGT value (Exhaust Gas Temperature) is rising, going above 350°C. N1 will rise above 20% and N2 above 60%. Be also sure that EGT temperature doesn't exceed 500°C, otherwise the engine could be damaged.

18. Repeat the same sequence for the right engine:
    a. Open right bleed air
    b. Switch on right fuel pumps
    c. Open right engine start switch safeguard
    d. Move right engine start switch to ON and keep it in this position
    e. Wait for N2 > 20%
    f. Open right fuel handle
    g. Verify that N1>20%, N2>60%, EGT>350°C

19. Now that both engines are running, turn the APU off :
    a. Start pump switch off
    b. APU bleed air switch off
    c. APU master switch off
    d. APU L&R bus switch off

Set the Voltmeter Selector on L position and verify that AC volt > 120 and Freq > 400.
Repeat for the selector in the R position. This is to verify that both engines are generating AC power.


Now both your engines are ready to take you above the clouds!

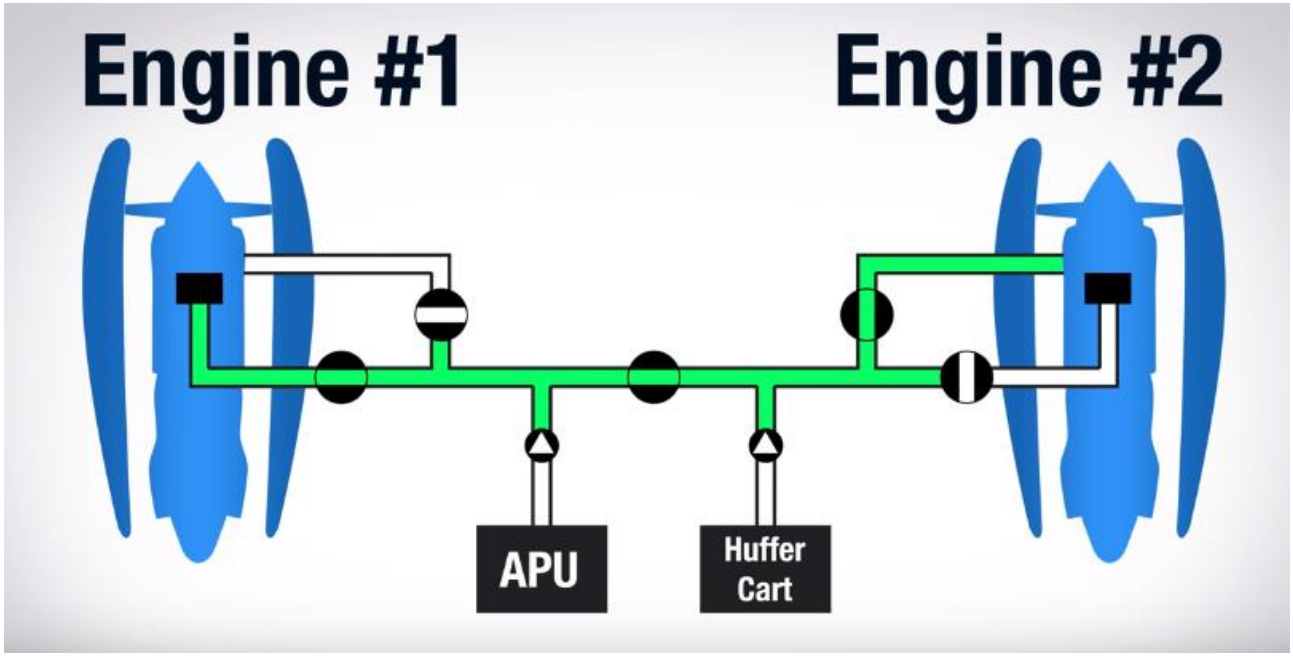
There is, of course, still a long check list of parameters to be verified before your take off. But what we did so far is just to start engines, and if you didn't activate any failure, x-plane takes care that your MD82 is ready to fly.

## 4.5 Cross starting

I don't know if "cross starting" is the correct way to call this technique, as usual advice and corrections are welcome.
We could start an engine with no APU and no ground power.
Let's imagine that, while flying, one engine stops. How to re-start the engine? Should we turn on again the APU to get power and bleed air? No need at all. The running engine will provide both power and bleed air.
Don't forget that each engine provides:

- Thrust to push the airplane fast enough to fly
- AC electrical power
- Bleed air for:
    - Other engine start
    - Air conditioning
    - Pneumatic devices
- Hydraulic pressure

I found a very interesting video on youtube, explaining many ways to start a jet engine.
Here the link: https://www.youtube.com/watch?v=GzhdxSsoT0g
There I found this image that explain how to start an engine using the other engine bleed air:




As you can see, we use engine #2 bleed air to start Engine #1.
Going back to our procedure:

- we start the left engine as we did at paragraph 4 page 6.
- We turn off the APU:
    - Start pump switch off
    - APU master switch off
    - APU L&R bus switch off
- Open both left and right engine bleed air valves
- Verify that APU bleed air switch is on the ON position
- Push the running engine throttle handle to reach 80% N2, so that the running engine will provide enough bleed air to start the sleeping one.

- Open right engine start switch safeguard
- Move right engine start switch to ON and keep it in this position
- Wait for N2 > 20%
- Open right fuel handle
- Verify that N1>20%, N2>60%, EGT>350°C

# 5 External power / air

Airplanes could even start their engines without using the APU that wastes valuable fuel.
Usually airports could supply both electrical power and compressed air when airplanes are parked.
The GPU (Ground Power Unit) supplies electrical power, while the ASU (Air Starter Unit) supplies compressed air.

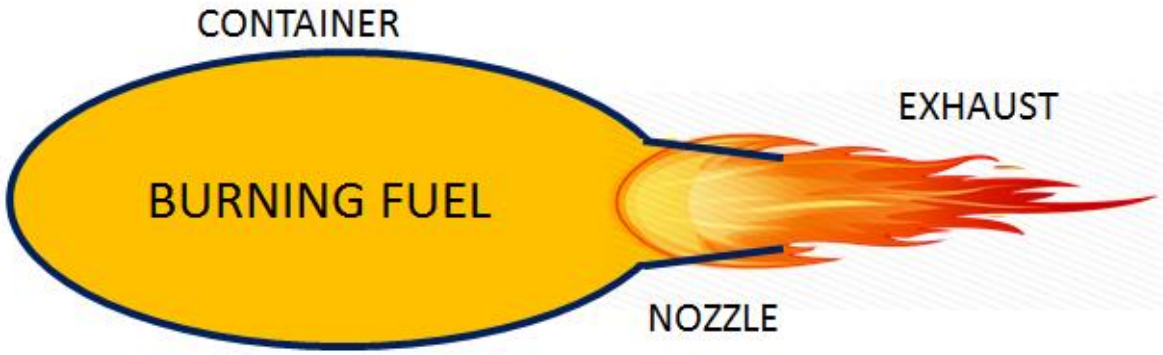

In the left image you can see the GPU connection wires, in the right side you can see the Air Starter Unit.
The usage of the GPU and ASU is quite expensive, that's why some carriers often ask pilots to start engines using the APU.
On the other side the APU burns fuel and makes noise.


Unfortunately the default x-plane MD-82 can't simulate the ASU. You can just connect your plane to the GPU, just to have some electrical power when APU and engines are OFF, but there is no way to start your engines by using ground compressed air.

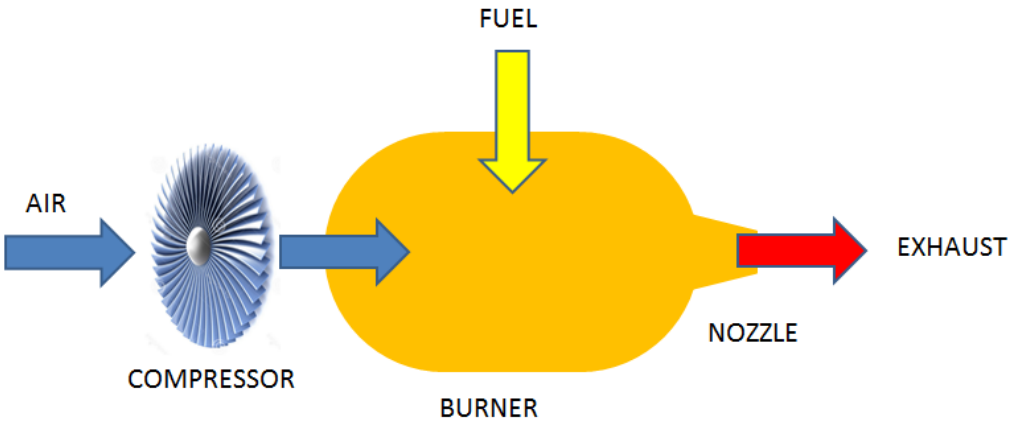
By the way, the MD-80 family is known for its poor air conditioning system while powered by the APU, that's why you could see, on real parked planes, the yellow pipe that supplies air conditioned.

# 6 A bit of theory

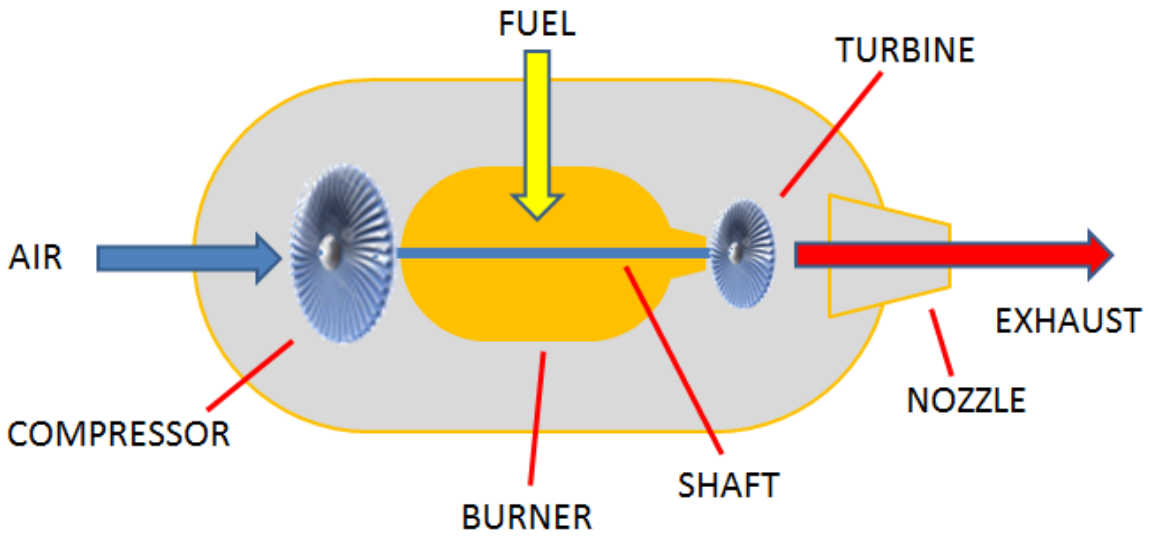
Now that you know how to start the engine, a bit of theory could help you to understand what you do and how it works. Our MD-82 is pushed by two Pratt & Whitney JT8D-217A/C turbofan engines.
Let's understand how a jet engine works.
First of all you've FUEL.
When you burn fuel, you get exhaust gas.
Put fuel into a container and let it burn. Exhaust gas will generate high pressure. Put a nozzle at one end of the container, and exhaust gas will escape from the container where the burning fuel is, generating a thrust.




But fuel by itself doesn't generate so much thrust. Experience says that it works much better if you mix fuel and high pressure air.
Put a fan that pushes air into the container, mix fuel and burn. On the nozzle side you'll have much more pressure and much more thrust.

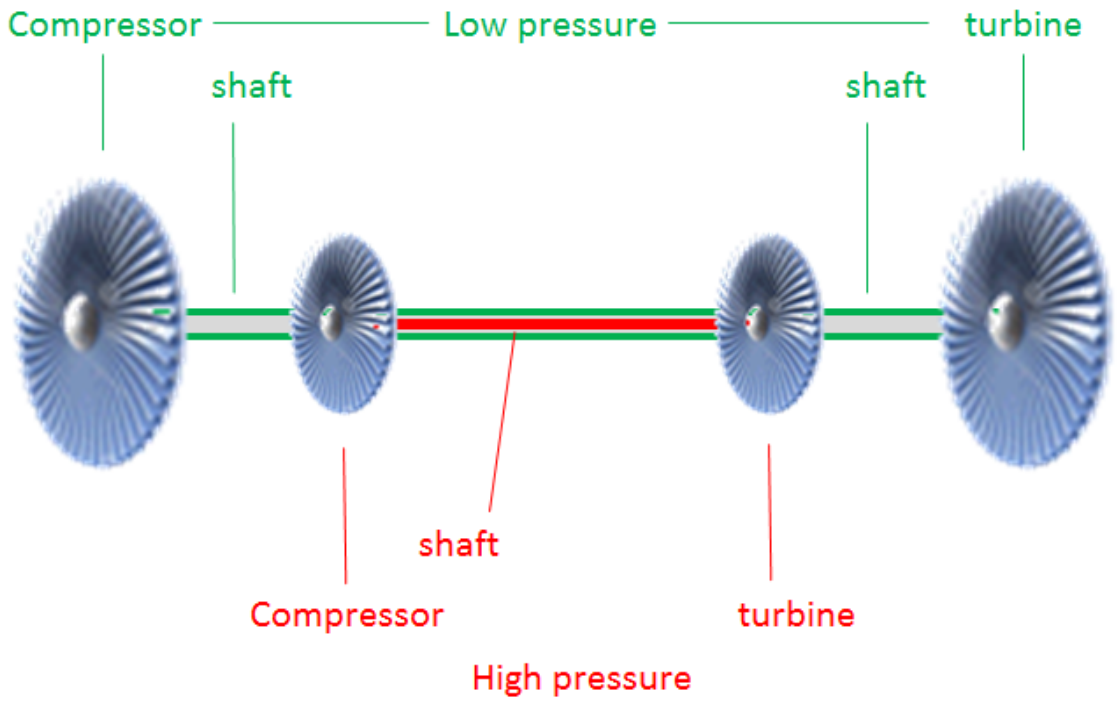


But who will provide energy for the compressor blades to rotate? We could use a little amount of the exhaust energy to spin the compressor. Let's put a turbine between the burner and the nozzle. The exhaust gas will spin the turbine. The turbine rotation, by the means of a shaft, will spin the compressor.

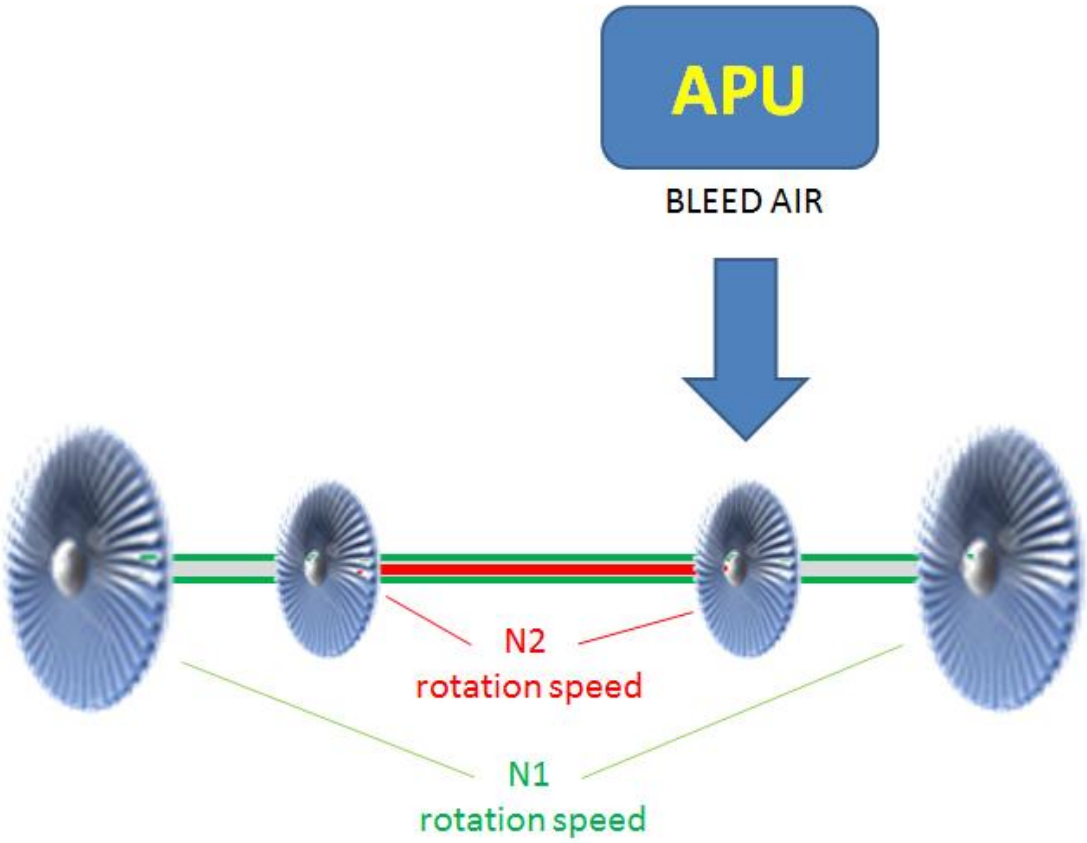



After spinning the turbine, the exhaust gas will still have enough energy to push the engine and the airplane at the requested speed.

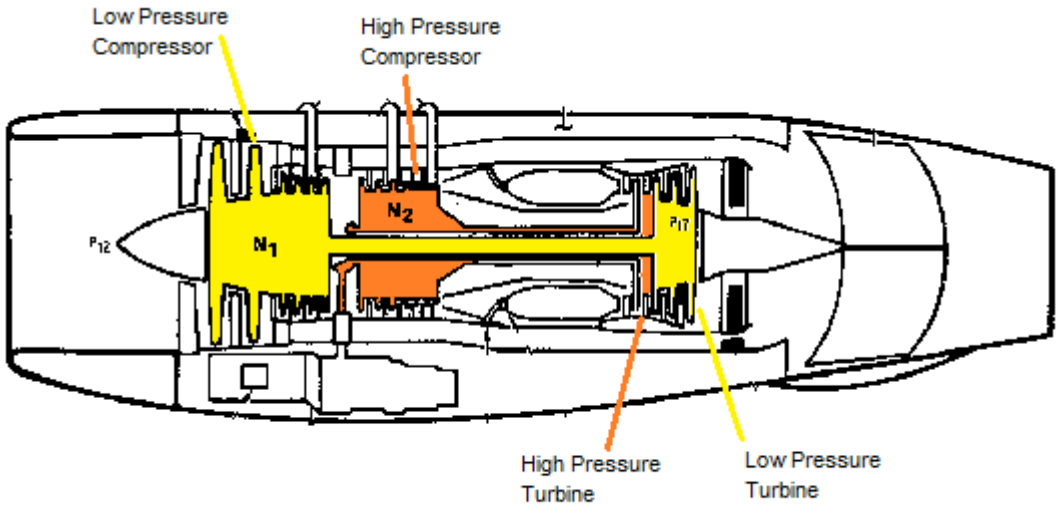
Let's just add that on our JT8D engine there are two compressors connected with two turbines and a double shaft. The high pressure turbine drives the high pressure compressor by the means of the high pressure shaft (red side) while the low pressure turbine drives the low pressure compressor by the means of the low pressure shaft (green side).

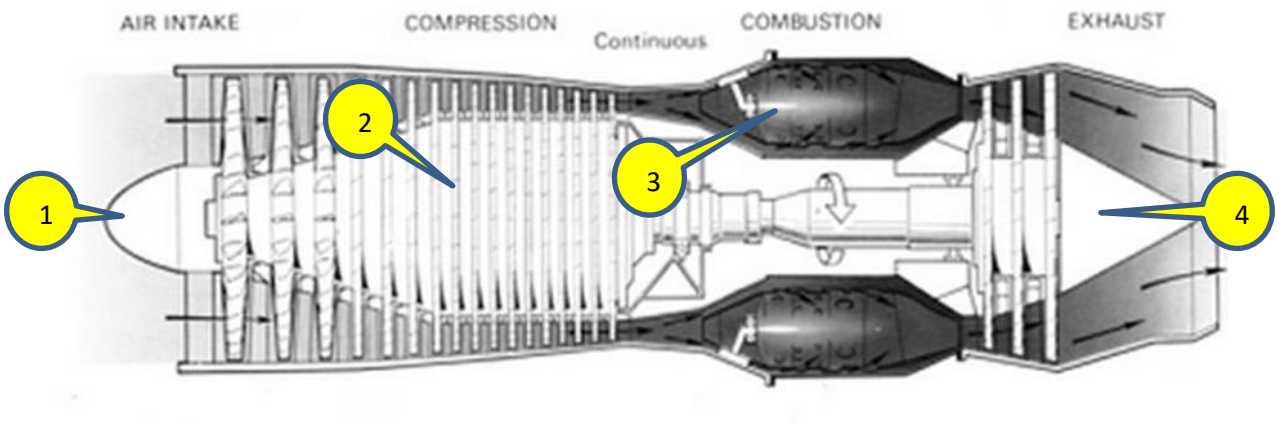



When we start the engine, we blow compressed (bleed) air from the APU directly into the high pressure section turbine:



When the high pressure section (turbine & compressor) rotation speed (N2) is fast enough, we open the fuel valve and power the ignition system, so that the combustion will start and continue, sustained by the compressed air. The exhaust gas will then rotate the low pressure section (turbine & compressor) that will then gain speed (N1) reaching its standard idle value (near 20%).



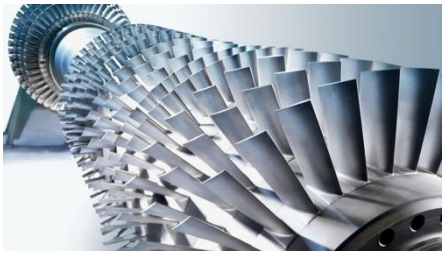



A turbofan engine works more or less like the piston engine of your car, following the four strokes schema:

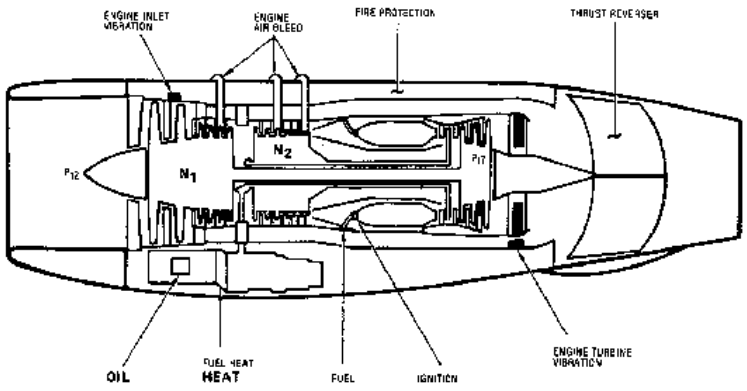
1. Intake: the air comes in at the air intake stage
2. Compression: the air gets compressed by the compression section.
3. Combustion: fuel is added to the hot compressed air. The air/fuel mixture burns, producing a great quantity of hot gas
4. Exhaust: the hot gas, passing through the turbine stage, produces the power to drive the compressor stage (see stroke 2). Then the hot exhaust gas, getting out of the nozzle, gives the thrust that pushes the airplane.

The main difference between your car engine and a JT8d turbofan is that the four "strokes" happen in a continuous way, while in the piston engine they happen in different subsequent phases.

Compressors and turbines are just like a fan, but there are a lot of subsequent stages. On compressors, each stage pushes the air a bit more, to the next stage that will push even more and son on. The compressor has to be driven by some kind of engine that gives the energy.



The turbine acts in a reverse way: hot exhaust gas, coming from the combustion chamber, pushes the blades. As we saw above, just after the combustion chamber the gas will have a great pressure that will be enough to spin turbines and to give the thrust to push the airplane.



# 7 Web resources

Video tutorials and printed matter are, on my opinion, complementary. I like them both.
If you prefer video tutorials, youtube is an endless source of tutorials.

- Starting MD82 engines (FS9): https://youtu.be/70la_IADYCM
- MD 82 APU starting: https://youtu.be/h90n4u7VknA . This is done on MD82 add-on by ATS that can be found here: http://ats-simulations.com/products/view/md82
- Starting Mad Dog engines: https://youtu.be/w7aXhFZeQNw

There are, of course, many more of them. Just go on youtube and start a search on MD82 engine starting, or click here: https://www.youtube.com/results?search_query=md+82+starting

If you want more information about the P&W JT8D engine, I found an interesting slide show here: https://www.slideshare.net/RicardoCcoyureTito1/jt8-engine-1

If you want to see a PT8D engine running, look here:
https://youtu.be/PvZDIkBJp8k

And, at last, if you really want to understand how the PT8D engine is made and works, this is a wonderful video: https://youtu.be/TeplZ7Iht9Y

These are just a starting point. From here on, you can walk on your own feet.

# 8 Conclusion

This tutorial is just the first one of a series about using MD 82 with x-plane (v11). I used the English language because we all know that this is somehow the “official language” of the flying world. Unfortunately my ability with this language is not so good, because I never studied it at school time. That’s why every correction and advice will be welcome.

I’m sure that real MD-82 pilots will find lot of mistakes. Please let me know about them, and I’ll do my best to correct this tutorial.

Please, email me at flightdream@salrandazzo.it or leave a comment on my website www.salrandazzo.it/fd

Look at my website www.salrandazzo.it/fd for updates.

# 9 Release history

V 0.00 20-may-2017
Original document.

V 1.01 21-may-2017
Added engine cross start
Added summary and title numbering
Added “web resources” section

V 1.02 21-may-2017
TOC (Table of content) is now navigable (thanks to **Jack Johnson)**
Footer has a link to the TOC.

V 1.03 22-may-2017
Added “External Power/air” section.