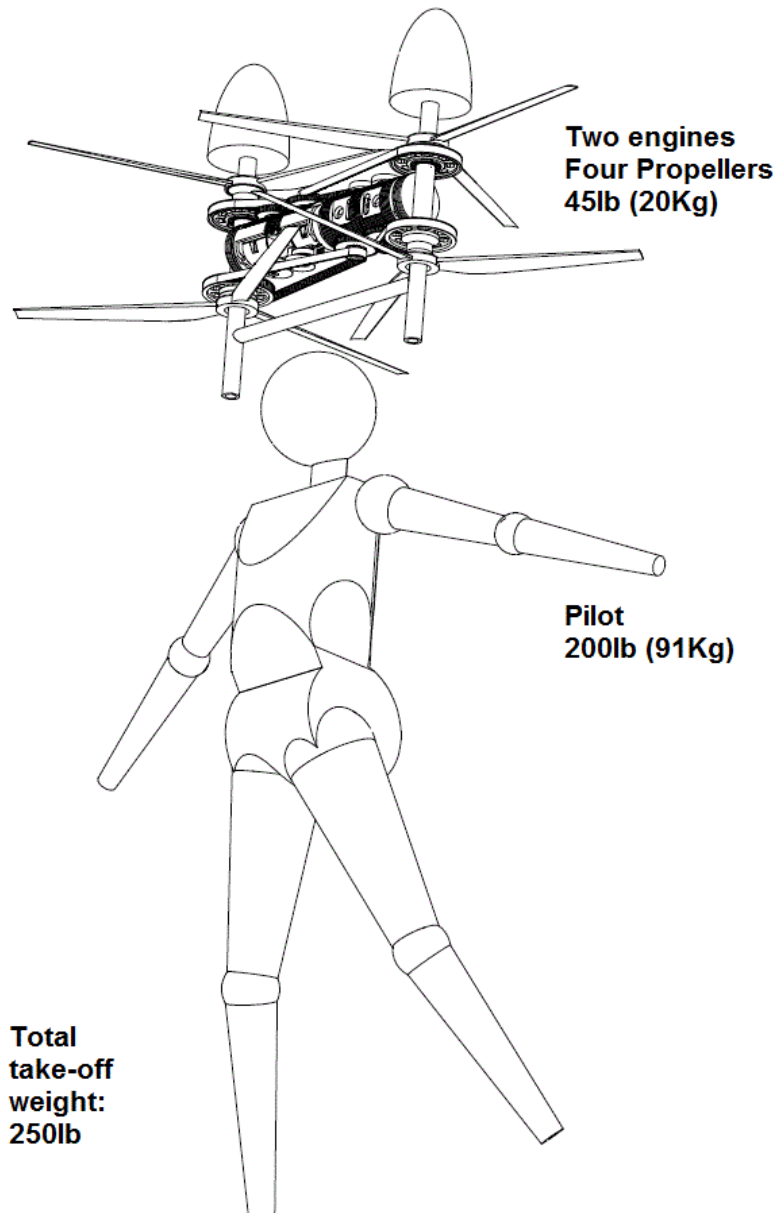


## PORTABLE FLYER

### ARCHITECTURE AND BASIC DESIGN CHARACTERISTICS

The PORTABLE FLYER comprises two OPRE Tilting Engines secured to each other to form (with their casings) the personal flying device's "backbone".



The one engine drives two counter-rotating propellers arranged above the backbone, the other engine drives two counter-rotating propellers arranged below the backbone.

The following presentation deliberately focuses on the engines because the PORTABLE FLYER is actually its engines. The goal is the development of a new kind of "passé partout" useful transportation means uncompromised on: safety, easy use, range, speed, mileage, emissions, ownership/running cost and portability (wearable).

At the ends of the backbone they are secured two “vertical” pipes whereon the propellers are rotatably mounted.

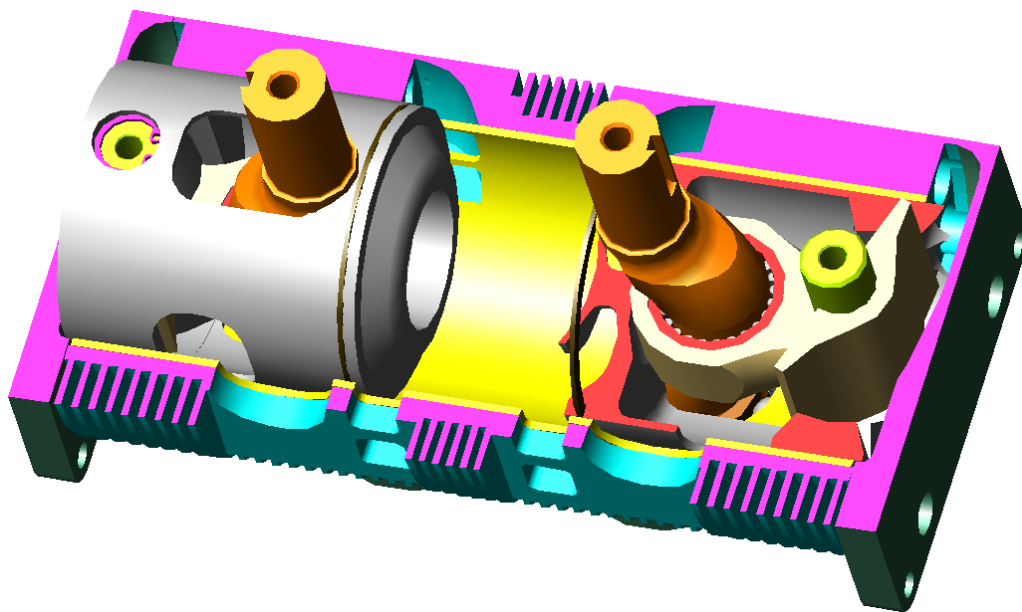
At the upper end of each pipe, a spinner (inside which is provided space for a parachute) is secured.

The lower ends of the pipes are secured on a “saddle” tighten to the shoulders / torso / back / armpits / suit of the pilot.

Through the pipes they pass the fuel, the control (gas cables, parachute trigger cables, signals from sensors, electric power if any, etc), the handling.

#### Each engine comprises:

- a casing (actually a strong pipe ~10” long and ~5” external diameter), with a cylinder liner formed into and along the casing; (securing the casings of the two engines “coaxially”, it is formed the backbone of the PORTABLE FLYER, which is actually an inflexible pipe of ~20” long, ~5” external diameter).
- a pair of opposed pistons sealing two sides of the same combustion chamber formed at the center of the casing;
- a pair of connecting rods, each connecting rod shaped (at its small end) into a tilting valve that controls the intake / transfer (gif video animation [http://www.pattakon.com/tilting/OPRE\\_Tilting\\_gif\\_video.gif](http://www.pattakon.com/tilting/OPRE_Tilting_gif_video.gif)); the “reverse” arrangement of the connecting rods (they are loaded in tension during combustion) extends substantially the piston dwell at the combustion dead center (more “constant volume” combustion) and transfers the thrust loads away from the hot/ported cylinder liner area;
- two counter-rotating crankshafts arranged at a small distance (~4” crankshaft axis to crankshaft axis) from each other, at zero phase difference from each other;
- a pair of synchronizing gearwheels (at operation they run unloaded).



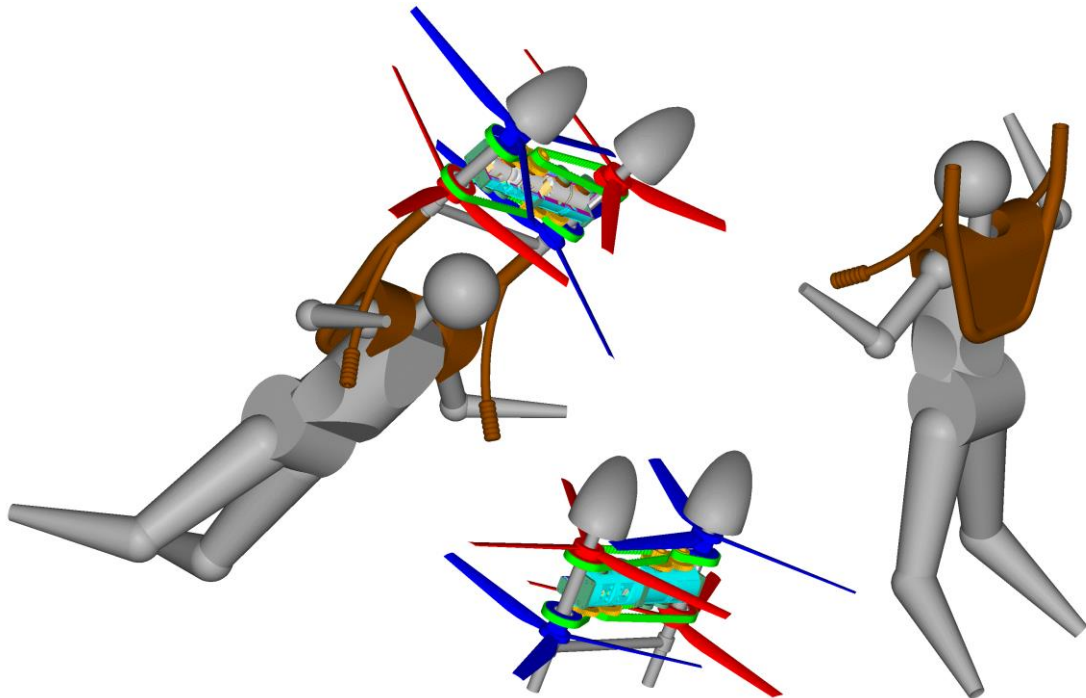
#### Propellers:

Each crankshaft, through a toothed belt and a pair of sprockets, drives a propeller at a transmission ratio (the number of the teeth of the sprockets is

selected to align the higher rpm of the crankshaft with the lower rpm of the propeller); the one toothed belt is longer than the other toothed belt;

**Saddle:**

At their lower ends the two hollowed pipes are secured on a saddle so that: the pilot to carry the PORTABLE FLYER while walking on the ground and to be carried by the PORTABLE FLYER when hovering or flying.



**Zero vibrations, zero gyroscopic rigidity, zero reaction torque:**

- The symmetry of the engine, the zero phase difference between the two synchronized and counter-rotating crankshafts, the common combustion chamber (same instant pressure on the piston crowns of the two opposed pistons, same (and opposite) instant torque on the two crankshafts), and the symmetrical load (two counter-rotating symmetrical propellers) rids the saddle (and the pilot) of all kinds and orders of vibrations (zero free inertia forces, zero free inertia moments, zero free inertia torques, and zero combustion vibrations of all kinds). This is an absolute requirement when a powerful high revving engine is to be tightened to the body of a person.
- The reaction torque is also permanently zero: no matter how wide the “throttle” is opened, or how abruptly the “throttle” opens or closes, there is no reaction torque (the only that happens is the increase or the decrease of the thrust force provided by the propellers).
- The symmetry and the counter-rotation of the propellers and of the crankshafts maintains the gyroscopic rigidity of the PORTABLE FLYER zero. Even when only the one engine is running (for instance due to a malfunction of the other engine), the gyroscopic rigidity is zero. Zero gyroscopic rigidity means that the pilot “instantly” and “effortlessly” can vector the engine/propellers (i.e. the thrust force) towards the desirable

direction, which is an absolute requirement for a safe, accurate and instantaneous control of the flight.

- Without zero inertia and combustion vibrations, without zero gyroscopic rigidity, and without zero reaction torque at the changes of the “throttle”, the control of the flight becomes slow, inaccurate, unsafe, uncomfortable and exhausting.

### **Unloaded synchronizing gearing**

The common instant pressure onto the crowns of the two opposed pistons of an engine, and the fully symmetrical load on the two crankshafts is eliminating the loading of (and the frictional losses in) the synchronizing gearwheels and is allowing their cooperation without lubrication if desired.

### **Two Independent power units**

Each engine driving its two counter-rotating propellers comprises a complete / independent / autonomous and perfectly balanced propulsion unit.

Each engine, alone, is capable (driving its two counter-rotating propellers) to power the PORTABLE FLYER.

This makes the safety of the PORTABLE FLYER during a vertical take off / landing better than the famous V-22 Osprey of Bell-Boeing wherein a malfunction of the transmission, or a broken / destroyed wing of the one rotor, equals to a crash. In comparison, a fallen apart propeller or a destroyed engine will not cause an accident or a crash of the PORTABLE FLYER, because the other engine-propeller-set can operate independently and is capable, alone, for a safe landing.

### **Parachutes**

Even in the case both engines of the PORTABLE FLYER fail (or run out of fuel), there is still the option of the parachutes into the (fixed on the frame pipes) spinners for a safe landing.

### **Counter-rotating and contra-rotating propellers**

The left upper and the left lower propellers compose a pair of “contra rotating” propellers (the one driven by the right engine, the other driven by the left engine, both rotatably mounted on the same pipe). The right propellers comprise another pair of “coaxial” contra-rotating propellers.

The two engines operate independently from each other and can run at different revs if desired (to optimize the overall thrust and mileage).

For instance, if the lower propellers are similar (same diameter, same pitch, same design etc) to the upper ones, the lower engine may run at different rpm to align its propellers with the different air stream they “see” as compared to the air stream the top propellers “see”.

The set of the four propellers can be regarded as two “contra rotating” sets of counter-rotating propellers.

A common characteristic of both, of the contra-rotating propellers and of the counter-rotating propellers, is the higher thrust to power ratio.

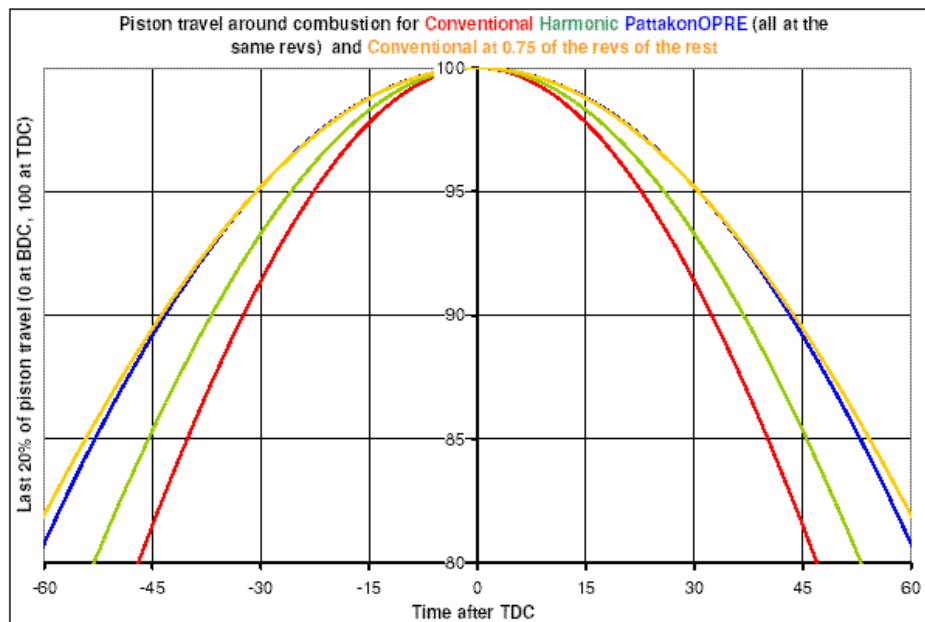
### **Central 2-Stage Ignition and Constant Volume Combustion**

A drawback of the conventional opposed piston engines is the location of the injectors and of the spark plugs: they are arranged away from the center of

the combustion chamber, and the combustion cannot start at (or expand from) the optimum location.

A characteristic of the OPRE Tilting 2-Stage-Ignition engines of the PORTABLE FLYER is the central two stage ignition: the piston crown and the cylinder head are shaped so that near the end of the compression, a secondary chamber is separated from the main chamber and undergoes a higher compression until the air-fuel mixture therein to auto-ignite (say, as in the compression ignition RC/model engines); a few crankshaft degrees before the TDC the secondary chamber starts communicating, through its transfer ports, with the primary combustion chamber (wherein the lean air-fuel mixture is compressed below the threshold for auto-ignition) triggering the spontaneous ignition of the charge in the main chamber.

With its extended piston dwell at the TDC (patented pulling-rod architecture, presented analytically at <http://www.pattakon.com/pattakonOPRE.htm> , <http://www.pattakon.com/pattakonOPRE2.htm> and <http://www.pattakon.com/pattakonPatOP.htm> wherein there are several video of prototypes running on Diesel fuel):



with its two stage ignition, and with its instantaneous (HCCI) combustion of the lean air-fuel mixture, the OPRE Tilting 2-Stage-Ignition has the required characteristics to achieve a **50% BTE** (Brake Thermal Efficiency), which means 22MJoule of mechanical energy per kilogram (2.2lb) of regular gasoline fuel burnt (63MJ of mechanical energy per US-gallon of regular gasoline).

### Comparison to a battery powered personal flying device

Considering: 50% BTE, 44lb (20Kg) total net weight of the PORTABLE FLYER, 5 US-gallons regular gasoline fuel (31lb, 14Kg) in the tank and a 44MJ/Kg (of regular gasoline) “fuel energy content”, the total weight (without the pilot) is 75lb (34Kg) at take off, and ~45lb, (~20Kg) at landing, and the mechanical energy that can be extracted from the fuel is 315MJ.

A high-tech modern set of batteries (having, say, an energy density of 500Wh/Kg = 1.8MJ/Kg) capable of providing the above calculated 315MJ of energy, weighs 385lb (175kg) at take off (the same at landing). Besides the batteries, they are required electric motors for the driving of propellers and a frame to hold everything (batteries, electric motors, pilot, etc).

The **EHANG184** (at <http://www.ehang.com/ehang184/specs/>) is an indicative example of such a battery powered personal flying device: 260Kg net weight, 100Kg payload, 100Km/h speed, 25 minutes autonomy and ~25miles (40Km) range.

Starting with the same energy content (315MJ), the total take-off weight (including the pilot) of the electric flyer is 2.5 to 3 times higher than that of the PORTABLE FLYER, which means it requires a few times more power to hover and fly (especially when the maximum dimension is limited and the noise penalty is high), **which means a many times smaller range**. The many times smaller range is a crucial disadvantage for the usefulness of the personal flying device and for the safety: even if the path (that the personal flying device is to follow) is full of battery recharging stations, to land and take off several times in order to go to a destination where the PORTABLE FLYER goes “non-stop”, is by itself very risky (the safest part of a flight seems to be the cruising). When there are not recharging stations (like when going to an island) the battery personal flyer is useless.

### **Brake Thermal Efficiency**

The 50% BTE may sound high, however: the Mercedes F1 engines, using the TJI system of Mahle (fast combustion using a pre-chamber and lean air-fuel mixture inside the main chamber), achieve a more than 50% Brake Thermal Efficiency (BTE), while the Mazda SkyActiv-X SP-CCI (HCCI) engines achieve a 20% higher mileage than the modern high-tech SkyActiv-G gasoline engines of Mazda (which are measured as the most efficient engines worldwide for 2016-2017). An explanatory technical video about the HCCI of Mazda is at <https://www.youtube.com/watch?v=a82Wt53gu78> wherein they are explained the advantages of the controlled HCCI lean combustion and its characteristics (the difference of the OPRE Tilting 2-Stage-Ignition HCCI from Mazda’s SP-CCI is the control over the HCCI combustion: in the one case (Mazda) the first stage of the 2-stage ignition is controlled by a spark plug that generates/controls an expanding fire-ball in a united combustion chamber, in the other case (OPRE Tilting 2-Stage-Ignition) the first stage of the 2-stage combustion is achieved by over-compression in the pre-chamber).

### **Engine reliability and simplicity**

The conventional gasoline aero-engines use, for safety reasons, two spark plugs per cylinder and two independent high voltage circuits. An OPRE Tilting 2-Stage-Ignition gasoline engine needs not a high voltage circuit. It actually needs not an electric circuit, at all (say, like the old compression-ignition engines (the Diesels) with the mechanical fuel injection).



And since the engine is to be run throttle-less on lean to very lean air-fuel mixtures, the fuel delivery system does not need be accurate: either injected or carbureted the engine will run OK (like the Diesels), which is another characteristic improving the reliability (and, at the end, the safety).

### **Cooling, simplicity, reliability and emissions**

In a controlled HCCI combustion (also characterized as “low temperature combustion” / “flame-less combustion”) the peak temperature in the combustion chamber is substantially lower than in the conventional spark-ignition progressive-combustion gasoline engines and in the conventional compression-ignition Diesel engines.

The higher BTE reduces the CO<sub>2</sub> footprint.

The homogeneous mixture and the substantially lower peak temperatures during the combustion not only enable the substantial reduction of the emitted NO<sub>x</sub> pollutants and the substantial reduction of the emitted particulates pollutants, but they also reduce substantially the required cooling.

With the combustion chambers of the two OPRE Tilting 2-Stage-Ignition engines disposed just under and above the propellers, in areas wherein the downwash stream is stronger than enough, the air-cooling appears the best choice (the liquid cooling is an option, but it adds weight, complication, and unreliability: the fewer the parts, the better the reliability).

## **DETAILED DESCRIPTION**

### **ENGINE**

Two OPRE Tilting 2-Stage-Ignition engines, each having 350cc (21.5 cubic inches) capacity (86mm (3.9”) bore, 30mm (1.18”) piston stroke, 30+30=60mm (2.36”) combined stroke).

The “OPRE” stands for Opposed piston Pulling Rod Engine while the “Tilting” refers to a valve secured on the small end of the connecting rod; the tilting valve controls the intake and the transfer (no need for reed valves or rotary valves). Animations at [http://www.pattakon.com/PatBam/PatBam\\_Tilting\\_3.gif](http://www.pattakon.com/PatBam/PatBam_Tilting_3.gif) and [http://www.pattakon.com/PatBam/PatBam\\_Tilting\\_4.gif](http://www.pattakon.com/PatBam/PatBam_Tilting_4.gif) . Details and “proof of concept prototype” at: <http://www.pattakon.com/pattakonTilting.htm> . Each “crankcase” (actually the space underside the piston crown, inside the piston) runs not-pressurized.

The thrust loads are taken at the cold ends of the engine, away from port openings.

The synchronizing gearwheels between the two crankshafts run unloaded and serve as balance webs, too.

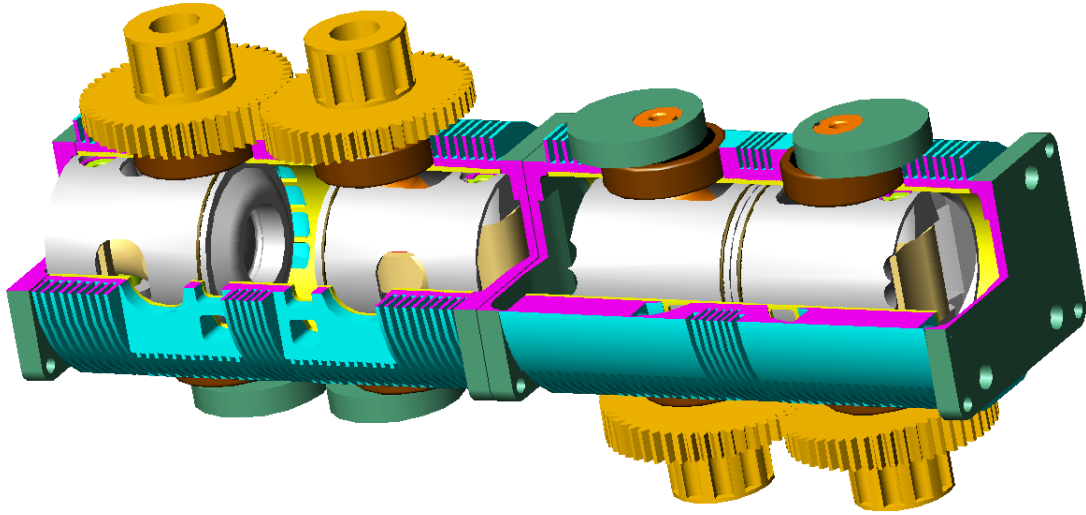
Each engine, alone, is perfectly vibration free, and is driving its own pair of counter-rotating propellers (zero gyroscopic rigidity).

The short piston stroke (30mm) allows high revs at low mean piston speed (reliability).

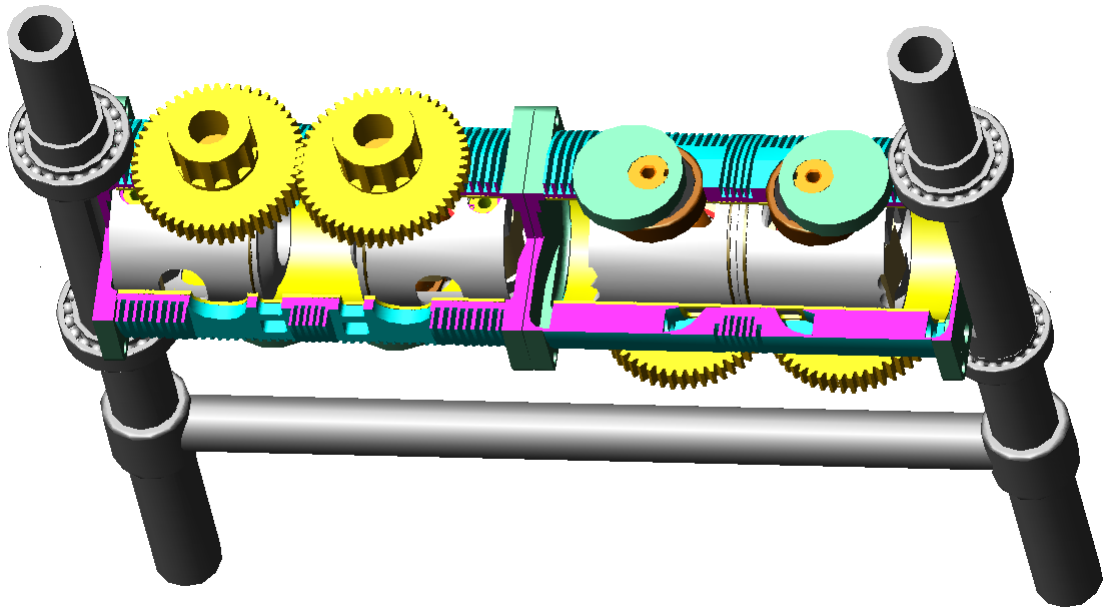
With HCCI (i.e. spontaneous) combustion into a compact bowl, the over-square design is fine; the combined stroke is 30+30=60mm; with 86mm bore, the design is by far less over-square than the famous Ducati Panigale 1299 (60.8mm stroke, 116mm bore). An electric circuit is optional.

The pulling rod architecture increases substantially (~40%) the piston dwell at the combustion dead center enabling more “constant volume combustion”.

The single-piece “pipe-like” casing improves the stiffness, the lightweight, the simplicity and the low cost.  
The two OPRE Tilting engines are bolted to each other and form a strong “backbone”.



At the ends of the backbone they are secured two pipes:



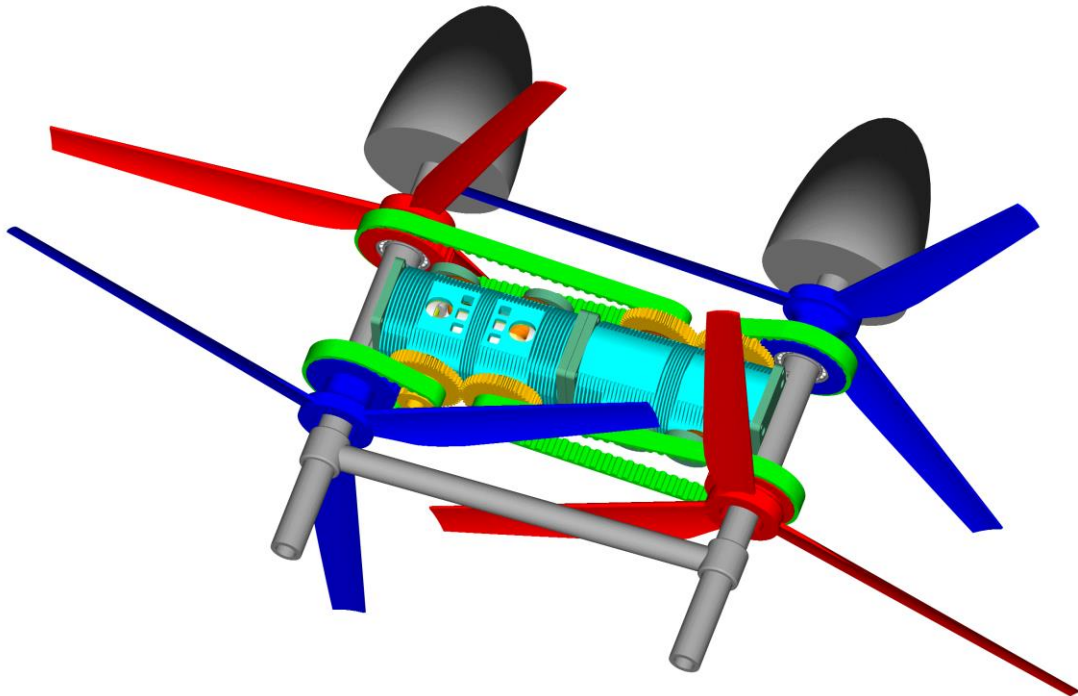
whereon two pairs of intermeshing propellers are rotatably mounted, with the one pair of propellers arranged above the backbone, and with the other pair of propellers arranged underside the backbone.  
The (holed) pipes provide passageways through which they pass the fuel and the control.

At the top of the pipes they are secured two (stationary) spinners wherein parachutes can be stored.

Each engine has two crankshafts with a pair of gearwheels synchronizing them (at operation the gearwheels run unloaded).



Each crankshaft is driving, through a toothed belt and a pair of sprockets, its respective propeller. The reduction ratio from the crankshaft to the propellers enables the optimization of the revs of the propellers and the optimization of the revs of the engines.



In case the one engine fails, or some propellers fall apart, or . . . the other engine with its propellers allows a safe landing.  
I.e. there are two independent propulsion units (each comprising an engine and two intermeshed counter-rotating propellers), each of which, alone, being capable for emergency landing.

This is a good step in safety, making this cheap PORTABLE FLYER safer, in some cases, than the OSPREY V22 wherein a heavily damaged rotor, during a vertical take-off or landing, may prove catastrophic.

With the 2-Stage-Ignition system, the combustion starts at the very centre of the cylinder (inside the bowl of the one piston) and completes instantaneously (HCCI).

According Mazda, their SkyActiv-X HCCI achieves a 20% fuel consumption reduction as compared to their last high-tech SkyActiv-G models.

The 2-Stage-Ignition does the same (strict control over the HCCI combustion) but in a by far simpler / cheaper way (mechanical / geometrical control).

With substantially lower fuel consumption (HCCI) and significantly improved reliability (no spark plugs, no high voltage circuit) . . .

### **Size and weight**

With 3-blade propellers having 39" (991mm) diameter, and with 21" (533mm) distance from propeller axis to propeller axis, the "horizontal" maximum dimension of the PORTABLE FLYER is  $39''+21'' = 60'' = 5\text{ft}$ .

The **maximum dimension** is **5ft 3in** (1,600mm).

The compact design is important especially when flying in adverse weather conditions (sudden wind gusts etc).

However, for a flying device more important than the small dimensions is the small weight.

Every oz, every gram of additional weight requires additional power and additional fuel and makes the control of the flight more difficult, the landing more risky and dangerous, and the noise louder.

And because weight cannot be removed from the pilot body, the only weight that can be removed is from the power unit and from the fuel (by using a more lightweight power unit and, more importantly, a more fuel efficient power unit).

The net weight of the PORTABLE FLYER (without the pilot and without fuel) is ~45lb (200N, 20kp) and this weight is for conventional materials (aluminum, steel and regular gasoline) like those used in the “proof of concept” OPRE Tilting prototype presented at <http://www.pattakon.com/pattakonTilting.htm> :

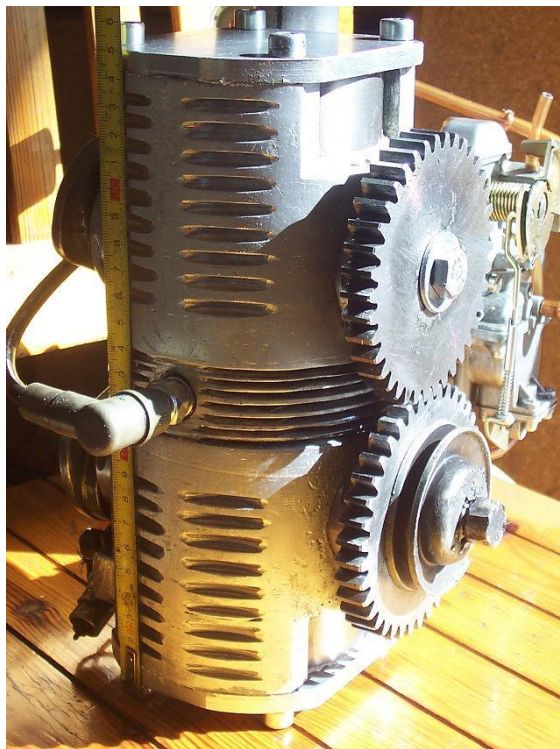
capacity: 333 cc,

bore: 84mm,

stroke: 30+30=60mm

weight: 8.5Kp (19lb) without the exhaust pipe and the carburetor

height: 250mm



By increasing the bore from 84mm to 86mm, the capacity goes to 350cc and the weight remains substantially the same. Two such engines secured “back to back” (collinear cylinder axes) form the backbone of the PORTABLE FLYER.

With high-tech lightweight materials (like carbon fibers, titanium, magnesium etc) the weight can reduce to less than 30lb (13.5Kg). The small weight and the compact dimensions make the PORTABLE FLYER true portable and easy to be carried on the shoulders of the walking or running or jumping pilot.

The pilot actually wears the PORTABLE FLYER like wearing a 45lb travelling backpack. The PORTABLE FLYER is not just portable, it is “wearable”.

Quote from the Internet:

*“Courtesy of U.S. Army Spc.: Soldiers and Marines in Iraq and Afghanistan routinely carry between 60 and 100 pounds of gear including body armor, weapons and batteries.”*

## Noise

The estimated noise level (50ft away) is 70 dBA during the take off and the landing. The estimation for the noise level is justified by:

- the low tip speed of the propellers (~45% of the sound velocity),
- the silent tilting valves that eliminate the noisy / impacting reed valves.
- the lean burn which reduces the pressure at the opening of the exhaust ports (the higher thermal efficiency of the instantaneous combustion leaves less energy to the exhaust gas; at take-off the two engines run at partial load, on lean air-fuel mixture),
- the minimization of the total weight (the most important, for the noise level, when the size is limited).

Note: as the load of the lean-burn throttle-less HCCI engine decreases, its BTE remains high (as in the Mazda SkyActiv-X HCCI and in the conventional Diesel engines); the opposite is the case for the stoichiometric throttled spark ignition gasoline engines wherein the lighter the load, the lower the BTE.

## FLYING AND CONTROL

### Quiet take-off

Limiting the tip speed (of the **39” diameter** propeller) at only 150m/sec (45% of sound velocity) for “quiet” take off, the resulting propeller rpm is 2,900rpm. With **28” pitch** and **3 blades per propeller**, the static thrust at 2,900rpm is calculated (with the [http://www.godolloairport.hu/calc/strc\\_eng/index.htm](http://www.godolloairport.hu/calc/strc_eng/index.htm) propeller thrust calculator) at ~75lb (~35Kp, 350N), while the power absorbed by each propeller is calculated at ~15bhp.

At the “quiet” take off, the total upwards thrust is  $4 \times 75\text{lb} = 300\text{lb}$  (136Kp, 1360N); with a total weight of 250lb (114Kg, 1140N) this means ~0.3g upwards acceleration; the required power per engine is  $2 \times 15\text{bhp} = 30\text{bhp}$ . With 2.4:1 “crankshaft to propeller” reduction ratio, the 2,900rpm of the propellers at the above “quiet” take-off, translates into 7,000rpm for the engines.

In order a 21.5ci (350cc) 2-stroke engine to provide 30bhp at 7,000rpm, it needs to make 22 lb\*ft (30mN) of torque at 7,000rpm (this is 86mN/lt specific torque, which is easily attainable even for naturally aspirating 4-stroke engines; i.e. the engines run at partial load at take-off: the low tip speed, the partial load with lean burn and the lightweight is the recipe for low noise). After the take off, the engine rpm (and the propeller rpm) can increase to enable a high cruise speed (above 100mph (160Km/h)). The small tip speed keeps the noise low.

### Top Speed

At top speed (~100kts, 185Km/h) the propellers rev at 4,350rpm (propeller tip

speed 2/3 of the sound velocity), and the engines are running at 10,500rpm (i.e. 10.5m/sec mean piston speed, still low for improved long term reliability).

### **Safety**

In case of malfunction of the one engine, or in case one propeller hits an obstacle and falls apart, or in case a transmission tooth belt is broken, or . . . , the “healthy” engine-propellers-set is sufficient for a safe landing.

With the one only engine running at 9,000rpm (mean piston speed: 9m/sec) and driving its two 3-blade 39” diameter / 28” pitch propellers at 3750rpm (2.4:1 reduction):

the total thrust force is calculated at 250lb (115Kp),

the tip speed is 195m/sec (57% of the sound velocity),

the power required by the running engine is 65bhp (which means: 36.8 lb\*ft (50mN) of torque from 21.5ci (350cc) capacity, i.e. **142mN/lt** specific torque, which is attainable by a good 2-stroke: the 2-stroke Rotax 850 ETEC provides more than 20% more specific torque (**175mN/lt**).

### **Fast take-off (at emergency, or from distant / unpopulated areas etc)**

With both engines running at 9,000rpm, the upwards acceleration at a “fast take off” is more than 1g (10m/sec<sup>2</sup>); it is like “falling towards the sky”.

Alternatively: the PORTABLE FLYER can carry two persons (the pilot and a passenger); in this case at a malfunction of the one propulsion unit, the emergency landing is not possible without opening the parachutes.

### **Cruising / consumption / mileage**

With the pilot wearing a wing suit or a tracking suit,

at 100mph cruising speed (87kts / 160Km/h / 44.5m/sec) the required thrust is about 66lb (30Kp, 300N and the calculated power is 300N\*44.5m/sec = 13.5kW = 18bhp (data taken from the “First jet powered Birdman flight” at [http://www.dropzone.com/news/General/First\\_jet\\_powered\\_Birdman\\_flight\\_613.html](http://www.dropzone.com/news/General/First_jet_powered_Birdman_flight_613.html) )

At cruising the propellers rev at 3,750rpm (propeller tip speed 57% of the sound velocity), and the engines rev at 9,000rpm (mean piston speed: 9m/sec). With only 75% propeller efficiency, the total power required from the two engines is ~24bhp.

With the engines running at 50% BTE (attainable with HCCI combustion and very lean mixture), the fuel consumption (gasoline) at 100mph (160Km/h) cruising speed is calculated at 3.9lt/h (2.5l/100Km), and the mileage at 100mpg.

For a distance of 200miles (320Km), they are required 2 US-gallons (7.6lt, 12.5lb, 5.7Kg) of regular gasoline.

For a distance of 20miles (32Km), they are required 0.2 US-gallons (1.2lb).

Each engine has to be capable of providing, at 9,000rpm, the 65bhp required for an emergency landing (as previously described).

Compared to the 24bhp total power (12bhp per engine) required for cruising at 100mph, the engine(s) at cruising will operate at very light load (ultra lean air fuel mixture, lambda near 5).

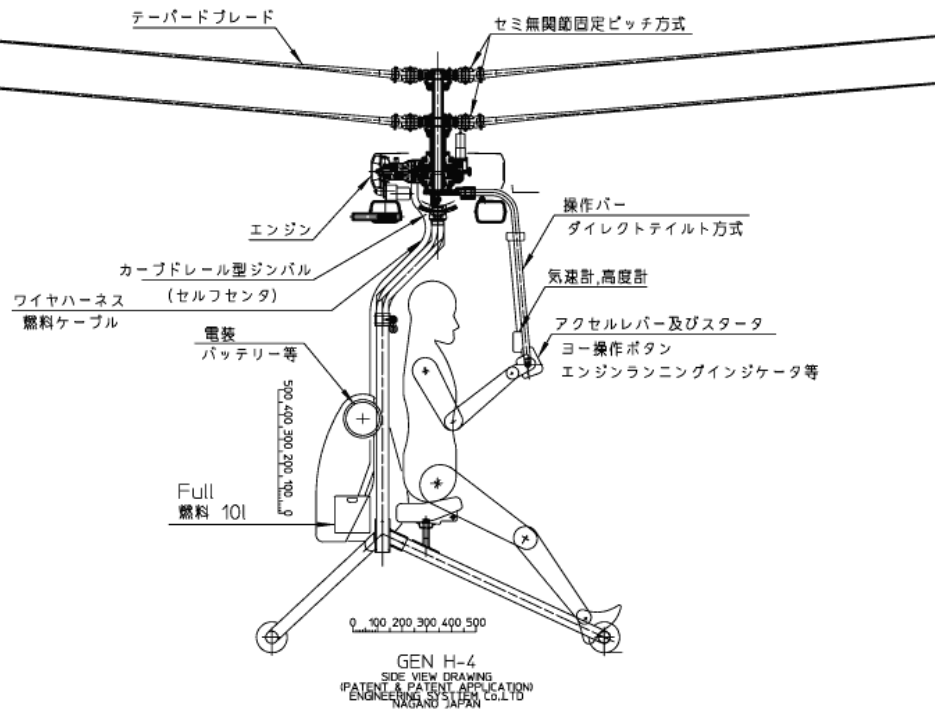
Note: as Mazda’s expert explains in the video for the SkyActiv-X, the BTE of their HCCI gasoline engine is maintained high (or even improves) at the partial loads (the opposite is the case for their conventional gasoline engines).



By combining the optimum efficiency of the propellers at cruising with the high BTE of the engines at the partial loads (very lean mixture) and with the low frictional losses of the 2-stroke engines, the overall efficiency maximizes.

### Take-off, landing, hovering and cruising

The stability and the controllability at vertical take-off, landing and hovering of the PORTABLE FLYER have no reason to be worse than in the GEN-H-4:



In the above GEN-H-4 the only control is the lever that displaces the center of gravity relative to the rotation axis of the two big (13ft / 4m diameter) contra-rotating rotors.

The PORTABLE FLYER looks like a symmetrical compact GEN-H-4, and can fly like the GEN-H-4: [http://www.pattakon.com/Fly\\_files/Hover\\_to\\_Cruise.gif](http://www.pattakon.com/Fly_files/Hover_to_Cruise.gif)

The PORTABLE FLYER can also be regarded as a personal / miniature OSPREY V-22 (with the fuselage being the body of the pilot).

**Like the OSPREY V22**, (which is actually an airplane that can also hover and take-off / land vertically), similarly the PORTABLE FLYER is an airplane (for horizontal high speed / high mileage flights) which is also capable for hovering, and vertical take-off / landing.

As the cruising speed of the PORTABLE FLYER increases, the aerodynamic drag displaces the pilot from the vertical pose to a more horizontal pose, reducing at the same time the frontal area and the drag coefficient.

With a Frontal Area of 0.5m<sup>2</sup> and an aerodynamic Drag Coefficient of 1.25 (typical values for a standing person), at 100mph (160Km/h) the drag force the “standing” pilot receives is, according the formula:

$DragForce = 0.5 * FrontalArea * AirDensity * VelocitySquare * DragCoefficient$ ,  
about equal to the weigh (~800N) of the pilot.

At a first approach this means that at 100mph, the long axis of the pilot will lean (depending on the suit the pilot wears) for some 45 degrees from vertical. The vertical component of the lift from the propellers equals to the weight, the horizontal component of the lift from the propellers partly balances the drag force and partly accelerates the PORTABLE FLYER forwards.

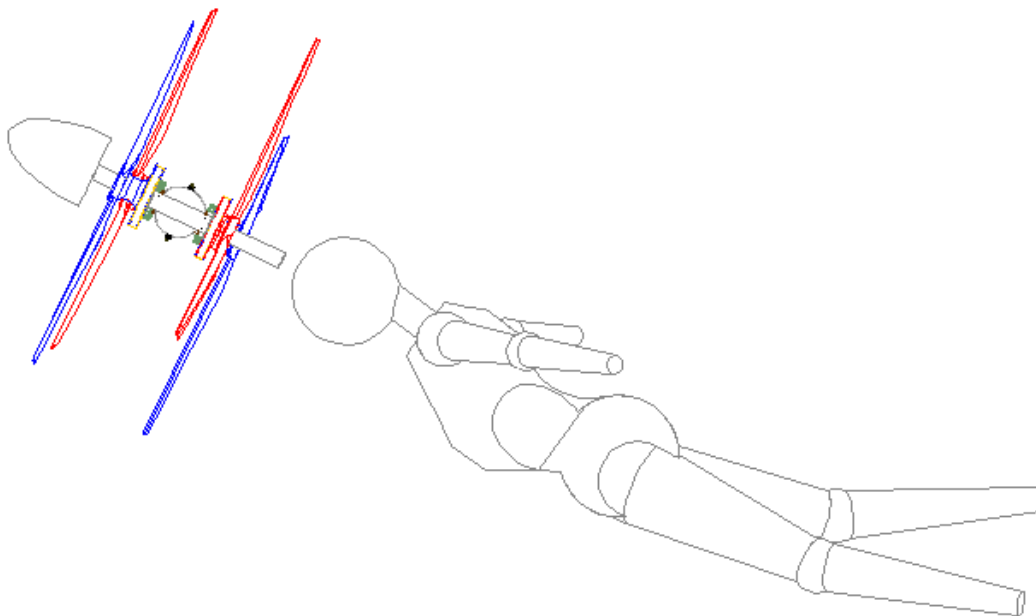
At a second approach the significant leaning reduces the frontal area and the drag coefficient as shown at:

[http://www.pattakon.com/Fly\\_files/Drag\\_Area\\_Human\\_Aerodynamics.png](http://www.pattakon.com/Fly_files/Drag_Area_Human_Aerodynamics.png) and [http://www.pattakon.com/Fly\\_files/Human\\_Drag\\_Various\\_Positions.png](http://www.pattakon.com/Fly_files/Human_Drag_Various_Positions.png) , which means that the actual leaning angle is larger.

The more horizontal the long axis of the pilot becomes, the higher the aerodynamic lift from his body (the ski jumpers, at "leaning" angles around 10 to 20 degrees, have a lift to drag ratio above 1.0 as the plot:

[http://www.pattakon.com/Fly\\_files/Lift\\_to\\_Drag\\_Human\\_Ski\\_Jump\\_Aerodynamics.png](http://www.pattakon.com/Fly_files/Lift_to_Drag_Human_Ski_Jump_Aerodynamics.png) shows).

Assuming that at 100mph (160Km/h) cruising speed the long axis of the pilot leans 60 degrees from the vertical axis, say like:



the frontal area is near half. Supposing the same drag coefficient as with the pilot standing (actually, the drag coefficient drops to less than half), the drag force reduces to half (~88lb, ~400N).

With a lift to drag ratio ~1.0, the lift equals to the drag, i.e. the lift takes half of the weight of the pilot. The rest half is taken by the vertical component of the propellers thrust.

If the pilot keeps the axes of the propellers at 45 degrees from vertical, then the PORTABLE FLYER will continue at the same speed and altitude.

If the pilot keeps the axes of the propellers parallel to his long axis (i.e. at 60 degrees from vertical) increasing the load in order to not lose height, some 66lb (300N) force accelerates the PORTABLE FLYER forwards. The increase of the cruising speed will cause a more horizontal pose for the pilot, and so on, until the top speed.



The above approach shows the importance of the pose of the pilot at cruising and at the high speeds: with the pilot near horizontal, the PORTABLE FLYER is like an airplane wherein the body of the pilot is the fuselage and the wing; the result is a high mileage, a big range and a tireless / pleasant flight.

### **Safety and high speed**

Having two independent propulsion units (each alone capable for emergency landings),

having also two parachutes (for just in case, say when it runs out of fuel), the safety is improved.

Flying in adverse conditions, like sudden weather change, gusts of wind, rain etc is a big risk in case of underpowered flying devices having large surfaces exposed to the wind.

The ability for high speed flights is mandatory for the safety; at windy weather a big size / slow moving (“hovering”) flying device is a “feather in the wind”.

A personal flying device having 30 kts maximum speed and flying along a sea shore, has a big safety risk when the wind starts blowing towards the sea at, say, 35kts.

Because every flying object is at the mercy of any gust of the wind, the most important characteristics for safety seem to be: the small frontal area, the small drag coefficient, the high power to weight ratio, and the ratio of the power to the product of the frontal area times the drag coefficient.

The human body is very well streamlined when hovering vertically and when cruising near horizontal.

If the PORTABLE FLYER can fly way faster than the wind, the strong wind and the strong wind gusts are not a problem any longer.

### **Lower weight advantages, higher BTE advantages**

With its lightweight and fuel efficient engines (they count for about 20% of the total weight at take-off) and with its unconventional architecture (wherein everything that can be omitted is omitted: the brain of the pilot is the only control system, the senses of the pilot (eyes, ears, skin etc) are the only sensors, the body / muscles of the pilot are the only “servomechanisms”), the overall weight of the PORTABLE FLYER at take-off is minimized and the required fuel (and the CO2 emissions: well-to-propellers) for a specific range is minimized.

### **Tethered tests and training**

The top end of the hollowed pipes can be used for the tethered tests of the PORTABLE FLYER and for the initial training of the pilot (the PORTABLE FLYER can be hanged from a roof (or from a tree branch etc) by ropes tighten on the top ends of the hollowed pipes).

### **Control again**

When a child begins riding a bicycle, it progressively learns how to react properly to the signals from the eyes, the otoliths and the rest body (i.e. on how to keep the control).

Just like driving a bicycle, the eyes / otoliths / body / brain of the rider / pilot of a PORTABLE FLYER are the sensors and the control system: the rider soon

discovers the way to react properly and to keep the control. **Because the PORTABLE FLYER is a true neutral propulsion unit: neither vibrations, nor reaction torque, nor gyroscopic rigidity; only a force that can "instantly" and effortlessly be vectored towards the desirable direction.**

In a PORTABLE FLYER it is better to be used the body of the pilot as the main sensing and controlling equipment (birds like), than developing and paying and carrying stabilizing and flight management systems.

The birds, the bats and the bugs fly because their bodies can provide adequate power for their weight. The power provided by a man's body is not adequate to lift its weight.

What a person needs, in order to fly, is neither a vehicle, nor sensors, nor servomechanisms, nor control units, nor transmission shafts, nor differentials, nor gear-boxes, not even a seat.

What a person does need, in order to fly, is **power** provided in a true neutral and manageable way. The **body** is: the vehicle and the sensors and the control unit and the servomechanisms and the landing system, just like the bodies of the birds, bats and bugs.

With a PORTABLE FLYER secured / saddled onto his shoulders / torso, a person can fly like a bird.

According several articles and videos published in the Internet, **Yves Rossy / Jetman** already "flies with the grace of an eagle, and the subtle body movements he uses to maintain flight - and perform his loops, rolls, and other maneuvers - mimics a bird of prey".

With only an altimeter and timer, Rossy uses his skin and ears as airspeed indicators.

**"You feel very well, you feel the pressure,"** Rossy says, **"you just have to wake up these senses. Inside an airplane we delegate that to instruments. So we are not awake with our body."** (in the following youtube video Rossy is shown controlling by his body, like an eagle, his flight over Dubai: <https://www.youtube.com/watch?v=Czy0pXRRZcs> )

The **"Zapata Flyboard Air"** presented at <https://zapata.com/air-products/flyboardair> (powered by jet turbines as Rossy's Delta Wing) is a true VTOL, it is also an excellently controlled personal flying device.

According the information provided at the FAQ of the above web site: its weight is 20Kg (44lb) plus the fuel, its flight duration is between 6 and 10 minutes, its range is 8Km (=5miles), its consumption is 5 US-gallons per flight (i.e. per 5 miles) which means a mileage of 1mpg.

What it lacks is a fuel efficient and "low carbon footprint" propulsion unit. It's dry weight is the same with that of the PORTABLE FLYER, but it needs some 100 times more fuel for the same range (100mpg mileage calculated for the PORTABLE FLYER versus 1mpg mileage for the Zapata Flyboard Air).

Another quite relevant demonstration is the youtube video at <https://www.youtube.com/watch?v=y1CVZ-lr260> wherein a **GEN-H-4** ultra-light helicopter having two contra-rotating-fixed-pitch-rotors is perfectly controlled by the pilot pure-mechanically (the pilot displaces the center of gravity relative to the rotation axis of the two rotors).

The stability of the above GEN-H-4 Flyer at the fast take-off (14" to 18" of the video) is remarkable.

At hovering some 30ft / 10m above the ground, the stability is excellent; this excellent stability is achieved without any noticeable effort from the pilot: From 1:02 to 1:15 of the video the pilot of the GEN-H-4 looks around calmly, as if he is seating in a chair in the veranda of his 4th floor apartment. He seems so relaxed that if he had a newspaper with him, he would read the news, too.

For comparison, in the <https://www.youtube.com/watch?v=ey5gPKRWbmU> youtube video it is shown the vertical take off and the vertical landing of the high-tech, no budget, **OSPREY V22** of Bell Boeing. The variable pitch rotors and the numerous electronic control systems cannot hide the stability issues (from 7" to 17" (take off) and then from 1':05" to 1':25" (landing)).

It reminds a fat cow trying to break-dance.

The oscillations of the OSPREY V22 are not harmless. The catastrophe shown in the <https://www.youtube.com/watch?v=zwZZmXgga2U> video is the outcome of over-corrected oscillations about the long axis of the OSPREY. The simple mechanical control of the GEN-H-4 (i.e. the displacement of a lever) and the human brain (the control unit) appear far superior and safer.

Another quite relevant video that shows how precisely the skydivers can control their fall (flight) is at <https://www.youtube.com/watch?v=nSi5HaJw3r4> . The weight of the skydiver is its only propulsion unit; by changing his/her body pose, the skydiver literally dances in the air.

The heavy disk loading (thrust to disk area) of the PORTABLE FLYER (similar to that of the OSPREY V22) causes a high downwash velocity, with the pilot inside it.

Either at take off / landing, or at hovering, or at cruising (low / medium / high speeds), pilot's limbs and head are in a high velocity air stream, which allows the control over the flight in a way similar to the way the skydivers control their flight / fall.

The PORTABLE FLYER besides the "weight displacement CONTROL" of the **GEN-H-4** (mentioned previously), has also the "aerodynamic CONTROL" of **Yves Rossy** (Jetman, also mentioned previously). Quote from:

<https://www.thenational.ae/uae/jetman-happy-to-call-the-uae-home-1.62201> :

"Arching his body "like a banana" from head to toe allows him to fly horizontally; subtle movements from left to right will change his flying direction.

**"I am the fuselage, and the steering controls are my hands, head and legs,"** Mr Rossy said.

Similarly, the body of the pilot of the PORTABLE FLYER is the fuselage, and the steering controls are pilot's hands, head and legs.

The PORTABLE FLYER can be displaced, relative to the body of the pilot, either by the shoulders / torso / back / spine of the pilot, or by pilot's hands pulling / pushing some handlebars. It is significant, at emergencies etc, the pilot to be able to control the PORTABLE FLYER keeping his hands free.

From the above references it is evident that the human brain and the human senses / body are adequate (just like the brain, body and senses of the birds,

bugs and bats) for safe controlled flights. The problem is that the human body is not adequately strong to provide the required power for the flight. What a human needs in order to fly is plenty of power provided, if possible, in a completely neutral way.

**This is what the PORTABLE FLYER is: it is like an extension of the human body and it is providing the required power in a true neutral way. The brain, the senses and the muscles do the rest.**

## **SUMMARY**

In the double-propulsion-unit OPRE Tilting PORTABLE FLYER presented above, nothing appears near or beyond the current state of the art limits. Lightweight carbon-fiber propellers of various designs and sizes are available in the market at low prices.

Toothed belts are common place for power transmission / revs reduction. The structure of the PORTABLE FLYER utilizes the engine casings as its backbone.

The perfect vibration free (including both, inertia vibrations and power pulses vibrations) is a requirement when a powerful engine is to be directly supported / secured on the body of the pilot/rider; otherwise a long (say of one or two hours) flight would be a torture.

The counter-rotating propellers eliminate the gyroscopic rigidity and allow the pilot/rider to vector the thrust immediately and effortlessly to the desired direction.

Every oz or gram of mass that can be omitted from a personal flyer, must be omitted. The more the mass of the flyer, the more fuel is required for a specific range and the more challenging the take-off / landing becomes.

The peroxide JetPacks consume some 30Kg of "fuel" in half a minute.

The jet powered personal flyers (Yves Rossi like, Zapata like etc) consume their fuel in less than ten minutes (BTE less than too small).

The electrical personal flyers are based on batteries; and the existing batteries have an energy density several times lower than the fossil fuels (gasoline, kerosene, Diesel etc). The energy density of the power source is more than important for a flying device.

**The body, the eyes and the senses of the pilot/rider are available; why not to use them as the fuselage, the sensors and the control system?**

Isn't this what the birds are doing?

Relative to the birds, the low power to weight ratio of the human body is the only thing that restricts us from flying / hovering.

This lack of power is what the OPRE Tilting engines and the propellers are curing at a true "neutral" and efficient way.

Among the advantages of the PORTABLE FLYER:

Improved Safety; Lightweight, Compact, Quiet, Powerful and Fuel Efficient; Reliable (simple, small number of parts, etc); True VTOL (as the GEN-H-4); Long Range and Fast (as the OSPREY in airplane mode); No need for Control other than the Brain and the BODY of the Pilot (just like the birds, bats and bugs); Vibration Free, Reaction Torque Free, Zero Gyroscopic Rigidity; Instantaneous, Direct and Easy Control of the Flight (as driving a bicycle, or a motorcycle, or a GEN-H-4).