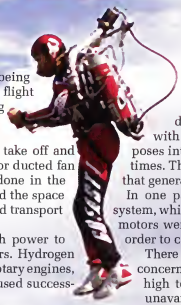
Ever since the legend of Icarus man has dreamed of being able to fly. Ma has since flown in various ways, such as kites that could carry men in China in the 5th century, hot air balloons in France in 1783 and we have been flying in heavier-than-air machines for more than a century. But the ultimate dream is to fly with the smallest possible machine that can lift a human into the air. In this article we look at machines which can – or at least perhaps have the potential to – do this.

Personal Flight Vehicles

by Dr David Maddison



Personal flight vehicles are defined as being designed to lift one or two people with flight equipment on their backs or standing or sitting on such equipment but not in an enclosure such as an aircraft cockpit.

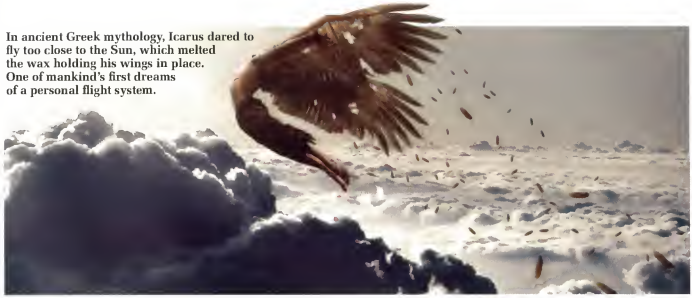
Such vehicles are mostly VTOL; vertical take off and landing, based on jet engines, rocket packs or ducted fan systems. Early work on rocket packs was done in the late 50s and early 60s for the US military and the space program where it was thought that they could transport astronauts over the lunar surface.

Personal flight vehicles require very high power to weight ratios and thus very powerful motors. Hydrogen peroxide, ducted fans with reciprocating or rotary engines, turbojet and turbofan motors have all been used successfully.

A hydrogen peroxide motor is simple in principle and uses "high test" hydrogen peroxide (85 to 98% H_2O_2), in contrast to medicinal hydrogen peroxid bought at the chemist which is 3%, food grade which is 30%. When the hy drogen peroxide fuel is bought into conta with a catalyst such as silver, it violently decon poses into steam and oxygen and expands by 500 times. The resulting gas is directed through nozzle that generate thrust.

In one particular application of a personal flig system, which we will discuss later, hydrogen peroxid motors were used at the tips of a helicopter rotor i order to cause it to rotate.

There are many YouTube videos and website concerned with experimenters making their ow high test peroxide fuels (since they are almo unavailable as only a few specialist companie make the fuel). Be warned: concentrated hydroge peroxide is an extremely hazardous substance and shoul



In ancient Greek mythology, Icarus dared to fly too close to the Sun, which melted the wax holding his wings in place. One of mankind's first dreams of a personal flight system.

only be experimented with if you know what you are doing.

Ducted fan propulsion systems involve a "fan" or propeller mounted in a duct or shroud. Typically the fan has more blades and is of smaller diameter than an unducted rotor.

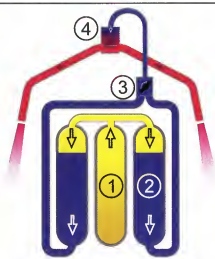
The smaller diameter fan can spin at a much higher rate than an unshrouded propeller because of the limit set by the tip speed which must be less than the speed of sound since performance drops dramatically when the tip speed approaches that limit.

So ducted fans have the advantage of compact size, relatively low noise, high efficiency at low speeds and high thrust, the ability (with appropriate mounting) of thrust vectoring and safety, as the shroud protects people and objects from coming into contact with the fan. Typical ducted fans are powered by a reciprocating engine.

A turbojet is a jet engine in which incoming air is compressed by compressor blades after which it enters a combustion chamber, where fuel is added and burned, causing the production of hot, high pressure gas. This gas then enters the turbine and expands, causing it to rotate and drive the compressor blades. After the turbine, the gas enters the tapering exhaust or "propelling nozzle" in which gas velocity is increased while pressure is decreased (according to the Venturi effect). The high speed exhaust generates thrust which propels the engine.

A turbofan is a variation of the turbo-jet engine which has large fan blades at the front of the engine that exceed the diameter of the gas turbine at the core of the engine. The large fan causes a proportion of air to bypass the engine core and the bypass air provides a proportion of the thrust.

Turbofan engines are more efficient than turbojet engines and are widely used on commercial jet aircraft. One potential disadvantage is that they are larger than a turbojet that creates the same thrust.



Operation of a hydrogen peroxide rocket motor as used in all existing rocket packs. 1) Compressed nitrogen at 4MPa or 580psi. 2) high test hydrogen peroxide 3) regulator valve 4) catalyst. The compressed nitrogen forces peroxide through the regulator valve which is controlled by the pilot and then into contact with the catalyst which causes the decomposition of the hydrogen peroxide and a volume expansion of 5000 times after which it is ejected at supersonic speed via the exhaust nozzles to create thrust.

Source: Dart evader derivative work: Malyszkz (Rocket_Belt_Propulsion.PNG), Creative Commons license.

Personal Flying Systems from the past

The Hiller Flying platform was developed in the 1950s by Hiller Aircraft as part of a US Army and US Navy program to develop a flying platform that could be flown with minimal training by the user. It utilised contra-rotating ducted fans powered by two Nelson H-56 30kW piston engines. The pilot controlled it by simply leaning in the direction he wanted to go. Several variants of the model were made and 1031-A-1 model was first flown in 1957 (see photos overleaf).

It weighed 168kg empty and could carry an 84kg payload (pilot plus fuel), with a top speed of 26km/h and maximum service height of 10m. Its flight time duration is not known.

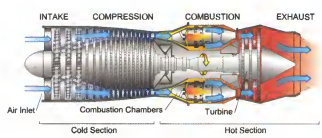
The aircraft was quite stable and could not tumble. If the pilot leaned over too far, the aircraft would tend to return to the vertical.

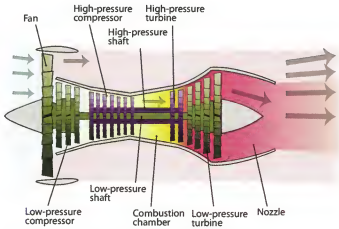
A video of the flying platform can be seen at "*Hiller Flying Platform*" https://youtu.be/W3FS3D1rCos.

The Pin-wheel helicopter

The Pin-wheel helicopter was built as part of a US military contract in 1954 and was powered by hydrogen peroxide rocket motors at the tips of the rotor blades. It was invented by Gilbert W. Magill and was intended to be folded up and stored in a small container. Since the rotor blades were propelled at their tips, there was no torque reaction to overcome and therefore no tail rotor was necessary.

It had surprisingly good performance, with a top speed of over 160km/h, a ceiling of around 15000 feet and a range of 32km on 20 litres of 90% hydrogen peroxide fuel.





These two diagrams show the difference between the turbojet engine (above) and the turbofan engine (right). ***Image source: (above) Jeff Dahl; (right) K Aainsqatsi – both Creative Commons licence.***

You can read more about this project, from before this aircraft first flew, in Flying magazine of February 1952 at https://books.google.com.au/books?id=3XUK_52VvmYC

Also see Popular Science of January 1952 https://books.google.com.au/books?id=ryEDAAAAMBAJ&pg=PA89

A video of this device flying can be seen at "*One-Man Helicopter (1957)*" https://youtu.be/GpPHT2UvplA

The Bell Rocket Belt

The Bell Rocket Belt is perhaps the most well known of all personal flight systems, having been used in TV serials such as *Lost in Space* and the James Bond movie *Thunderball* as well as in numerous public displays such as the opening of the 1984 Los Angeles Olympics.

The Bell Rocket Belt started to be developed in the mid 1950s for the US Army and was demonstrated to the Army in 1961 although they were not impressed with the short flight time of 21 seconds. It too used a hydrogen peroxide propulsion system. Control is conducted by moving the rocket nozzles and also tilting the entire pack to fly sideways as well as the pilot moving their body.

As the pilot will fall out of the sky when the fuel runs out at 21 seconds, it is vitally important to know when to land. There is a timer that beeps every second until the 15 second mark is reached and then sounds continuously telling the pilot to land.

The thrust developed was 136kg and it could fly at up to 55km/h. The rocket belt weighed 57kg and it carried 19 litres of fuel.

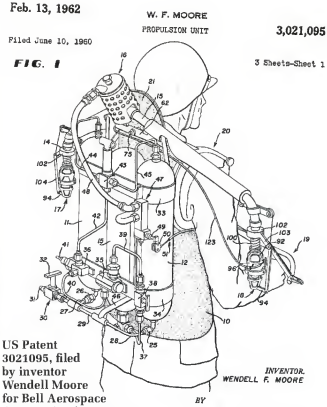
Wendell Moore was the inventor and today all existing rocket packs are based on his design. An attempt by some entrepreneurs to build an improved version of this rocket belt in 1992, called the RB2000, using more modern lightweight alloys and other materials resulted in a pack that had only slightly better performance than the original with a flight duration of 30 seconds and a fuel capacity of 23 litres.

The Hiller Model 1031-A-1 Flying Platform showing a soldier using it as a shooting platform.

Bell Pogo

One version of the Bell Pogo was like a two-person version of the Bell Rocket Belt. NASA had an interest in it

The Hiller Flying Platform, as it can be seen today at the Steven F. Udvar-Hazy Center in Chantilly, Virginia, USA, a part of the Smithsonian Air and Space Museum.



US Patent 3021095, filed by inventor Wendell Moore for Bell Aerospace Corporation in 1960, entitled "Propulsion unit".

Bell No.2 Rocket Belt at the Udvar-Hazy Center of the Smithsonian National Air and Space Museum in Chantilly, Virginia, USA. The centre tank contains pressurised nitrogen which forces the hydrogen peroxide in the side tanks into the catalyst structure on top where it rapidly decomposes into steam and oxygen, whereupon it expands in volume by 5000 times and is ejected out of the nozzles on the side.

as a lunar exploration vehicle and the US Army had an interest in it as a vehicle to cross ravines. NASA decided the risk of a crash was too high and the Army decided it was too complicated to use without a lot of training. The other version of the POGO was designed for one person.

For a video of both the one and two person Bell POGOs in operation see http://videos.howstuffworks.com/discovery/33674-strange-planes-the-bell-pogo-video.htm

de Lackner HZ-1 Aerocycle Flying Platform

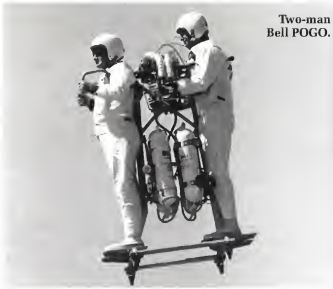
The de Lackner Aerocycle was designed as a one man reconnaissance platform for the US Army. The designer, Charles Zimmerman, proposed a platform beneath which helicopter-like rotors were mounted. Control was to be effected by the pilot shifting their body weight, so-called kinesthetic control.

The aircraft first flew on the 22nd November 1954 and 12 were built for the US Army and 160 test flights were conducted.

It had an empty weight of 78kg, a maximum weight of 206kg and a fuel capacity of 3.8 litres. It was powered by one Mercury 20H 30kW marine engine and had a maximum speed of 121km/h and cruise speed of 89km/h.

Its range was 24km and maximum flight time was 45 minutes with a service ceiling of 5000 feet.

It was intended to carry up to 54kg of cargo or an extra



Two-man Bell POGO.

The de Lackner HZ-1 Aerocycle was available in both land-based and (as seen here) amphibious versions.

The Bell Jet Flying Belt, the world's first jet-engine powered jet pack.

19l fuel tank to extend its range from 24km to 80km.

The aircraft was meant to be easy to fly and non-pilots were meant to be able to operate it with only 20 minutes of instruction but it was soon determined that it was not easy to fly and only a trained pilot could operate it.

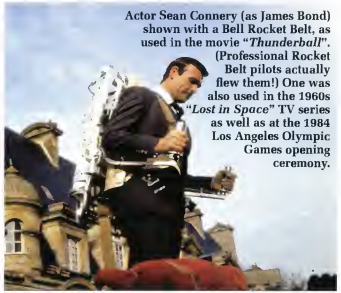
Two accidents were caused by the 4.6m diameter counter rotating blades striking and disintegrating. The conditions under which the blades would strike each other were never able to be determined and these crashes and the fact that only trained pilots could fly it caused the cessation of the program.

A video of the Aerocycle flying can be seem at "*One-Man Amphibious 'Copter*"; https://youtu.be/1oYS_5SgU_s0.

Bell Jet Flying Belt

The world's first jet pack was the Bell Aerosystems Jet Flying Belt, built for the US Military. It was designed to overcome the limitations of the hydrogen peroxide fuelled Bell Rocket Belt with its sub-30 second flight times. A new miniature jet engine, called the WR19 inside the company (F107 outside the company), needed to be developed for this project by Williams Research Corporation (now known as Williams International) as there were no small jet engines available at the time.

This engine was later used in cruise missiles such as the Tomahawk. As used in the Flying Belt, it weighed 27kg and produced 195kg of thrust while consuming about 136kg of Jet-A fuel per hour. The flight time was about 20 to 25 minutes at speeds of up to 135km/h. The engine was classified as a military secret at the time and never used in non-military aircraft. Its performance was such that it



Actor Sean Connery (as James Bond) shown with a Bell Rocket Belt, as used in the movie "*Thunderball*". (Professional Rocket Belt pilots actually flew them!) One was also used in the 1960s "*Lost in Space*" TV series as well as at the 1984 Los Angeles Olympic Games opening ceremony.

produced the same power as small civilian aircraft at the time (1965) but at one twentieth of the size. Even today, the power to weight ratio of this engine is hard to match.

The engine was mounted vertically on the Flying Belt, with the air inlet at the bottom and the exhaust at the top and then into nozzles on either side. These could be tilted forwards, backwards or sideways by the pilot to control motion, just like in the Bell Rocket Belt.

The Jet Belt first flew on 7th April 1969 but on 29th May 1969, Wendell Moore, who invented this and the Rocket Belt, died at age 51 and work on the project stopped forever. Who knows where this work would have gone if he had not prematurely passed away?

With Wendell Moore's death, the project eventually did not have the support of the military as the weight of the device was too great, making landings hazardous for the pilot and the maintenance requirements of the engine were too much, not to mention the hazard to the pilot of an uncontained turbine blade failure. At this time, helicopters had also developed into very effective military air vehicles for transporting soldiers.

A video of the operation of this device can be see at: "*Jet engine Jet pack : World's first Gas-Turbine backpack. The Bell WR19 Jetbelt*" https://youtu.be/DpJxzswUDD0

Williams X-Jet

The Williams X-Jet was in a way a development of the Bell Flying Belt. Engineers tried to work out how to extend the flying time beyond the 20-25 minutes of the Flying Belt. This required carrying more fuel. They were inspired by the Hiller flying platform (see above) which the pilot stood on. Such a platform would enable the carrying of more fuel than could be carried on the pilot's back.

The X-Jet had a modified Williams F107 engine with 258kg thrust, somewhat more than the same engine used in the Flying Belt. The X-Jet's empty weight was 182kg and fully loaded it was 250kg. It had a maximum speed of 96km/h, a service ceiling of 10,000 feet and endurance of 30-45 minutes, around twice as long as the Jet Belt.

Flight control was by leaning in the direction of desired travel and by thrust control. It worked successfully and was demonstrated to the US Army in the 1980s but no suitable military application could be found that could

The Williams X-Jet, nicknamed "the flying pulpit".

not be achieved with helicopters.

Videos of the Williams X-Jet can be seen as follows: "*The WASP (Williams Aerial Systems Platform)*" https://youtu.be/XJARrc40imk. This video is a video of a display screen at the Boeing Museum of Flight in Seattle, Washington, USA: "*WILLIAMS X-JET*" https://youtu.be/wLsqyphVERA Also see "*Your Personal Flying Machine X Jet WASP!!*" https://youtu.be/27HaGvHzbgQ

Coaxial Helicopter

The Gyrodyne XRON model was a small helicopter built in the USA in 1960. It was powered by a tiny 41kW Solar Turbines model YT-62-S turboshaft engine running on kerosene.

This aircraft was originally developed for the US Navy and later the US Marine Corps. One use envisaged was to drop this aircraft to an airman downed behind enemy lines to facilitate their escape. It was also developed into an unmanned drone. It won the "most manoeuvrable helicopter" prize at the Paris Air Show in 1961.

For a silent video of military qualification trials of this aircraft see "*Gyrodyne disposable XRON military qualification flight auto-rotation*" https://youtu.be/ogIS_VbORbc

There are also other videos of different variants of this aircraft.

An Australian registered Gyrodyne XRON one man, turboshaft-powered open cockpit helicopter.

Mythbusters' Attempt to Build a Jet Pack

In series 3 episode 8 of *Mythbusters*, they set about building a jet pack with plans obtained off the internet. They have an extremely well equipped workshop and are highly experienced and capable machine builders but they could not get the device made from these plans to fly.

Of course, as shown in this article, jet packs or personal flight vehicles as we refer to them are possible but all the devices that work have taken very large amounts of money, time and resources to get to a flying state.

The episode of *Mythbusters* where they try to build the device can be viewed at "*Mythbusters S03E08 Jet Pack*" https://youtu.be/h8zIfkMp08U

Myth: BUSTED!

Gluhareff Helicopters MEG-1X and MEG-2X

In 1952 Eugene Gluhareff created a company to build "backpack" helicopters powered by his pressure jet engine. The MEG-1X of circa 1957 weighed less than 31kg and had a single rotor blade with a tip-mounted pressure jet motor and counterweight. Maximum take-off weight was 104kg and maximum speed was 88km/h with a hover ceiling of 4900 feet. Flight endurance was 14-18 minutes.

The US Air force was impressed with the MEG-1X and asked Gluhareff to build another model, the MEG-2X, which had two blades and also a MEG-3X. These aircraft were not commercially produced and were perhaps the smallest helicopters ever built. It is understood that they only made tethered flights.

The pressure jet engine is extremely simple with no moving parts and is somewhat a akin to a pulse jet engine. Said to be "sonically tuned", it relies on precise control of sound waves in the combustion chamber. For further information see https://en.wikipedia.org/wiki/Gluhareff_Pressure_Jet

Kits are available to build a pressure jet engine.

For a video of this aircraft see "*One man Backpack helicopter Powered by G8-2 Pressure Jet Engine invented by Eugene Gluhareff 1956*" https://youtu.be/s0DY4Qe14A4

Trek Aerospace EFV-4A

The Trek Aerospace Exoskeleton Flying Vehicle (EFV) was first tested in 2003 and has a unique design with two counter-rotating 1-metre overhead ducted fans driven by an 88kW rotary motor.

Gluhareff MEG-1X backpack helicopter in a tethered flight test.

The Trek Aerospace EFV-4A.

The aircraft is controlled via a fly-by-wire system and each duct can be tilted individually. It has a top speed of 180km/h and range of 295km with a 46 litre tank. Its dry weight is 170kg and its maximum payload is 162kg. Maximum take off weight fully fuelled is 378kg.

Development of this vehicle and others based upon it seems to have ceased and Trek Aerospace now provides services related to ducted fan technology.

A video of the EFV in operation can be seen at *"Trek Exoskeleton Flying Vehicle, Personal JetPack"* https://youtu.be/KUs8riw9Afo

Personal flight vehicles under development

We will now look at some personal flight vehicles that are currently in existence or under development, such as the Jetpack Aviation JB-9 and JB-10.

Jetpack Aviation is a company run by Australian entrepreneur David Mayman and American Bill Suitor, based in California. They have recently developed and flown the JB-9 JetPack, which it and its predecessors have been under development for over 40 years. The JB-9 uses turbojet engines chosen for their compact size and lighter weight in comparison with turbofan engines, even though they have higher fuel consumption and higher exhaust temperatures.

Battery technology is important with a jet engine pack as the current drain during engine start up can be up to 50A and ongoing current is up to 15A.

The JB-9 carries about 38 litres of kerosene which is burned at the rate of about 3.8 litres per minute for around a ten-minute flight time, with an electronically limited speed of 100km/h. A JB-10 model with a top speed of 200km/h is under development

On 3rd November 2015 Jetpack Aviation flew the JB-9 around the Statue of Liberty in New York (see video).

Under further development are auto-stability systems and a parachute system that will automatically deploy. The developers are discussing the possibility of JetPack racing as a competitive sport. Also under development are improvements to engines and engine management systems, a four engine version and a flight simulator for training. Longer term plans include a fully stabilised version and the possibility of turbofan engines instead of turbojets.

Videos to watch: *"JetPack Aviation JB-9 JETPACK"* https://youtu.be/f3AwBSwFV2I; *"JB-9 JetPack Flight (Jet engine audio)"* https://youtu.be/QhnXxJs0GpE

The Martin Jetpack

The Martin Aircraft Company of New Zealand is developing a personal "Jetpack" that seems to have every possibility of becoming the world's first mass-produced system and it is under final test right now. Note that even though it is called a "Jetpack" it is powered by two ducted fans.

The Jetpack is not wearable like, for example, the Jetpack Aviation machine but has its own landing skids and the pilot stands within the machine.

It uses a custom-designed 1.2-litre 2-stroke V4 156kW engine weighing 48kg. Standard automotive gasoline is used, in a 45-litre tank. Flight duration is 30 minutes and the cruise speed is 30 knots or 56km/h. It uses "fly by wire" with no direct connection between the control surfaces and pilot stick. It has a range of 30-50km, depending upon environmental conditions, with an operational ceiling of 3000 feet. Its weight is 200kg empty.

Flying the Jetpack Aviation JB-9.

The Martin Jetpack is designed for ease of flight; if the pilot lets go of the controls it will simply hover in place.

View of the Martin Jetpack from above showing arrangement of the ducted fans.

Naturally, with an aircraft of this nature if there is an engine failure it will simply fall out of the sky, so it incorporates a ballistic parachute to arrest any fall, even from a very low altitude of six metres (see test of parachute in first video).

Deliveries are expected to start in the second half of 2016. Its initial applications will be for police, fire services, defence and emergency response organisations but it also has potential uses in the recreational market and in its unmanned remote control version, can deliver payloads of up to 120kg, unlike a quadcopter which might be restricted to a few kilograms.

It is capable of operating in a "mule train" mode in which one unit is piloted and up to five other unmanned units are electronically linked to the first one, to follow it and land.

The Martin Jetpack was Time magazine's top 50 inventions in 2010.

There is a free App available for either iOS or Android called "Martin Jetpack" that provides an augmented reality simulation and also allows you to watch videos of the Jetpack and review technical data.

Videos to watch:

"Martin Jetpack 5000 feet flight – highlights" https://youtu.be/SHPedpE70Es

"P12 Test Flight April 2014"; https://youtu.be/LDp1XztObUQ

"World's first commercial jetpack set for 2016 launch"; https://youtu.be/rvmuDQjxKxg

"Martin Jetpack Flight Demonstration 6 December 2015 Shenzhen, China"; *"Martin Jetpack Concept of Operations"* https://youtu.be/blg2LfXXqdk

Jet Pack International

Jet Pack International (www.jetpackinternational.com), based in Colorado, manufactures hydrogen peroxide fuelled rocket packs of the Bell design and puts on spectacular public shows. They offer the H202 model with a flight time of 23 seconds, a maximum distance of 402 metres and a fuel capacity of 16 litres. They also offer the H202-A with a flight time of 33 seconds, maximum distance of 762 metres and a fuel capacity of 20 litres. Their new unit code named "Falcon" is under development but no details have been released.

Hoverbike

Hoverbike (www.hover-bike.com/MA/), based in the UK, is the brainchild of Chris Malloy, of New Zealand, who started his project in his garage in Sydney. It is described as a flying motorcycle and has the approximate configuration of a quadcopter although the front and rear blade pairs overlap each other. It is intended to be flown manned or unmanned.

It started out with a two-blade design which was found to be too expensive and complicated to control, with an otherwise elegant design. Compare that with the home made hoverbike of Colin Furze, described elsewhere who also had control problems with a two blade design. Hoverbike is now concentrating on the four blade design.

Hoverbike indicate they have had extensive interest in the product from the military and other organisations. Hoverbike is relying upon crowd funding and has so far raised $89,210 of a required $1.1 million (at time of going to press). A lucky donor will win a Hoverbike if the project is successful.

The Hoverbike will use a flat twin 4-stroke 1.17-litre 80kW engine and 30 or 60 litres of fuel, depending upon whether secondary tanks are fitted. It will have a fuel burn of 30l/hr, a dry weight of 105kg, a maximum take off weight of more than 270kg and a total thrust of greater than 295kg, with an estimated range of 148km on the primary 30 litre tank and an estimated maximum hover altitude of around 10,000ft.

Aero-X Hoverbike

Aerofex (http://aerofex.com), based in California, has had the Aero-X Hoverbike concept in development since 2008. It will be able to fly 3 metres off the ground at up to 72km/h carrying two people or a load of up to 140kg. Its flight duration on one tank of fuel is 1.25 hours. It is 4.5m long, 2.1m wide, 1.25m tall and has a dry weight of 356kg.

Aero-X hoverbike.

Colin Furze's home-made hoverbike.

It runs on automotive gasoline with a 3-rotor rotary engine. Cost is US$85,000.

For a video of the Aero-X, see *"Off-Road Hover Bike Will Be Available in 2017"* **https://youtu.be/uwxaZ9KCdcE**

Homemade hoverbike – YouTube Build

Colin Furze has built a hoverbike which can be seen in a YouTube video entitled *"Homemade Hoverbike"* at **https://youtu.be/soxxPyaAT1k**

Within the description of that video there are a number of links to various aspects of the build plus his other projects. Also see a Q&A on the build at **www.vessel.com/videos/aHh3cE8s5**

His website is at **www.colinfurze.com**

The hoverbike is powered by two para-glider motor units with their propellers and support frames. He says that control is very difficult and solutions to the control problem are not so easy, especially as the machine barely generates enough thrust to lift the rider so additional weight is not feasible. Nevertheless, the vehicle does work.

He notes he may build a Mark 2 version which might include a carbon fibre frame and larger propellers and motors and some ideas to make the device more stable.

Flight using a Jet Pack International jet pack.

Catalin Alexandru Duru's "Hoverboard"

Catalin Alexandru Duru invented a battery powered "hoverboard" which seems rather similar to an octocopter that any drone enthusiast might fly but obviously scaled up to be much more powerful and sophisticated. He set the Guinness Book of Records mark on 22nd May 2015 for the furthest flight by a hoverboard at 275.9m with a flight time of around 90 seconds. His company, Omni Hoverboards (**http://omnihoverboards.com**) is working on a next generation however no details are available on the website.

For a video, see *"Farthest flight by hoverboard - Guinness World Records"* **https://youtu.be/Bfa9HrieUyQ**.

Zapata Racing Flyboard Air

Zapata Racing (**http://zapata-racing.com/en/**) is a company that produces hydro-propulsion equipment for water sports that enable a user to launch themselves into the air with powerful water jets delivered to the user via a hose connected to a powerful pump in a floating vehicle. The user remains tethered to the vehicle via the hose so is not capable of independent flight. They took this concept to the next level with the development of an independent jet powered platform called "Flyboard".

The Flyboard has six small jet engines, four internal engines to provide lift and two mounted on the outside

Chris Malloy's Hoverbike in ground-tethered test.

to provide stability and forward motion. The four internal engines produce around 186kW each for a total of 755kW or around 1000hp total. There are on-board electronics to stabilise the device similar to what are used in a drone. The stabilisation software works by controlling the inclination of the thrust nozzle of the internal jets and the speed of the two side mounted jets.

The Flyboard is not easy to fly and its inventor, Franky Zapata, says it is impossible to fly without 50 to 100 hours experience on their water jet version of the Flyboard however they are working on a model that is easier to fly and can be used by the general public and military.

Unlike some other personal flight systems, this one has some redundancy and can fly if one of the four internal motors fails. It also has triple redundancy of the WiFi channels it uses and the stability sensors. Jet A-1 fuel is carried in a backpack worn by the pilot.

The inventor has plans to ride the Flyboard into the clouds and will carry a parachute for safety. The inventor has also fallen into the water many times during experimental flights and says that he has not been hurt doing so. The Flyboard is capable of reaching an altitude of 10,000 feet, has a top speed of 150km/h and a flight duration of ten minutes.

On the 30th April 2016, the Flyboard achieved the world record distance for a hoverboard reaching 2252.4 metres.

The Jetman

Yves Rossy, otherwise known as the Jetman, developed a rigid 2.4m span wing with four small jet engines which he attaches to his back. His body acts as the fuselage and he controls the direction of flight by moving his body.

The engines are modified Jet Cat P200s which are the largest type of model aircraft jet made by Jet Cat with a thrust of nearly 24kg each. See www.jetcatusa.com/rc-turbines/turbine-details/p200-sx/

To launch, Jetman dives out of a helicopter as the aircraft has no landing gear; except for his legs! When it is time to land, he releases a parachute and floats to the ground.

Jetman has flown as fast as 304km/h with his jet-powered wing and crossed the English Channel in 2008,- reaching as much as 200km/h for the 13-minute, 35km flight.

In 2009 he attempted to cross the Strait of Gibraltar but was forced down by strong winds just a few kilometres from Spain.

Fortunately, he was not hurt and he and his machine were retrieved from the ocean within ten minutes.

Record breaking (at the time) flight of hoverboard. For safety reasons this flight, and that of other similar vehicles are made over water to minimise pilot injury in the event of engine or other failure.

In 2011 he flew across the Grand Canyon and the FAA, the US Government agency responsible for aviation regulation, classified his wing and him in combination as an "aircraft".

For a video of Jetman in action see "*Yves Rossy: Fly with the Jetman*" https://youtu.be/x2sT9KoII_M

Tecnologia Aeroespacial Mexicana

Tecnologia Aeroespacial Mexicana (www.tecaeromex.com/ingles/indexi.html) is a Mexican company that specialises in hydrogen peroxide rocket engines for various applications such as rocket packs, a helicopter with rocket propulsion at the blade tips (tip jet), rocket powered dragsters, rocket bikes and a rocket car.

They manufacture rocket belts to order and sell them to suitably qualified individuals, along with equipment to make high test hydrogen peroxide which is otherwise almost unobtainable.

Aerochute

Aerochute (www.aerochute.com.au) is an Australian company based in Melbourne that produces a powered one or two man parachute called the Aerochute. The product was discussed in the May 2015 issue of Silicon Chip, at

Alexander Duru and his hoverboard. Essentially it is an octocopter.
Image by Daniel Petkov

Jetman in flight. Note the four small model aircraft jet engines. Flight is controlled by him moving his body. The fuel used is kerosene.

the Australian International Airshow.

The company is engaged in ongoing development, in conjunction with the Swinburne University of Technology, of an electric version of this vehicle. A remotely operated version of the vehicle has also been developed which has range of 3 hours or 180km. While it can fly unmanned, it retains its seats so that it could fly to a remote area, pick up one or two injured people and then fly back. It could also

Flyboard Air. Note the fixed boots which keep the pilot attached to the aircraft. Also visible are the two outboard jet engines. Not visible are the four internal jet engines.

Jetman's jet powered wing in a folded state for transport and also so he can get into helicopters prior to launch.

be used to pick up or deliver supplies. Another application of the remotely operated vehicle is for aerial surveys, perhaps with remote sensing or photographic equipment.

A final development of this company is a "fly by wire" control arrangement whereby the pilot guides the vehicle via a joystick rather than the traditional controls (which remain for the purpose of redundancy).

Troy Hartman

Troy Hartman (www.troyhartman.com) is an aerial stuntman who attached jet engines to his back that produced 90kg of thrust to propel himself with a paragliding wing. You can watch a video of his flight at *"The Troy Hartman Jetpack"* https://youtu.be/Yolum7_0UCA.

Jet Powered Wing Suit

Finn Visa Parviainen developed a pair of jet boots to propel his wing suit for level flight and even climb until he runs out of fuel. He then lands in the usual way of winged suit flyers, using a parachute. For a video of his flight see *"Phoenix-Fly: Wingsuit Jet Pilot"* https://vimeo.com/16632926

Airvinci

As we went to press, Canadian company Airvinci announced that their single rotor, dual-engined "backpack helicopter" was ready for a trial flight.

The brainchild of Tarek Ibrahim and developed in his suburban garage, his dream was to develop a safe, compact and affordable means of transport, even if only to miss the daily traffic jams by flying users between home and the office!

Flyboard Air in operation. *Source: Zapata Racing.*

Visa Parviainen in flight with his wing suit and jet boots.

Initially conceived as a heavy-lift drone (left), Airvinci now plan test flights for their human-carrying model (right) next year.

Comparisons have been made between it and the Martin Jetpack but Airvinci claim their craft, also a ducted fan design, will have a far greater range and with two engines, will be much safer than single-engine designs.

Initially developed as a heavy-lifting drone helicopter, the Airvinci has now morphed into a full-sized, person-carrying VTOL model. This is expected to undergo trials during 2017.

Ibrahim says that the Airvinci will have multiple applications; as well as a traffic-snarl-beater, he sees it being used as a "sky taxi" to take users direct from their homes to airports for their flights, or even as a launch vehicle for skydivers, taking parachutists up to 12,500 ft and then automatically returning to their base once the occupant has jumped out!

He also envisages a huge number of applications in search and rescue, firefighting, public utilities and so on.

Airvinci website is www.airvinci.com, where there is also a video of the Airvinci presentation made at TEDx Toronto last October.

Conclusion

A wide variety of personal flight systems have been developed over the years and continue to be developed. Safety is of paramount concern and if these systems are to become widespread for personal transportation they must be fail-safe in the event of an engine failure, either by generating lift with a wing such as the Aerochute or with a ballistic parachute as with the Martin Jetpack. SC