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## THE SKYCAR: Transportation of the Future

p.10

# THE SKYCAR: Transportation of the Future

By Karie White

> "Mark my word: A combination airplane and motorcar is coming. You may smile. But it will come…"
> Henry Ford, Chairman, Ford Motor Company – 1940

Ready to think outside the box? The M400 roadable Skycar® is a four-person Vertical Takeoff and Landing Vehicle (VTOL) that has been developed by Moller International. Formed in 1983 and headed by Paul Moller, President, the company's key purpose is to design, develop, manufacture and market personal VTOL. If you thought the futuristic daily driver of George Jetson was mere carton fantasy, think again!

## THE SKYCAR

Let's compare the M400 Skycar with what's available now, the automobile. Consider the most technologically advanced automobiles, the Ferrari, Porsche, Maserati, Lamborghini, or the more affordable Acura, Accord, or similar. It seems as if all the manufacturers of these cars are promoting the new and greatly improved "aerodynamics" of their products. The auto industry boasts of aerodynamics, performance tuned wide track suspensions, electronic ignition and fuel injection systems, computer controllers, and the list goes on. However, despite all these aerodynamic enhancements and computerized advancements, you are still left on the ground and stuck in traffic.

The Skycar changes this. Imagine: Traveling from your garage to your destination, cruising comfortably at 275 MPH (maximum speed of 375 MPH) while achieving up to 20 miles per gallon on clean burning, ethanol fuel. No traffic, no red lights, no speeding tickets, no runway required. Just quiet direct transportation from point A to point B in a fraction of the time.

Moller International has developed and integrated the technologies required for small, powered-lift VTOL aircraft. These include electronic stabilization and control systems, efficient ducted fan designs, thrust vectoring mechanisms and aerodynamically stable composite airframe structures. The single most significant spin-off technology utilized by the Skycar is the Rotapower® engine, a Wankel rotary engine.

The Rotapower engines have only two major moving parts, weigh less than 80 pounds and occupy less than one cubic foot. The bulk of the remaining technology is electronic and replaceable in modules. The onboard redundant systems identify a failed or failing component. Safety and reliability are crucial elements in Moller's VTOL.

As we all know, size greatly affects ground mobility and the parking space required to store one's mode of transportation. The Skycar, with its compact size, can be stored in a space the size of a standard single car garage. While travel is largely spent airborne, the landing gear on the vehicle makes roadability possible for short distances.

Initially introduced as the M400, four-seat model, the Skycar technology has the ability to be both scaled up to a six passenger, M600, and scaled down to a one passenger, M100. This allows a versatile, cost efficient vehicle size to accommodate a variety of military, paramilitary, private, and commercial transport missions.

## THE AIRFRAME

A VTOL aircraft with its larger installed power must be aerodynamically efficient at high cruise speeds if it is to use that installed power efficiently. Also, if the airframe of the volantor is not appropriately aerodynamic, fuel consumption increases and its maximum travel distance (range) becomes unacceptable. The ideal airframe must also be lightweight so the craft can obtain a favorable power to weight ratio. Lastly, it must be strong for stabilization and safety.

The determination of aerodynamic efficiency comes down to the following:

- When the aircraft is moving at high speed, does the propulsive air move efficiently through the propulsion or thrust system?
- Does the aircraft have a small frontal area?
- Does the aircraft have a small wetted area (surface area in contact with the airstream)?
- Is the vehicle sufficiently streamlined to ensure that its aerodynamic surfaces are free from airflow separation and therefore present a clean aerodynamic design?
- Does the configuration achieve a good lift/drag ratio at high cruise speeds?

Some light planes built today, particularly those in the experimental or homebuilt category do an excellent job satisfying the above conditions. A measure of aerodynamic performance is the passenger transport efficiency (PTE) as measured by: PTE = (Passenger Miles / Gallon)

A few four-seat aircraft have a PTE near 70 at 250 MPH although they will generally have a fairly high landing speed without STOL (Short Takeoff and Landing) provisions (flaps, slats, etc.).

As viewed by Moller, the key to a successful high-speed design with a high PTE is finding a way to simultaneously satisfy the five stated aerodynamic requirements.

- An efficient VTOL aircraft requires the propulsive airflow to move almost horizontally through the system during cruise because even a modest bending of the flow can introduce a substantial drag due to momentum losses.
- A frontal area under 25 ft$^2$ is realistic for a VTOL aircraft carrying up to four passengers.
- A wetted area to frontal area ratio under 15 is achievable with an efficient airframe design.
- The drag coefficient based on wetted area (CDwet) is a good measure of the aircraft's freedom from airflow separation. A well-designed aircraft should achieve CDwet of .005 at cruise while a state-of-the-art design arrived at after extensive wind tunnel testing could have a CDwet <.004.
- Lift/Drag Ratio (L/D) will be high with a large wing area and a high aspect ratio. However, this high L/D will only occur at speeds significantly lower than desired cruising velocity. A high aspect ratio is also hard to achieve in a light vehicle where the fuselage becomes a lifting body, due to its size relative to the small wing area required for efficient high-speed flight with a modest payload. For this reason, the maximum lift/drag ratio of a powered lift aircraft is likely to be less than that for a conventional airplane, but could match or exceed its PTE at higher cruise speeds (>250 MPH).


**vo - lan - tor** (vo-lan'ter) n. A vertical takeoff and landing aircraft that is capable of flying in a quick, nimble, and agile manner. -- intr. & tr.v. -tored, -toring, tors. To go or carry by volantor. [Lat. volare, to fly. Fr. volant, to move in a nimble and agile manner ]

The Skycar volantor's composite airframe is constructed mostly of FRP (fiber reinforced plastic), commonly known as carbon fiber composite. Carbon fiber is highly acknowledged for its superior strength, which distinguishes it from fiberglass and resin composites. The use of FRP enables the Skycar to be both lightweight and robust. The company has its own 250 mph wind tunnel in which over 1000 hours of detailed flight testing using both powered and un-powered models has been performed to ensure that the optimum design has been instituted.

## THE ENGINE

VTOL aircraft require a great deal of power to obtain lift-off and perform a safe landing. Since the engine must lift its own weight along with the weight of the craft and passengers, it must be lightweight. Economy is another area that requires much attention. Purchase price, operating costs, and maintenance costs are all factors which, if too high, can make the engine impractical. Lastly, to be truly efficient, an engine must be environmentally friendly. The company acknowledges that ideally, clean burning engines capable of using the most readily available fuels would provide the best option.

The need for a moderately high disc loading results in a relatively high installed power in order to hover. For the installed powerplant weight not to become excessive, the engines must be light for their power output. The key element in determining the VTOL aircraft cost may then become the powerplant. If, for example, one uses 200 lb/ft< disc loading, it can be shown that:

(Installed Horsepower / Gross Vehicle Weight) ~ 0.5

In this case, a VTOL aircraft with a modest payload requires installed power in the 1000 HP range and an engine HP to weight ratio near 2. A turbine can meet this weight requirement; however, a small 100 HP turbo-shaft can cost $100,000, while a single 1000 HP turbo-shaft can cost $300,000. The smaller turbo-shaft gives poor specific fuel consumption, while the single engine provides no back up. Any design using turbo-fan engines will expect even higher engine costs.

To meet the 2 HP/lb requirement in a small fuel-efficient form, only two engine alternatives appear to be possible at an economical cost:

- A turbo-charged or super-charged fuel injected 2-cycle engine. This engine would need to be developed.
- A rotary engine that employs aluminum housings, peripheral porting and an air-cooled rotor. Engines of this design are in existence.

Moller rotary engines were developed from technology obtained from Outboard Marine Corporation (OMC) and are of the Wankel-Type. During each rotation of the rotor a four-stroke spark ignition combustion process occurs in each of the three pockets of a triangular rotor. After one full rotation of the rotor the engine has completed the four-stroke process three times. They therefore provide a high power-to-weight ratio at a reasonable cost and are very small for their power output. One person can easily carry the 150 HP model used in the M400. Eight Rotapower engines are used in the production model volantor.

Wankel-type rotary engines in general are very reliable as a result of their simplicity. The number of moving parts in a Moller rotary engine (dual-rotor) is approximately seven percent of those in a four-cylinder piston engine. The Rotapower engine is also multi-fuel capable. Moller rotary engines in the volantor are typically configured to run on unleaded gasoline however, Moller has recently demonstrated the engine's ability to run on diesel to the Army and on Natural Gas to another organization.

Additionally, ethanol has proven to be a great choice for the Rotapower engine. Through a cooperative agreement with the Ethanol Promotion

*[continued on page 14]*

and Information Council (EPIC), Moller tested ethanol under a wide range of conditions in its line of rotary engines. Results included remarkably low emissions, (with the toxic emissions generated by the Rotapower engine below the California Super-Ultra Low Emissions Vehicle (SULEV) standards as well as the ambient levels of some U.S. cities), and very effective cooling of the rotor. "It runs so clean that when we disassembled and inspected the engine after a test it was spotless inside; just like new," said Paul Moller.

## THE POTENTIAL

While personal ownership is the first thought that comes to mind, the Skycar has unlimited potential in other markets as well. As mentioned earlier, military, paramilitary, and commercial transport are all potential benefactors of the Skycar. In fact, one might find less personal ownership and more residence taken up in these other applications.

The Skycar's combined VTOL and speed capability make extreme rapid response possible and make the Skycar ideal for Search and Rescue, Emergency Medical, or Surveillance, as just a few examples. Helicopters have traditionally offered the flexibility necessary in these applications allowing for ingress and egress into a limited space where fixed wing aircraft do not have access. The performance penalties for using helicopters as compared to fixed wing aircraft have been a low maximum cruise speed of approximately 125 mph, a limited range of around 300 miles, and a restricted operational ceiling of less than 15,000 ft. A M400 Skycar, by utilizing its VTOL capability, has the flexible access of the helicopter plus some. It additionally has the 375 mph maximum speed, 750 mile range, and 36,000 foot ceiling of a high performance aircraft. The M400 can also climb at more than a vertical mile per minute.

The Skycar also pairs nicely functioning as a commercial air taxi or air limousine service. Corporations may choose to own and operate their own Skycars. Furthermore, because Skycar economics support fleet-type operations with ride-sharing rather than large-scale individual ownership, fewer Skycars than autos could serve the same number of people in auto-intensive countries such as the US.

## ANTICIPATING THE SKYCAR

The technology for the Skycar received its comprehensive US patent in May 1992, followed by foreign patents in major industrial countries. To date the Skycar has exhibited limited tethered flight capability. (While testing, the Skycar must be tethered to a crane as not to violate FAA aircraft regulations). More tethered tests were scheduled for 2006 on an undisclosed date. The company is currently upgrading the Skycar's engines as to further improve this work of genius. The improved prototype is now called the "M400X". As an interesting fact, Moller has tried to auction the M400 prototype on Ebay twice without success. The latest auction, being October 2006, ended with a bid of $3,000,100.00 (US dollars) and the Reserve not met.

The Skycar is awaiting FAA certification. Moller International is working closely with the FAA. For purposes of safety, a Skycar operator will be required to have a private pilot's license. Once ease of operation and safety are thoroughly demonstrated, the expectation is that the "average Joe" will be able to competently operate this VTOL.

While progressing toward certification, Moller has been taking refundable deposits on the M400 since 2003. There are an estimated 100 orders in place. The company anticipates FAA certification by December 31, 2008. Presently the list price for a Skycar is near one million dollars. Moller foresees the VTOL eventually selling for about $60,000. So, prepare yourself, the futuristic transportation styling of tomorrow is closer than you may think.

*Content for this article has been extracted with permission from Moller International's website, www.moller.com.*

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