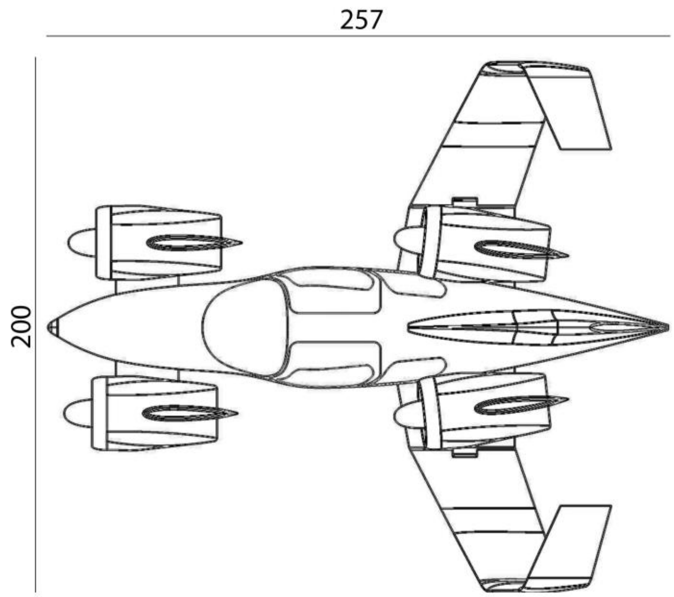
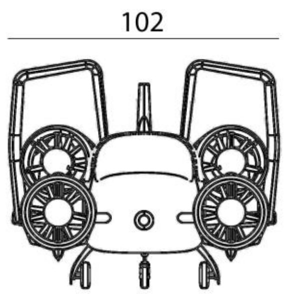
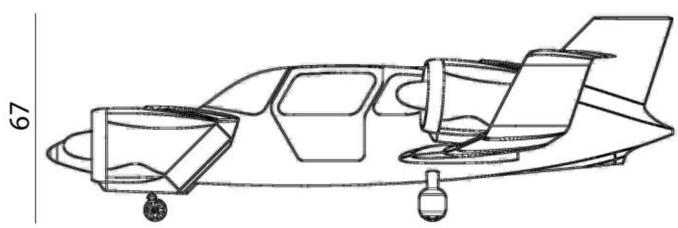
The Skycar® 400

High-speed, 4-passenger VTOL aircraft







THE MOLLER SKYCAR® 400

Over the past 30+ years Moller International and it predecessor companies have been working on the development of the technologies required for the Skycar®, the first practical vertical take off & landing (VTOL), high-speed, low-cost personal aircraft.

The Skycar 400 is the 5th generation of VTOL aircraft developed by Dr. Paul Moller and is now at the "operational prototype" stage. The Skycar® combines the high-speed capabilities of a fixed-wing aircraft with the vertical take off and landing capabilities of a helicopter. Its ducted fans provide lift and propulsion without the dangerous exposed rotor blades and high maintenance costs of rotary-winged aircraft. The vehicle uses state-of-the-art fly-by-wire computer technology to monitor, control and maintain stability of the aircraft, while

Skycar® 400 Performance Specifications[1]	
Max speed @ 20,000'	308 mph
Cruise speed @ S.L. (65% power)	284 mph
Rate of climb @ S.L.	3,979 fpm
Time to transition (0-131 mph)	14.49 sec
Range @ 131 mph (21.3 mpg)	805 miles
Max endurance (S.L. @ 131 mph)	5.9 hours
Net payload	720 lbs
Gross weight	2,400 lbs
Continuous Engine Power (Total)	725 hp
Boost power avail.	1,155 hp
Disc loading	140 lb/ft^2
Maximum L/D	12.5

[1]Volantor—A vertical takeoff and landing aircraft that is capable of flying in a quick, nimble and agile manner.

simultaneously making it simple and easy to operate.

ENVIRONMENTALLY ATTRACTIVE

Low noise is clearly necessary for an aircraft to operate in noise sensitive areas. The Skycar's multiple ducted fan arrangement is designed to generate low fan noise with its modest disc loading and tip speeds. Hover tests with earlier models have demonstrated a noise level of 85 decibels at 50 feet, less than 30% of the noise level produced by a Cessna 150 during take-off. The company's on-going work in mutual noise cancellation is expected to further reduce the noise level in the Skycar®.

The Rotapower® engine used in the Skycar® has demonstrated the ability to meet the Ultra Low Emission Vehicle (ULEV) standards without exhaust after treatment. However the preferred fuel for the Skycar® is ethanol, which provides even lower NO_x, HC, and CO emissions while potentially removing CO_2 from the environment.

SAFETY

The most important issue in aviation is safety. The design of the Skycar® incorporates a number of safety features including:

- **Multiple engines**—The Skycar® has four engine nacelles, each with two computer controlled Rotapower engines. All engines operate independently and allow for a vertical controlled landing should any one fail.
- **Multiple computers**—For redundancy the Skycar® has four independent voting computers for flight management, stability and control.
- **Emergency airframe parachute**—An airframe parachute can be deployed in the event of a critical failure of the aircraft. With this parachute, the pilot, passengers and the Skycar® can be recovered safely.
- **Rotapower engines**—Wankel-type rotary engines are very reliable as a result of their simplicity. The three moving parts in a two rotor Rotapower engine are approximately seven percent of those in a four-cylinder piston engine.
- **Enclosed fans**—Each nacelle fully encloses the engines and fans, greatly reducing the possibility of injury to individuals near the aircraft.

- **Redundant fuel monitoring**—Multiple systems check and report on fuel for quality and quantity.
- **Aerodynamically stable**—In the unlikely event that insufficient power is available to land vertically, the Skycar's aerodynamic stability and good glide slope allow the pilot to maneuver to a local airport for a transitional landing or if all power is lost to use the airframe parachutes.
- **Automated stabilization**—Since computers control the Skycar® stability during hover and transition, the only pilot input is speed, direction, rate of climb and altitude.
- **Emergency options**—The Skycar® can land almost anywhere, and therefore avoid dangerous situations created by a sudden weather change or equipment failure.

By emphasizing simplicity, durability and redundancy, Moller is making safety an inherent attribute of this revolutionary aircraft.

PROJECTED PERFORMANCE

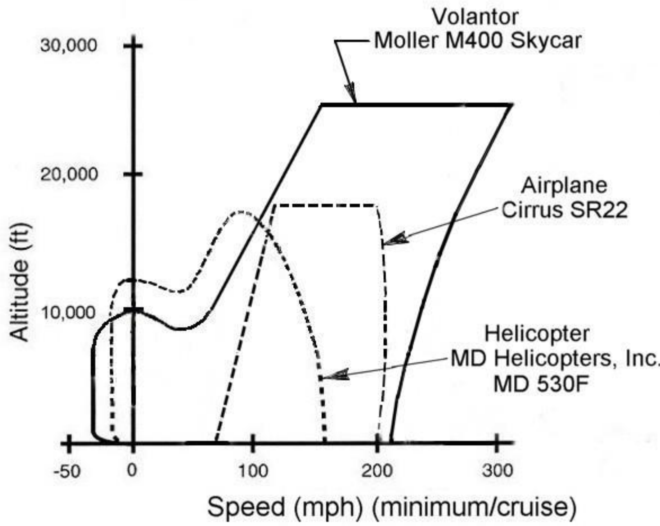
The Skycar® performance exceeds that of any light helicopter, including a top speed that is up to three times faster. When compared to a high-performance airplane, the Skycar® has vertical takeoff and landing capability, is safer and potentially less expensive. The performance boundaries of the Skycar® are much less restrictive than those of both helicopters and airplanes. These expanded operating limits are the natural consequence of combining VTOL and high-speed cruise in a single aircraft. The resulting flexibility allows many transportation applications to be addressed for the first time. The figure to the right compares the projected performance envelope of the Skycar® 400 with the performance envelope of a helicopter and a high-performance airplane.

POWER REQUIRED

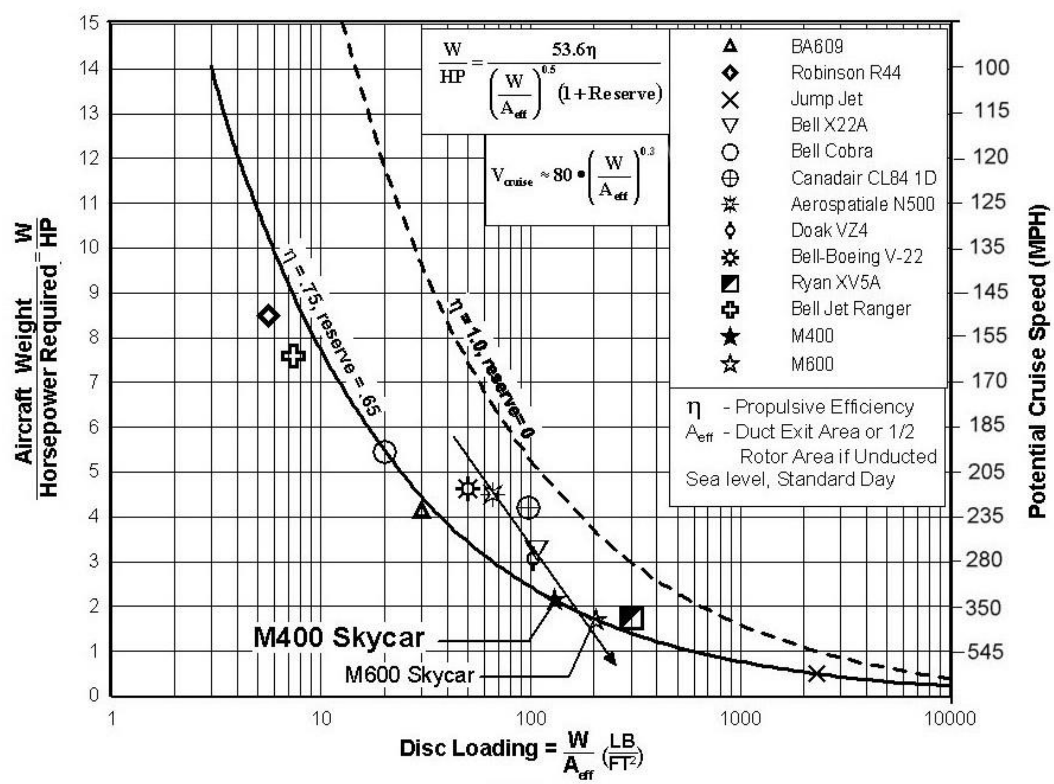
All existing VTOL-capable aircraft have installed power requirements that relate directly to the maximum speed at which the aircraft can fly efficiently for a specific vehicle weight. The parameter that characterizes this relationship is disc loading, which is vehicle weight divided by lifting fan area. Helicopters have low disc loading, low maximum speed and low installed power. Harrier-type VTOL aircraft have high disc loading, high maximum speed and high installed power. Between these two extremes are unducted fan aircraft such as the V-22 Osprey and ducted fan aircraft such as the Skycar® volantor.

For larger rotors or fans, the energy lost from air “short circuiting” from the higher pressure downstream of the fan to the lower pressure upstream is small. As fans become smaller and the disc loading increases, the losses become significant. As a disc loading of approximately 100 lbs/ft², surrounding the fan with a close-fitting duct becomes advantageous to overall propulsive efficiency.

The volantor’s much higher disc loading than the helicopter dictates that it will require more than three times the installed power for the same lift per horsepower. This requires the use of a powerplant like the Rotapower® engine that can achieve a high



horsepower output per pound of engine weight together with a low engine cost per in horsepower. The figure below documents that there are no magical short cuts to generating viable VTOL aircraft. If one wants to operate at a Skycar® aircraft’s speed and payload then the type of aircraft to achieve that goal is identified (ducted fan) as is the appropriate disc loading (~150 lbs per ft²).



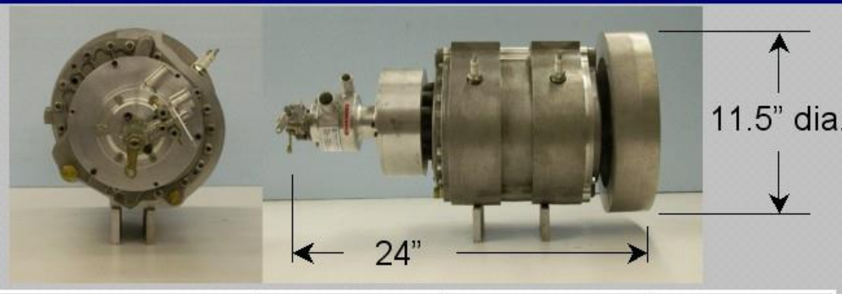
ENGINES

Moller International has acquired and developed proprietary technology enabling the company to manufacture high-performance, low cost Rotapower engines producing more than two horsepower per

Engine Comparisons

November 3, 2004
Reno, NV

Rotapower® Engine versus other powerplant alternatives



	Rotapower Engine(1)	Aircraft Piston(2)	Automotive Piston(3)	Turbine(4)
Maximum Power	160 hp (emergency)	150 hp	190 hp	125 hp
Continuous Power	120 hp @ 7,000 RPM	150 hp @ 2,700 RPM	190 hp @ 7,600 RPM	125 hp
Weight	70 lbs (includes fan hub)	243 lbs	253 lbs	72 lbs
Volume	2 ft^3	12 ft^3	9 ft^3	1.8 ft^3
Frontal Area	0.75 ft^2	3 ft^2	4 ft^2	.9 ft^2
Major Moving Parts	3	42	28	1
SFC (Gasoline)	.4 lbs/hp-hr (Supercharged diesel cycle)	.45 lbs/hp-hr	.4 lbs/hp-hr	.69 lbs/hp-hr
Radial Balance	Yes	No	No	Yes
Engine Response	Rapid	Modest	Modest	Poor
Cost Per Horsepower	$25	$160	$20	$800

(1) Rotapower 900cc (1.8 liter 4-stroke equivalent); (2) Textron-Lycoming 0-320; (3) Toyota 2ZZ-GE (1.8 liter); (4) Williams WTS 117

pound of engine weight. This power-to-weight ratio is essential for ducted fan VTOL applications such as the Skycar. The engine's round shape and small size allow it to be placed in the center of the duct behind the fan hub where it directly drives the fan without a gearbox, reducing weight and complexity.

WHY IS A PRACTICAL VOLANTOR LIKE THE SKYCAR® NOW FEASIBLE?

The Skycar's ability to take off and land vertically and still maintain a useful payload and range, places an extraordinary premium on its use of lightweight components and materials. Three current technologies govern the Skycar's weight and therefore, its viability.

- **Powerplants**—the Company's Rotapower® engines provide the required attributes for this type of aircraft. Their features include small frontal area to minimize duct drag, perfect radial balance to allow hard mounting, high power for a given weight and volume, a history of reliability, and most importantly, low cost per horsepower generated.

- **Materials and material processes**—composite materials can have strength greater than the strongest alloyed metals while weighing less than the lightest metals. Their use provides the opportunity to minimize airframe weight. Composite materials can be used to generate complex aerodynamic configurations with minimum tooling. They also provide inherent noise dampening and a sealed structure for cabin pressurization.

- **Avionics**—the stabilizing computers, sensors, fly-by-wire controls, communications hardware, etc., must achieve high performance at a reasonable cost. They must be lightweight, small, reliable, and require low power if they are to meet the goals of a practical volantor. Avionic components have undergone dramatic performance and cost improvements and continue to do so.

UNIQUE FEATURES

The Skycar® is classified as a powered-lift aircraft. It uses multiple thrust-generating nacelles. Each nacelle encloses two counter-rotating fans driven by separate engines. This arrangement ensures that as long as one engine is operating in each nacelle, thrust will be available to provide stability and control during hover and transition from forward flight.

Sensors that measure angular rate, angular acceleration and attitude are used to determine the precise position and motion of the Skycar® in relation to the desires of the pilot. This sensor information is used to electronically maintain stability and control by automatically adjusting power levels of each engine to decrease or increase local thrust as required.

Moveable vanes (variable camber) mounted behind the engines in a patented configuration deflect the thrust to control the direction of flight: vertical, horizontal, banking, turns, etc. –no ailerons, flaps, nor elevators are needed—the speed of each engine determines the local, instantaneous thrust level while the vanes provide the local, less time-sensitive thrust direction. In addition to the vane deflection system, the nacelles rotate through approximately 45° during takeoff and landing. In combination with the vane deflection system this provides very efficient vertical thrust for vertical takeoff, landing and hovering. As forward speed increases the nacelles will rotate from their initial position to horizontal followed by reducing the vane deflection from 45° to near 0°. Since the nacelles reach the horizontal position at relatively low forward speed, leading edge lip stall (flow separation) is prevented.

OPERATOR REQUIREMENTS

The FAA has established a "powered-lift" pilot's license. This, together with a thorough familiarization with the flight controls of the Skycar, will be required for its safe operation, primarily to ensure adequate flight management and navigational skills. A Skycar® is not piloted like traditional fixed or rotary wing aircraft. It has only two hand-operated controls that the pilot uses to direct the redundant computer control system to carry out his or her desired flight maneuvers.

The left hand control twists to select desired operating altitude and moves fore and aft to select rate of climb and descent. The right hand control twists to select direction and moves side to side to provide traverse movement during hover and early transition. This same control moves fore and aft to determine speed and braking.

STREETABLE ISSUES

Ultimately, the Skycar® aircraft is designed for use from existing heliports and new, small "vertiports" located in urban and suburban areas. In many cases this will require traveling on surface streets for short distances, therefore the Skycar® has been designed to allow for use on conventional roads at low speed (< 30 mph). To accommodate this use, the maximum folded width of the production Skycar® 400 is 8.5 ft., which meets the Department of Transportation's (DOT) size requirement for highway use. The Skycar® will conform to other automotive conventions where possible, but, for example, it would not be practical to meet the crashworthy requirements of the DOT. Fortunately

operational requirements are left up to the states to decide. For example, most states treat three wheel vehicles as motorcycles, which avoid DOT crashworthy requirements. Virtually all states have a speed limit below which vehicles can operate without meeting these requirements. Generally this limit is the city street speed limit. While a future variance may be possible it is comforting to know that the Skycar® will have the legal opportunity to operate on city streets as long as it has adequate brakes, steering and lighting. It is anticipated that ground motive power will be provided through the wheels.

ECONOMIC COMPARISON

It is anticipated that the Skycar® will appear in a military role first. For that reason the following comparison includes some alternatives that are or may be available to the military. Large helicopters and tilt-rotor aircraft have the one advantage over the Skycar® of being able to carry a large single piece payload. This advantage vanishes for a specific payload if it can be distributed into smaller packages that can be transported by a Skycar-type volantor. The following figure shows that the Model 400 and 600 Skycars are far more efficient as VTOL transport vehicles versus large VTOL aircraft. It is projected that the Skycar® 400 can be sold for $500,000 at levels of 1,000 units per year. Even at an initial unit price of $1 million the Skycar 400 is still five times less expensive than the V-22 Osprey in net tons of payload delivered relative to its acquisition cost.

	NET PAYLOAD[1] / ACQUISITION COST $\left(\frac{\text{Tons}}{\text{Million (\$)}}\right)$	NET PAYLOAD x SPEED[2] / ACQUISITION COST $\left(\frac{\text{Tons x MPH}}{\text{Million (\$)}}\right)$	NET PAYLOAD x RANGE[3] / FUEL CONSUMPTION $\left(\frac{\text{Tons x Miles}}{\text{Gallons}}\right)$
Skycar® 400 ($500,000 cost)	.75	172	5.7
Skycar® 600 ($750,000 cost)	.83	208	5.4
V-22 Osprey Tiltrotor	.075	21	1.16
Sikorsky H60D Heavy helicopter	.14	21	2.9
MD 520N Medium helicopter	.825	127	2.9
Robinson R44 Light Helicopter	1.15	145	2.75
BA 609 Tiltrotor	.15	47	4

FOR COMPARISON WITH FIXED WING AIRCRAFT

Cirrus SR20	1.5	230	5.25
EADS TBM 700	.8	280	5.2
Mooney Bravo M20M	.8	182	5.23
Lancair Columbia 400	1.15	203	6.51
Cessna T182T	1.07	136	3.91
Adam A500	.84	203	5.04

[1]Net payload is useful payload minus fuel. [2]Uses 45%-55% power for speed and range.[3]Assumes all aircraft operate with sufficient fuel for 750 mile range

CERTIFICATION

Moller International is currently working with the FAA to obtain certification of the Skycar® under the "powered-lift normal" category. A team of FAA personnel and industry representatives drafted the original airworthiness criteria to govern the certification tests. Moller International was a member of that team.

SKYCAR® AVAILABILITY

The Skycar® is currently undergoing flight-testing. Please see our web site (www.moller.com) for the latest deposit information and updates, or contact us via e-mail at info@moller.com.

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