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Personal V/STOL Aircraft

Volantor-A Powered Lift Aircraft for Personal Use

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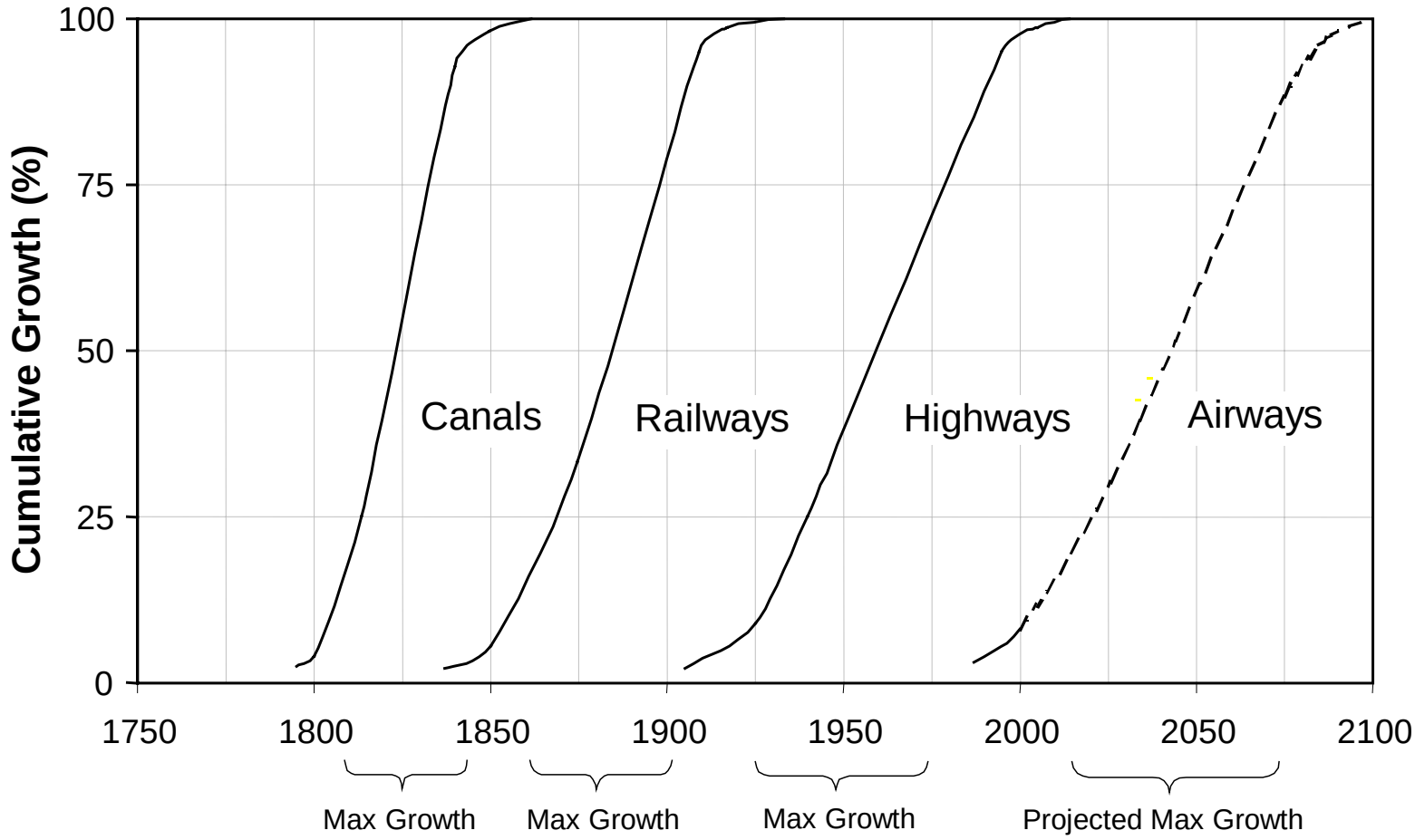
Dr. Daniel Goldin—Past NASA Director and Administrator, has set down a powerful National General Aviation Vision:

"*Enable doorstep-to-destination travel at four times the speed of highways to 25% of the nation's suburban, rural and remote communities in ten years and more than 90% in 25 years*."

In another speech before the International Automotive Roundtable, he said:

"*You know? Not only will we have personal travel on the ground but we will have personal travel in runway independent aircraft: and those runway independent aircraft perhaps will cost in volume production what it might cost to build a high-end luxury car*."

Cumulative Growth of U.S. Transportation Infrastructures



Travel Statistics

- 91% get to work by road
- 3.3 million workers travel 50 miles one-way
- 75% of all freight value is by truck
- 33% of all miles traveled is 50 miles or more one-way

Personalized Airborne Transportation Requires:

- Volantors that are economical and convenient
- Highway in the Sky infrastructure
- Congress to reprioritize aeronautics at NASA and elsewhere

Volantor Desired Attributes

- VTOL capable
- Safe
- Reliable*
- Easy to operate
- Modest direct and indirect cost
- Low emissions and fuel consumption
- Quiet (< 75 dba @ 50 ft. for vertiport operation)

* Improved by eliminating gearboxes and variable pitch fans

Skycar volantor

Fast (> 300 mph)
4 passenger
Economic in air

Neuera volantor

No pilot's license
Low cost

Autovolantor

Economic on the ground

Volantors are Dependant Upon Evolving Technologies

- Powerplants (key)
- Materials and material processes
- Avionics

Design Elements of Volantor Technology

- Simple pitch and roll control through engine RPM changes
- Elimination of need for gearboxes and gear train
- Elimination of need for variable pitch fans
- Ability to tolerate an engine failure during hover
- Engines capable of producing over 2 hp per lb of engine weight
- Low cost per horsepower for engines

Safety Features of Volantors

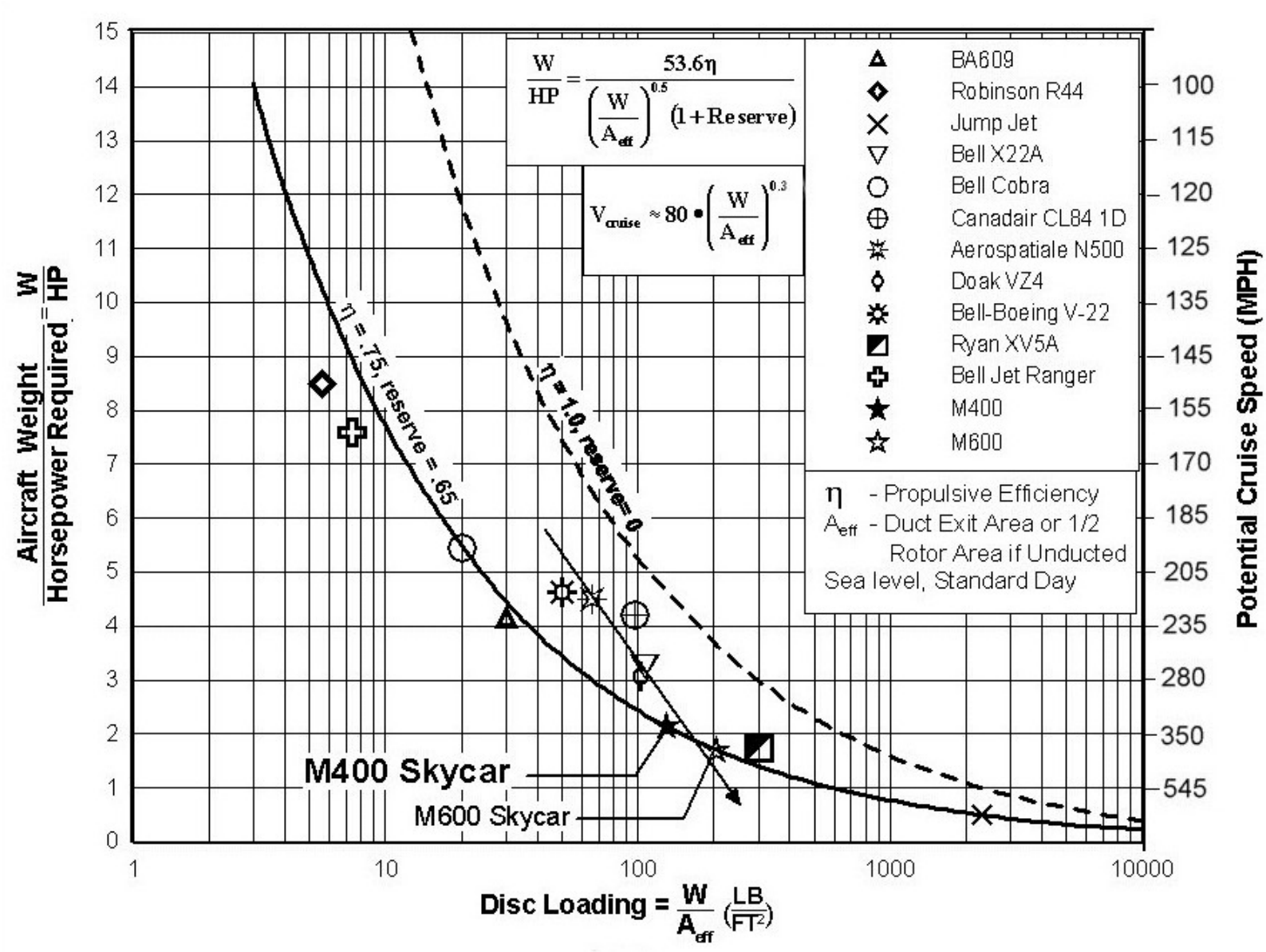
- Redundant artificial stability system and fly-by-wire controls
- Reliable and simple rotary engines
- Enclosed fans provide lower risk of injury
- Redundant fuel monitoring
- Multiple engines (8) allows one-engine-out during hover

Skycar Volantor Design Considerations

- Efficient operation over large range of altitudes
- Safe operation over large range of speeds
- Roadability
- Limited fan diameter (high disc loading)

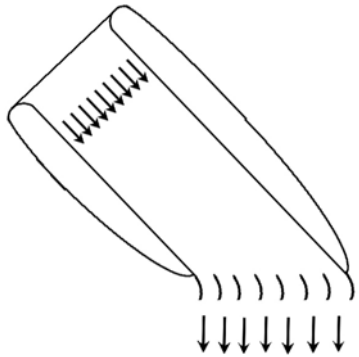
Consequences of Higher Disc Loading

- Higher cruise speed
- Less sensitive to weather conditions
- Slipstream effects more localized
- Low inertia fans allow simple roll and pitch control
- **Higher installed power**

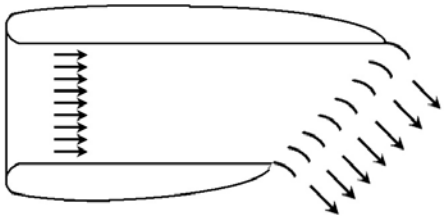


Skycar requires 710 hp to hover at 2,400 lbs
or 1,155 hp with necessary reserve

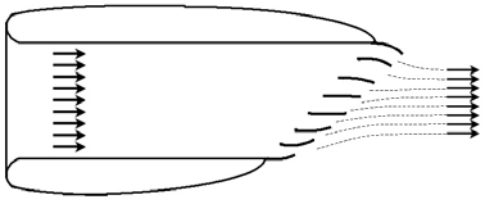
Advantages of Partially Rotating the Nacelles and Adjusting Exit Area



VTOL



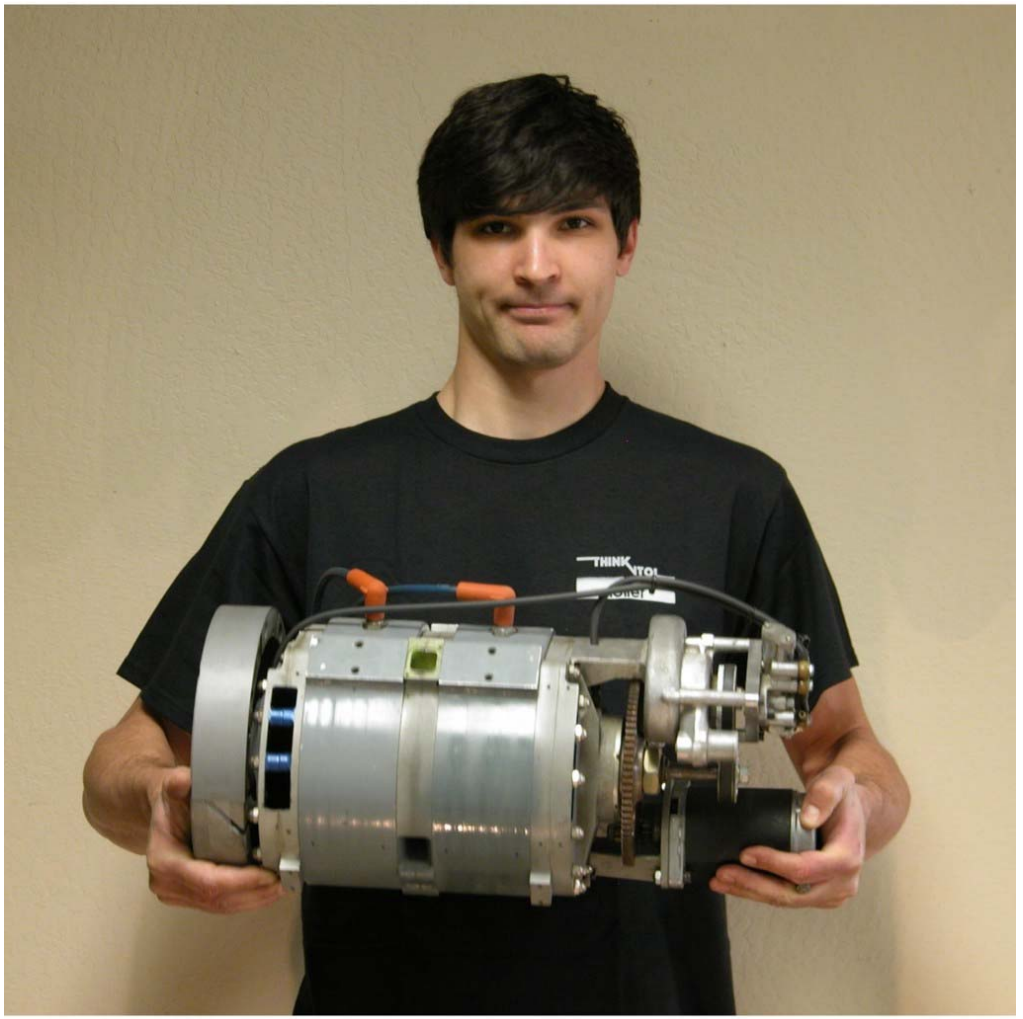
Transition



Cruise

- Reduces FOD
- Disc loading is reduced in hover
- Eliminates need for variable pitch fans
- Reduces pressure loss through duct during cruise

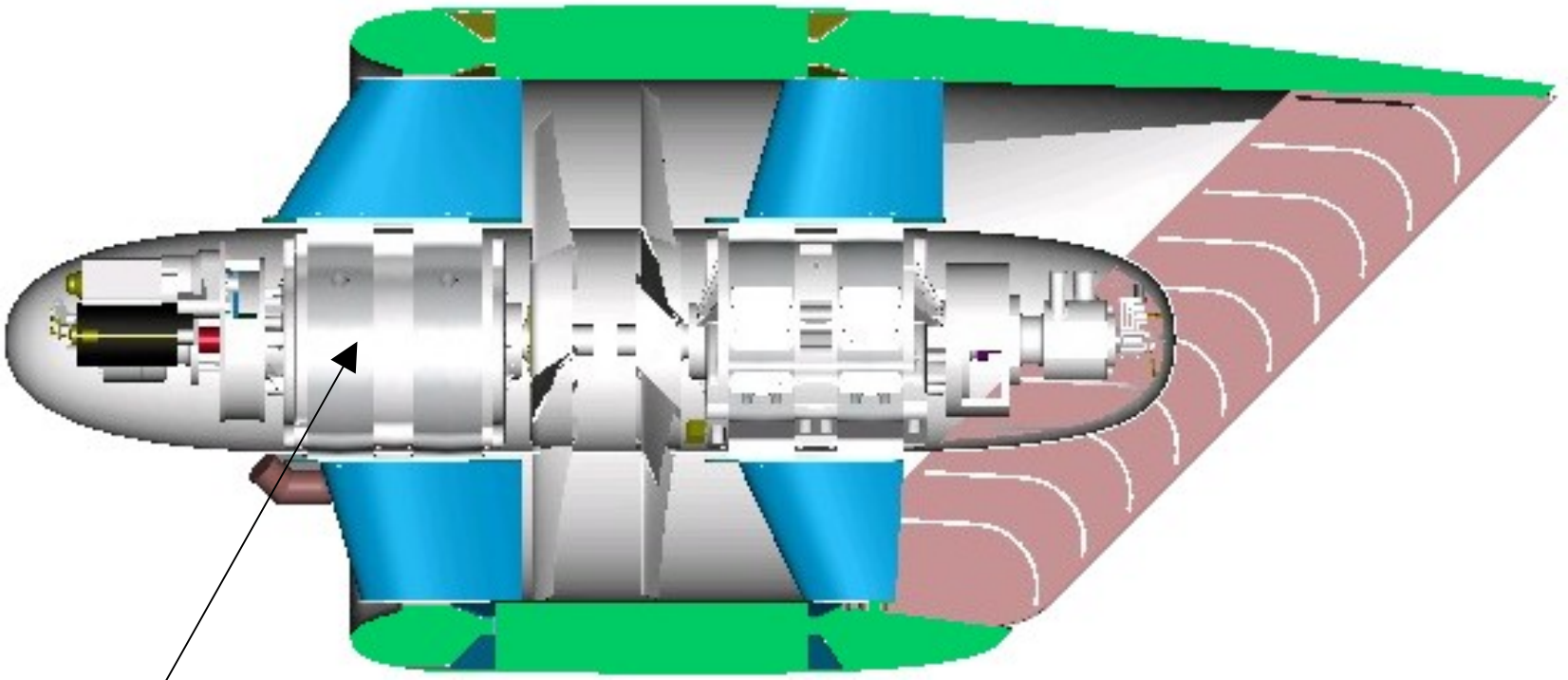
Skycar Volantor Powerplant



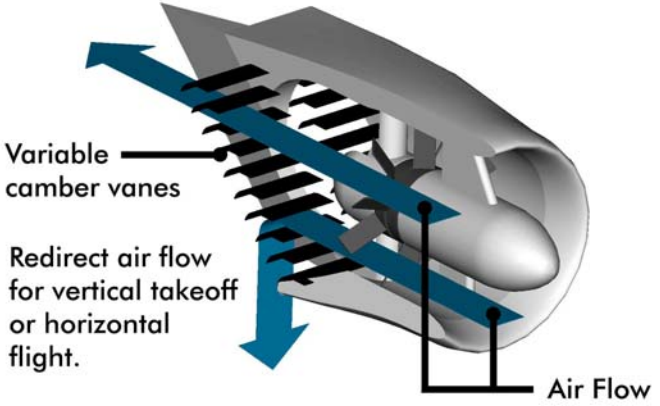
Model Shown:
Two Module Version

Power	- 160 hp
Weight	- 68 lbs
Volume	- 0.9 cu. ft
Displacement	- 450cc per module
Options	- 1 to 9 modules

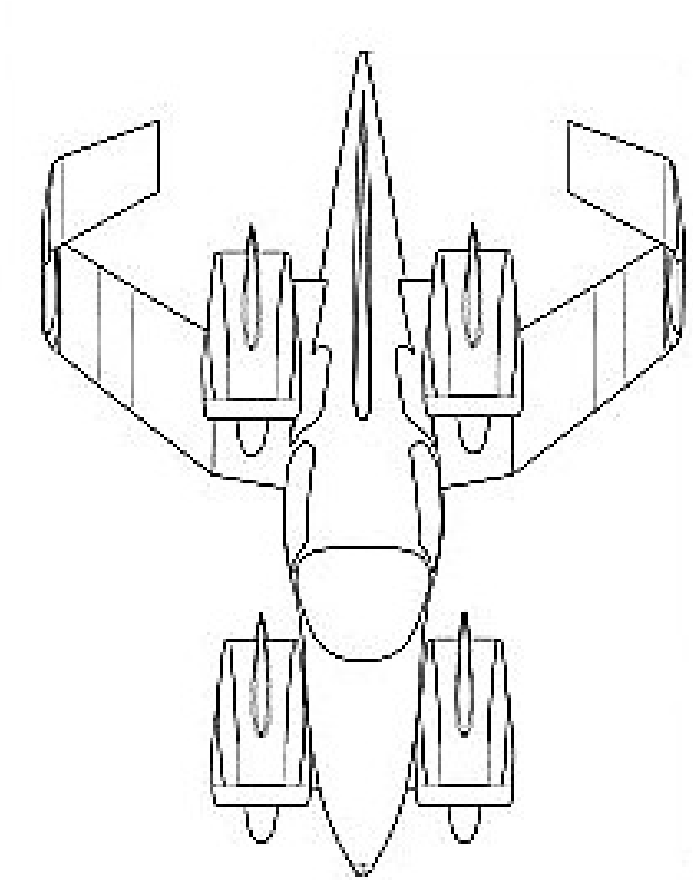
Lift/Thrust Nacelle Configuration



90 hp (145 hp boosted)



Airframe Configuration



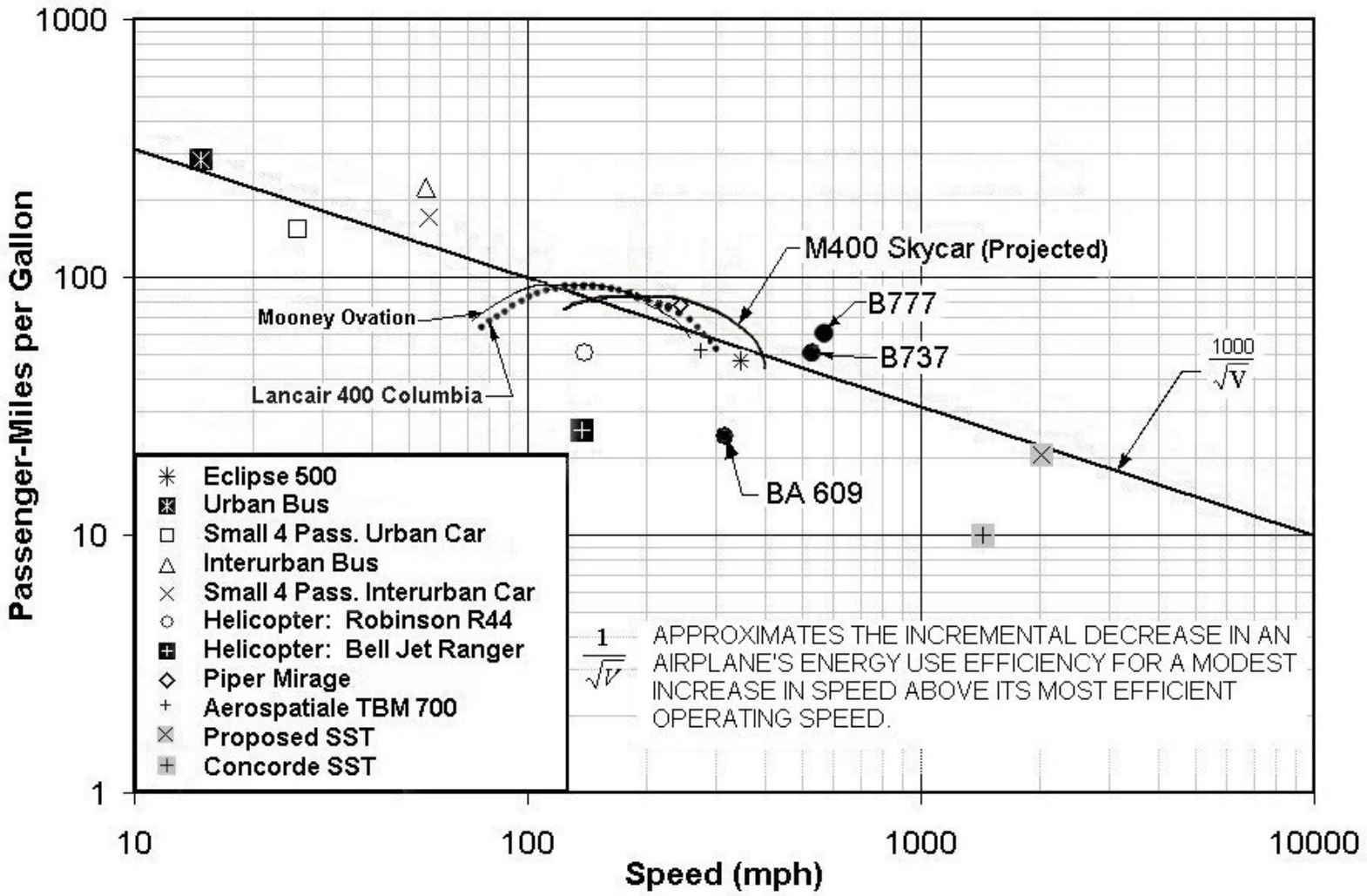
Wing configuration evolved for the following reasons:

- Volantor is stall resistant
- Cockpit access and visibility improved
- VTOL flight possible with wings folded
- Maximum width is 8.5 feet (wings folded)

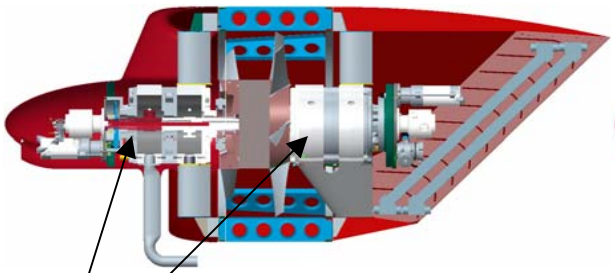
Skycar volantor challenge: Achieve 100 passenger miles/gallon @ 250 mph

- Skycar Advantage:
  - Higher wing loading allows an equivalent flat plate drag < 2 ft^2
- Skycar Disadvantage:
  - Weight penalty due to higher installed power
  - Mismatch between power required for hover and that for cruise

Performance Above Transition

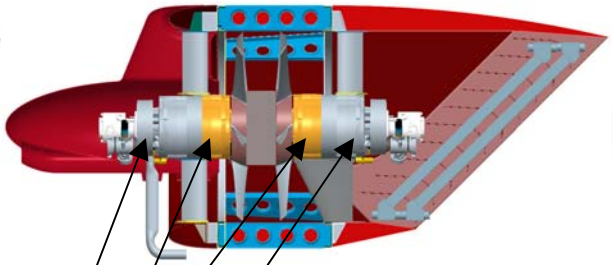


Rotapower Engines (only)



Rotapower Engines (145 hp each)

Option 1
Electric Motors for Reserve Power

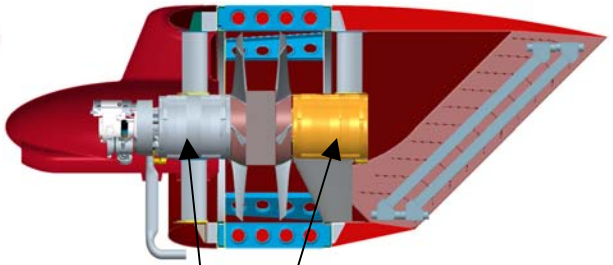


Rotapower Engine (90 hp)

Two Electric Motors (55 hp each)

Rotapower Engine (90 hp)

Option 2
Rotapower Engine for Cruise Only



Electric Motor (150 hp)

Rotapower Engine (100 hp)

Providing complementary power from batteries or ultra-capacitors			
	Lithium Ion & Iron phosphate	**Lithium Ion & Cobalt oxide**	**Ultra-Capacitors**
Energy (Watt hr/LB)	**50**	**82**	**5**
Power (Watts/LB)	**1,800**	**180**	**5,000**
Est. Cycle Life	**>10,000**	**<750**	**Indefinite**

Option 1 – Battery/motor provide only reserve power:

Weight for required power (LB)	**76**	**760**	**27**
Hover time – engine failed (Seconds)	**76**	**Not possible**	**8**

Option 2 – Engines provide only enough power required for efficient cruise:

Weight for required power (LB)	**206**	**2060**	**73**
Hover time (Seconds)	**87**	**Not possible**	**9**
Hover time – engine failed (Seconds)	**75**	**Not possible**	**7.5**

Hybrid Skycar Upside Conclusions

- ~15% increase in payload
- Improved starting sequence
- Improved engine efficiency in cruise (improved passenger miles per gallon)
- Potential for ~35% increase in payload (in future)

Hybrid Skycar Downside Conclusions

- Option 2 (engines provide cruise power only) limits ability to hover for more than a minute
- Additional systems to manage with more components to qualify and maintain
- Considerable risk in technology development
- Potentially more expensive

Autovolantor Specifications

Autovolantor

Skycar Volantor (Hybrid)

	Autovolantor	Skycar Volantor (Hybrid)
AUW	2400 lbs	2400 lbs
Fuel Capacity	12 gallons	40 gallons
Range	350 mi (50 mi flight)	750 mi
Net Payload	400 lbs	850 lbs
Passengers	2	4

The Skycar hybrid model was presented at the 2007 SAE Aerotech Congress & Exhibition and provides a basis for the autovolantor's design

Autovolantor Design Criteria

- Must be esthetically appealing (contract)
- Carry two passengers side-by-side
- Combined range ~350 miles (50 miles in the air)
- Ground range on batteries ~ 40 miles
- Minimal skill to operate (artificial stabilization in hover)
- Aerodynamically stable in forward flight

Autovolantor Design Approach

- Maximum hover and transition time is 90 seconds
- Installed Engine power is that required to operate efficiently during flight
- Hover and transition power are derived from both battery/motor drive and engines
- Short ground trips will utilize only battery/motor drive
- Long ground trips will utilize series hybrid drive

Autovolantor Conclusions

- A hybrid type two-passenger autovolantor is shown to be technically feasible
- Most efficient airborne cruise speed is 135 mph
- Minimum time to transition from take-off to cruise speed and immediately land is 22 seconds (90 seconds available)
- Maximum airborne range is 104 miles
- Fuel consumption during flight is 4.6 times higher than during ground travel
- 12 gallon fuel capacity provides 352 mile combined range (50 miles in air)
- Ground range on battery is 35.5 miles

Disruptive technology goes through three phases:

- First it is ridiculed by those ignorant of it potential;
- Next it is subverted by those threatened by it potential;
- Finally it is seen as self-evident