

# ***Autovolantor – An Automobile That Can Occasionally Operate Above Traffic***

## **Flying Cars**

(Session WATC24, 2:00 pm, Room 208)

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# Objective

- Determine the feasibility and performance of an automobile that can exit traffic vertically and then maintain aerodynamic flight for some distance

# Design Criteria

- Must be esthetically appealing
- Carry two passengers side-by-side
- Ground range ~ 150 miles
- Airborne range ~ 75 miles
- Minimal skill to operate (artificial stabilization in hover)
- Aerodynamically stable in forward flight
- Useful ground range on batteries alone (goal: 40 miles)

# Elements To Be Evaluated

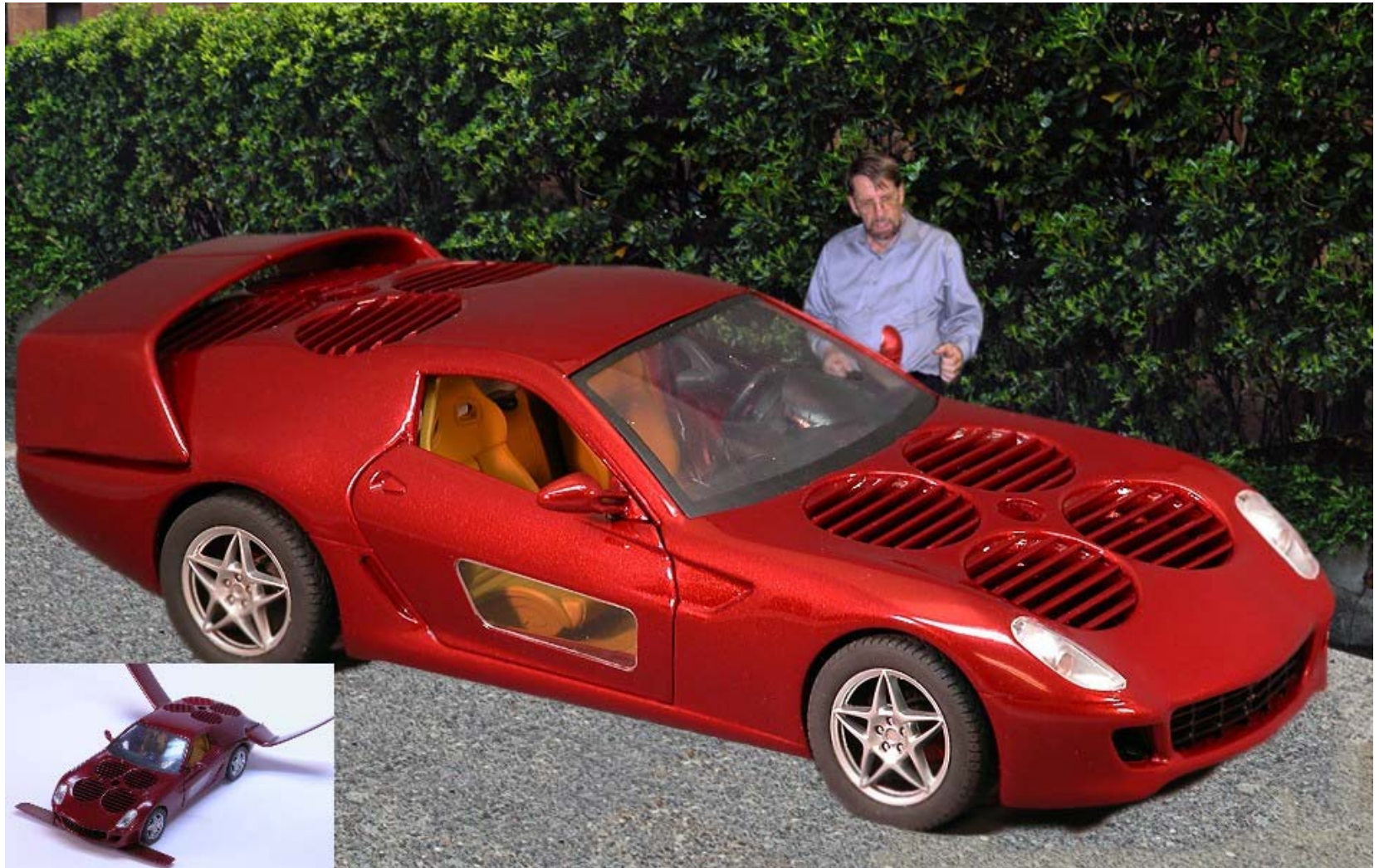
- Configuration to achieve esthetic appeal on ground
- Lift / Drag Ratio
- Aerodynamic stability
- Roll control moment in hover
- Power and energy required
- Air and Ground range

# Wind Tunnel Models

(design based on Ferrari 599 GTB)



# The Autovolantor



*Composite image of autovolantor*

# Weight Considerations



Autovolantor



Skycar Volantor\*

Fuel Capacity

16.5 gallons

40 gallons

Net Payload

375 lbs

855 lbs

Autovolantor has 618 lbs available for suspension and ground drive assuming it weighs the same as the 2,400 lb M400 Skycar

\*Hybrid version where 60% of installed power is from a battery while other 40% is from rotary engines.

# Wind Tunnel Tests

## (Power Off)

- Aerodynamically stable in pitch and yaw (small margin)
- Maximum L/D ratio ~ 5 at 135 mph and 2,400 lbs
- Extended rear wing required to achieve stability
- Canard increases maximum L/D from 3 to 5

# Power Required

- **Forward Flight = 250 hp** from rotary engines  
(320 hp installed, Propulsive Efficiency  $\eta = .7$ , L/D=5 @ 135 mph)
- **Hover Power = 670 hp**  
(Propulsive Efficiency  $\eta = .74$ , Disc loading =  $\frac{W}{A_{\text{exit}}}$  120 lbs/ft<sup>2</sup>, 320 hp from engines, 350 hp from electric motors for 90 seconds)

Allowing 20% reserve for engine failure, acceleration, and control, installed power is ~800 hp or 320 hp from engines and 480 hp from electric motors for 30 seconds

# Roll Control Power

- Moment of Inertia for 2,500 lb car is approximately 5,000 lb-ft<sup>2</sup>
- Control power about roll axis assuming 15% excess thrust is 360 ft-lbs

	Angular Acceleration	History
Autovolantor	2.31 rad/sec <sup>2</sup>	None
X-14A	.7 rad/sec <sup>2</sup>	4 crashes
XC-142 & VJ101C	1.2 rad/sec <sup>2</sup>	successful

# Battery Needed to Meet Energy Requirements

- Altrairnano energy density = 90 watt-hr/kg
- Energy conversion efficiency from battery to fan = .8
- Electrical power for take off and transition (90 sec) = 350 hp / .8 = 438 hp
- Battery weight = 200 lbs

# Battery Needed to Meet Power Requirements

- Altairnano claims a battery with power density = 5,500 watts/kg
- Emergency electrical power (30 sec) = 480 hp / .8 = 600 hp
- Battery weight = 179 lbs to achieve required power

# Fuel Consumption

- Assumptions:
  - SFC = .4 lb/hp-hr
  - Conversion efficiency from engine to wheels = .7
  - Power required at wheels at 65 mph = 18 Kw = 24 hp
- Fuel required for airborne range of 75 miles = 56 lbs (to recharge batteries = 4 lbs; rotary engines during flight = 52 lbs)
- Fuel required for ground range of 150 miles = 32 lbs

# Summary Fuel Consumption

## TOTAL FUEL USEAGE FOR 225 MILE RANGE

88 lbs = 14.7 gallons

(provides a 11.1% reserve)

For 75 mile flight plus 150 mile ground = 15.3 mpg

For 10 mile flight plus 150 mile ground = 22.1 mpg

Range on batteries alone = 20 miles

(assumes 85% discharge)

# Conclusions

- A specialized sports car called autovolantor that can rise vertically above traffic and then fly for some distance is shown to be possible.
- The autovolantor combines the attributes of the hybrid powered Skycar volantor with those required for the Plug-in Hybrid Electric Vehicle (PHEV).
- Doubling battery energy storage over the next two years would provide the autovolantor with a battery-powered ground range of 40 miles.\*

\*Design goal of many PHEVs including the GM Volt