# KEY CHARACTERISTICS OF A WINNING CARPLANE

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## ABSTRACT

A cost competitive carplane (aka roadable aircraft or flying car) that meets all pertinent safety and regulatory requirements is eminent. At the current time there are ten different organizations that have some sort of carplane under development. These proposed vehicles have a wide variety of anticipated operational characteristics. But what characteristics are the important ones for this new dual-mode means of travel? Air Speed? Ground Speed? Operational Cost? Range? Payload? Seating Capacity? Take-Off and Landing Distance? This paper takes a rational look at these and other operational characteristics and prioritizes them based on market need.

The paper builds on previous work by the author pertaining to carplanes, including: "A Proposed Transportation System for Roadable Aircraft" presented at the 2010 Transportation Research Board Annual Conference (1). Information contained on the author's website www.carplanenews.com is also utilized as a basis for this article.

Carplanes, which are on our doorstep, represent a completely new mode in the transportation industry. Those carplanes that provide the key operational characteristics consumers want, at an acceptable price, will be the ones that dominate the market by providing suitable competition to current single-mode means of travel. When consumer needs are met by this "winning" carplane a revolution will occur in ground transportation.

**INTRODUCTION**

So far, traffic engineering has essentially been a two dimensional problem – but that's about to change. With the introduction of vehicles such as the Terrifuga Transition and the ITEC Maverick, sustained production of a cost competitive carplane (a.k.a. flying car, roadable aircraft) that meets applicable safety standards - both on the ground and in the air - is now eminent. As one might expect, our highway system and air traffic control system are not presently arranged in a manner conducive to widespread roadable aircraft operation. That's a nice way of saying that nobody, in any country, is taking these emerging vehicles and their effect on our transportation system seriously - at least not yet. System considerations often lag technical innovation, so it will undoubtedly be the case that a coordinated system for efficiently handling carplanes will develop only after these vehicles start causing operational problems by doing such things as landing on back roads or flying at low levels over populated areas.

It's time to start imagining what an integrated transportation system that includes carplanes might look like, both in the short term when carplanes are little more than a potentially annoying curiosity, and in the long term when carplanes blanket the sky. It's also time to start envisioning the operational characteristics that a "winning" carplane will have. Let's start by looking at carplanes that are either on the market or are currently being developed. It's interesting to note that some of these vehicles are neither cars on the ground nor planes in the air, but they share the dream of seamless transition from drive mode to flight mode and back again - so they still warrant classification under the generalized "carplane" moniker.

**THE CURRENT CONTENDERS**

Table 1, which is adapted from the www.carplanenews.com website, summarizes the operational characteristics of nine commercially produced carplanes that are either available now, will be available in the very near future, or have a prototype vehicle that is being tested. The tenth carplane described in the table is a US Army military endeavor that is expected to result in an operational vehicle by the end of 2015.

A review of the table shows some natural groupings of carplane types. The first two carplanes listed in the table (the Super Sky Cycle and the Pal-V One) are gyroplanes in the air and 3-wheeled motorcycles on the ground. The third carplane listed (the Switchblade) is also a 3-wheeled motorcycle on the ground but uses an airplane-type airfoil design in the air. The fourth and fifth carplanes listed (the Maverick and the Skycar) fly as powered parachutes and drive as four-wheeled off-road capable automobiles. The sixth, seventh and eighth carplanes listed (the Transition, BiPod and Gmbh) use airplane-type airfoil designs in the air and are four wheeled “non-off-road” cars on the ground.

Carplane ideas have come and gone in the past, with a few actually flying, but for one reason or another they have remained novelty vehicles with no real market penetration. However, we are now at a point in the production of powerful lightweight engines, the development of advanced aerodynamic designs, and the availability of sophisticated GPS-based vehicle positioning and control systems wherein the design and manufacture of a practical carplane is quite doable. Here are the ten current contenders:

1. **The Butterfly Super Sky Cycle** - This is really a “motorcycle-gyroplane”, not a “car-plane”, but I have included it because it is available right now in kit form for about $60,000 US and it does indeed “drive and fly”. In fact, it was “driven & flown” to the Sturgis motorcycle rally in Sturgis, South Dakota, US back in 2010. A gyroplane looks a little like a helicopter (with a “whirlybird’ rotor on top) but takes-off and lands more like an airplane. However, takes-offs and landings can be accomplished in a much shorter distance than with a standard airplane airfoil design, Both its land and air speeds are decent but having only one seat and being a kit that you have to finish yourself are major drawbacks. Additional drawbacks include having to secure both a gyroplane license and a motorcycle license and being exposed to the weather.

2. **Pal-V Europe -** This is also a "motorcycle-gyroplane" rather than a "car-plane", but having a two person enclosed three-wheeled motorcycle as the ground vehicle rather than the single person open cockpit of the Super Sky Cycle. The expected maximum speeds of this vehicle are good at 112 mph (180 kph) on the ground and in the air and they supposedly have a prototype that has actually flown. However, with an anticipated kit price of $300,000 US it is much more expensive than the Skycycle.

For ground operations both the rotor and rear-facing prop fold as the tail and the support members become "tight" to the body.

3. **The Samson Switchblade –** This will be a “motorcycle-plane” rather than a “car-plane”, having a two person enclosed three-wheeled motorcycle as the ground vehicle. However, the air vehicle will have standard airplane characteristics rather than being a gyroplane with a rotor. The expected speeds of this vehicle are outstanding at 90 mph on the ground and 200 mph in the air. With an anticipated kit price of only $85,000 US it would be a high performance vehicle at a very attractive price point. The problem is that, so far, they just have a ground prototype that hasn’t flow one nautical mile. Since it has standard airplane airfoil characteristics it requires a longer distance to take-off (1600 feet).

The wings fold under the body and the rear tail becomes “tight” to the body for ground operation.

4. **The ITEC Maverick –** This is really a "car-powered parachute", not a "car-plane", but it has the basic capabilities of a carplane and it only costs $84,000 US (completely assembled, not a kit). It was developed for use in the jungle where the road system is discontinuous so it looks and drives like a fast 3-person dune buggy on the ground. It takes-off and lands in relatively limited space using a parachute for lift and a rear-pointing propeller for power while in the air. The major disadvantage is that the Maverick is slow in the air with a maximum air speed of only 40 mph (64 kph). That's fine if you just want to have fun and cruise around but it keeps the Maverick from being a competitive transportation alternative unless you live in an area where roads don't go directly between origins and destinations - such as near large bodies of water, mountains, or other geographical restrictions. It might also be an attractive ride if you live in an area where traffic congestion is so bad that 40 mph (64 kph) is a decent speed.

5. **The Parajet Skycar –** This is also a “car-powered parachute”, not a true “car-plane”. It is very similar to the Maverick. A few years ago they “drove and flew” the prototype vehicle from London, England to Timbuktu in Africa but they have been strangely silent on development activities over the past couple years.

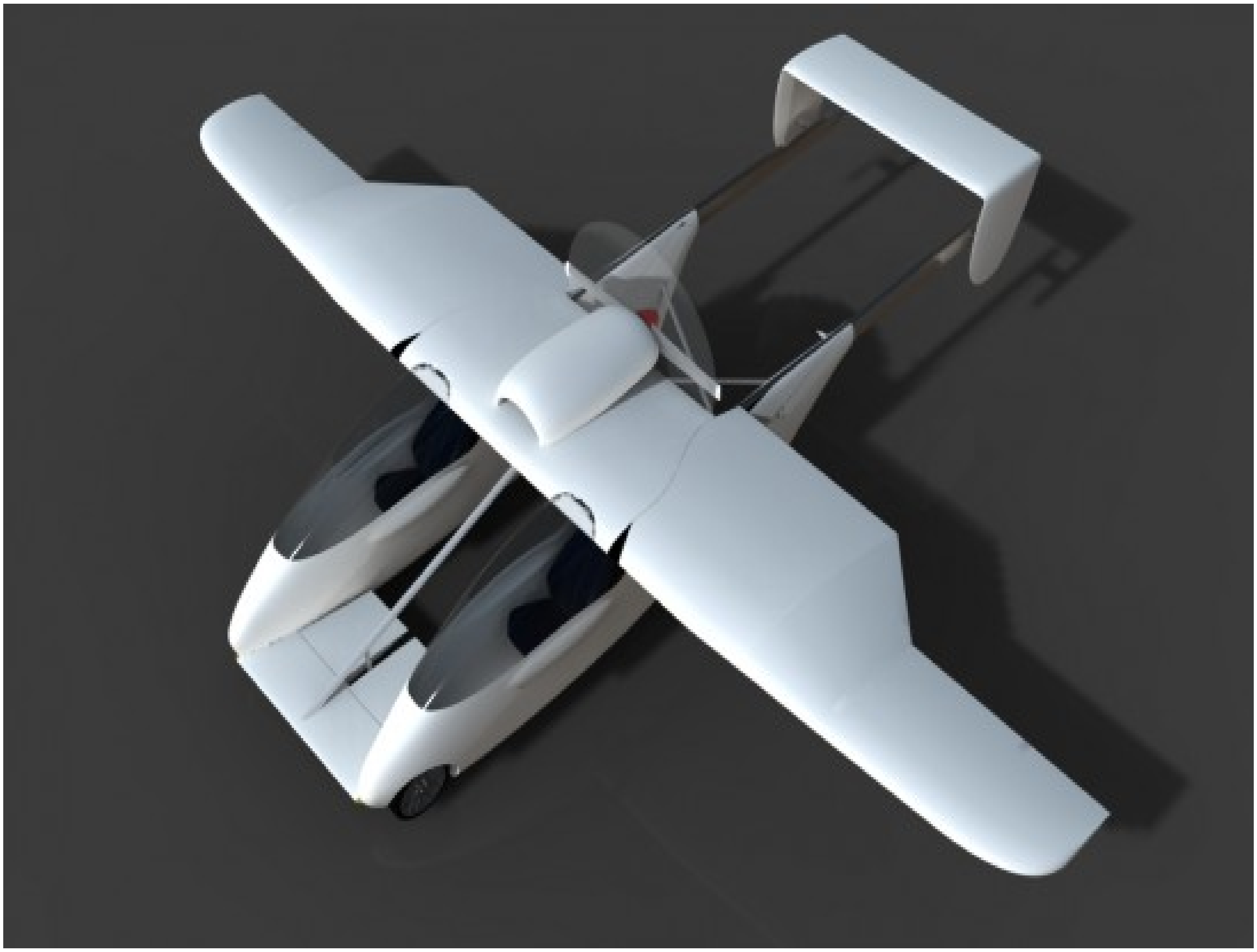
The body style is currently being modified so what you see here will soon be the old version of the Skycar.

6. **The Terrifuga Transition –** This should be the first true commercially available "car-plane" with a two person enclosed cockpit and a cruise airspeed of 105 mph (169 kph). At $279,000 US it's a little expensive but this vehicle is probably the most serious long-term contender, having been designed, constructed and test flown by a rather sophisticated group of MIT-trained engineers. Other than the price, the only real disadvantage of the Transition is that it requires a much longer distance to take-off (1700 feet) than some of the other contenders so a real runway is needed, not just a big parking lot. You also wouldn't want to drive the Transition off-road like you could the Maverick or the Skycar.

7. **Scaled Composites BiPod –** Another true "car-plane" that is being developed in California by the legendary airplane designer Burt Rutan and his associates at Scaled Composites. It is a two person enclosed cockpit vehicle with a hybrid electric-gasoline propulsion system that is expected to deliver an impressive maximum airspeed of 197 mph (275 kph) and surprisingly short take-off and landing distances of only 400 feet (120 meters). The wings must be manually stowed and deployed, which is not as nice as other carplanes that will do this with the push of a button. An actual vehicle exists and that vehicle has undergone some low level flight testing. However, there has been little development over the past two years.

Although this picture makes it look like the BiPod is headed for the skies the word is that, as of this time, it has never flown higher than this.

8. **Carplane GmbH –** This two person “car-plane”, which is being developed in Germany, looks a lot like the Bipod but with automatic wing deployment. The speeds aren’t as impressive as the BiPod but the take-off and landing distances are even shorter. Right now they only have a road vehicle and haven’t done any flight testing. The expected initial price is a hefty $300,000 US with a delivery date of 2016 or later.



Looks good in their animation but, as of this date, they still don’t have a prototype flying.

9. **Plane Driven PD-2 –** Here is another true "car-plane" with a two person enclosed cockpit and a cruise airspeed of 140 mph (225 kph). At $270,000 US for the kit it's expensive like the Transition but this vehicle is much faster in the air, a potentially huge advantage. The developers have taken a standard tail-wheel airplane and added a conversion unit that turns it into a funky looking three-wheeled motorcycle. The major drawback at this point is that it takes almost an hour to convert the vehicle between air use and road use whereas the Transition makes this change in under a minute. Like the Transition, Bipod and German Carplane, you wouldn't want to drive this vehicle off-road like you could the Maverick or the Skycar.


The ground mode is shown above. When it's time to fly the wings fold forward and the rear drive assembly is disconnected and stored in the rear seat compartment.

10. **The US Army Transformer –** This impressive military "car-plane" will be a four-person armored off-road vehicle capable of carrying a whopping 2000 pounds (907 kg) of people and equipment. The expected speeds of this vehicle are pretty good at 65 mph (105 kph) on the ground and 150 mph (240 kph) in the air - and its expected cost to produce is an extremely surprising $203,000 US. This will be a vertical take-off and landing vehicle that will use tilting ducted fan technology. A prototype is expected by the end of 2015. Since it will probably take many years after that date before the technology is released for commercial use, don't expect to see this vehicle driving down the highway before 2020. But this project is being pursued by the US military and, unlike many carplane developers, the US military definitely has the financial resources to fund the needed research and development. A really nice vehicle with some excellent performance characteristics could eventually come out of this effort.

**KEY CHARACTERISTICS**

With the above discussion of current candidate carplanes in mind, we now identify the key characteristics of a "winning" carplane - a carplane that will dominate the market. The characteristics are provided here in what I consider to be priority order:

1.) **Number of Occupants –** For a carplane to attract a reasonable audience it has to carry at least two people. Although flying alone is sometimes all right for business purposes, flying with someone else enhances the entire flying experience - which is probably the reason there are not that many single seat airplanes in production. Travel practicality and trip enjoyability, especially for social and recreational trips, dictate that there be at least two seats. If the wife or the golf buddy can't go along, the trip won't be as nice. An attractive car plane will have at least two seats.

2.) **Payload –** Payload is the difference between the weight of the vehicle (with full fuel tanks) and its allowable gross weight. Or, to make things simple, the maximum allowable weight of all passengers and baggage. If we assume an average man weights about 185 pounds (80 kg) and the average woman weighs about 155 pounds (70 kg), and knowing that you need 60 pounds (30 kg) of luggage capacity for a week away in the airplane, this produces a required minimum payload of about 400 pounds (180 kg).

3.) **Cruise Airspeed** - A carplane is of limited value if you can travel faster on the ground than you can in the air. A slow carplane still has the advantage of being able to fly over mountains, bodies of water, and areas where there are no roads (jungles, desserts, swamps, etc.), but its travel time advantage is maximized when it can travel from point A to point B faster than a ground vehicle when competing highways are available. Consequently, given that grade separated highway speeds are often restricted to about 70 mph (110 kph); a minimum cruise airspeed of 100 mph (160 kph) is preferred. Requiring this 100 mph (160 kph) airspeed eliminates certain airfoil designs such as a parachute or a delta wing. You pretty much need a rigid wing (either fixed or rotating) to consistently achieve this kind of air speed.

4.) **Range** – A carplane becomes a relatively attractive alternative to driving when the total trip distance is greater than about 200 miles (320 km). Consequently, we need the carplane to have an effective range of at least 200 miles plus a ½ hour fuel reserve for safety reasons. A carplane with a fuel usage at 100 mph cruise of 6 gallons per hour (23 liters per hour) would have a fuel efficiency of about 16 miles per gallon (7 km per liter). To provide a 1/2 hour or 3 gallon (11 liter) reserve and assuming 1/2 gallon (2 liters) of unusable fuel will be left in the tank, the total size of the fuel tank needs to be at least 19 gallons (72 liters) for a 200 mile (320 km) range. The size increases to 25 gallons (95 liters) for a 300 mile (480 km) range. To maximize its competitiveness, a carplane with a minimum fuel tank size of 25 gallons producing a 300 mile effective range is desired. Besides providing a suitable range, efficient fuel usage also reduces the primary cost of operation. Running the carplane on less expensive "mogas" (ethanol free auto gas with a sufficient octane rating) is another way to reduce operating costs.

To carry two people at the desired payload with an attractive cruise speed and range, the aircraft needs to be lightweight. However, required car safety features (air bags, bumpers, crumple zones, etc.) can add considerable weight to a vehicle. Designing the vehicle as a **three-wheeled motorcycle** is one way to eliminate these requirements and meet the desired performance characteristics. There is an inherent advantage to such a design as both the Pal-V and Switchblade designers have discovered.

5.) **Initial Cost –** There are quite a few private airplanes with excellent operating characteristics that can be purchased for under $150,000 US. A rather large market of potential owners exists at this price point. However, some of the current carplane candidates, such as the Transition and the Pal-V, have prices closer to $300,000 US which limits the potential market of users. Obviously, the less a carplane costs the more people who can afford to purchase one, but keeping the price under $150,000 US is a reasonable goal to shoot for.

6.) **Ground Speed –** A carplane is driven on the ground to avoid adverse weather conditions that prohibit flight (storms, high winds, icing, etc.) and to solve both the "first mile" problem and the "last mile" problem - providing single vehicle connectivity between origin and destination. To be competitive with ground vehicles an airplane does not have to be equally as fast on the ground, but it does have to travel at a high enough speed to use all available roadways – including grade separated freeways (motorways) which often have a minimum posted speed of 40 mph (65 kph). And the carplane needs to be fast enough so that it does not obstruct other traffic on rural two-lane roads, most of which have a posted speed of 55 mph (90 kph). Consequently, a minimum ground speed of 55 mph (90 kph) is desirable.

7.) **Air/Ground Conversion Time –** First we need to define a couple of terms. Let's define the **air/ground conversion time** as the time it takes to convert the carplane from ground mode to air mode, or vice versa. This time is under the complete control of the carplane designer. Let's then define the **air/ground transition time** (when taking-off) as the time from when the carplane enters the airport environs to the time when its wheels leave the runway or (when landing) as the time from when its wheels touch the ground to the time it leaves airport property. This time is obviously not completely under the control of the carplane designer since airport security rules will dictate how quickly carplanes are given access "thru the fence". We see that air/ground conversion time is a subset of air/ground transition time. In any event, the air/ground transition time needs to be within reason so that the carplane's overall travel time advantage is not eliminated. For short trips, a ground vehicle will obviously be superior to a carplane since a ground vehicle does not have to go out of its way to locate somewhere to take-off and somewhere to land and does not incur any air/ground transition time. However, there is some distance at which the tradeoff begins to favor the higher cruise speed of the carplane. This break-even distance becomes less as the air/ground transition time is minimized. An air/ground conversion time of less than 15 minutes would be reasonable and we would expect the corresponding air/ground transition time to be around ½ hour.

8.) **Maximum Crosswind –** Here's an operational issue that you wouldn't normally think of, but it ends up being rather important. There are many days when the skies are clear yet certain types of aircraft remain grounded because winds near the ground are too high for them to safely take-off or land. For example, a weight shift control aircraft (also known as a trike or a delta wing) is very difficult to control under windy conditions near the ground, especially gusty crosswinds. A carplane design that allows take-offs and landings to occur up to a maximum crosswind of 15 mph (25 kph) would be preferred. Being grounded on a clear, sunny day by moderate crosswinds can be very frustrating.

9.) **Take-off and Landing Distance** – The shorter the take-off and landing distance, the greater the number of runways that become usable by the carplane. Since general aviation airport runways are seldom less than 2000 feet in length, all of the carplanes can make use of these facilities. However, some back country airstrips can be a little shorter than this and make-shift runways (parking lots, back roads, etc.) can much shorter than this.

10.) **Highway Fuel Usage** - A highway fuel economy rating of at least 25 mpg (11 kpl) would keep operating costs reasonable for the ground portion of the carplane trip.

Using these criteria we can assign points to each of the carplane contenders, and relative weights to each evaluation criteria, to see who has the greatest potential for filling the market need. Since maximum crosswind is only know for two of the candidates, this criteria has been eliminated from consideration in this numerical evaluation. It was also necessary to estimate some of the values for the other criteria based on the stated performance of similar vehicles. The results of this numerical evaluation are provided in Table 2 with the final scores and rankings shown below:

**EVALUATION RESULTS**

| RANK | CARPLANE | SCORE |
|---|---|---|
| 1 | Transformer | 422.5 |
| 2 | GmbH | 286.0 |
| 3 | BiPod | 274.9 |
| 4 | Switchblade | 271.2 |
| 5 | Maverick | 262.2 |
| 6 | Transition | 234.8 |
| 7 | PD-2 | 221.2 |
| 8 | Skycar Mk2 | 220.5 |
| 9 | Pal-V One | 216.6 |
| 10 | Super Sky Cycle | 195.3 |

**Available Now or Soon** (highlighted: ranks 5–10)

The DARPA Transformer emds up being the carplane offering with the highest rating and the Butterfly Skycycle emds up having the lowest. If the US Army can pull-off their intended design, they should have a clear market leader when the design is made available for commercial production. Absent this offering, the German GmbH carplane looks very attractive.

An examination of the evaluation results reveals that, in general, carplanes that are either currently on the market or are expected to be available soon have a lower rating than those with a more distant production date. This is undoubtedly due to the tendency of manufacturers to make optimistic projections with respect to vehicle performance (speed, payload, price, etc.) when the vehicle is in the prototype stage and then refine these projections (usually in the negative direction) as the vehicle nears production and real-world limitations rear their ugly head. The Terrafugia Transition is a good example, with the price steadily increasing and the performance characteristics decreasing as the vehicle nears production.

## SUMMARY

Carplanes are on the doorstep and now is the time to start thinking about how they will fit into our transportation system, and how they will compete with the automobile – the current dominant form of personal transportation. The evaluation system discussed in this paper serves as a means to compare the competitiveness of candidate carplanes and to identify the key characteristics that will make their use attractive. As these vehicles make their appearance and the “winning” carplanes begin to fill our skies, a radical change will occur in point-to-point transportation.

## TABLE 1 - CARPLANE SUMMARY

**NA** = Not Available

| Company Name | **Butterfly Aircraft LLC** | **Pal-V Europe NV** | **Samson Motorworks** | **ITEC** | **Parajet** | **Terrafugia Inc.** | **Scaled Composites** | **Carplane Road/Air Vehicle** | **Plane Driven** | **US Army (DARPA)** |
|---|---|---|---|---|---|---|---|---|---|---|
| Web Address | www.thebutterflyllc.com | www.pal-v.com | www.samsonmotorworks.com | www.mavericklsa.com | www.parajet.com | www.terrafugia.com | www.scaled.com | www.carplane.com | www.planedriven.com | www.darpa.mil |
| Vehicle Name | **Super Sky Cycle** | **Pal-V One** | **Switchblade** | **Maverick** | **Skycar Mk2** | **Transition** | **BiPod** | **Carplane GmbH** | **PD-2** | **Transformer** |
| Company Location | **Texas** | **Netherlands** | **California** | **Florida** | **England** | **Massachusetts** | **United States** | **Germany** | **Florida** | **United States** |
| Air Vehicle Type | **Gyroplane** | **Gyroplane** | **Rear Propeller Airplane** | **Powered Parachute** | **Powered Parachute** | **Rear Propeller Airplane** | **Rear Propeller Airplane** | **Rear Propeller Airplane** | **Front Propeller Airplane** | **Ducted Fan** |
| Air License Required | Gyroplane | Gyroplane | Private Pilot | Powered Parachute | Sport Pilot | Sport Pilot | Sport Pilot | Sport Pilot | Private Pilot (Tailwheel) | None - Military Use |
| Ground Vehicle Type | 3 Wheel Motorcycle | 3 Wheel Motorcycle | 3 Wheel Motorcycle | 4 Wheel Car | 4 Wheel Car | 4 Wheel Car | 4 Wheel Car | 4 Wheel Car | 3 Wheel Motorcycle | 4 Wheel Armored Car |
| Ground License | Motorcycle | Motorcycle | Motorcycle | Automobile | Automobile | Automobile | Automobile | Automobile | Motorcycle | None - Military Use |
| Price (US $) | $74,995 - Kit | $300,000 | $100,000 - Kit | $94,000 | **NA** | $279,000 | **NA** | $138,000 to $302,000 | $270,000-Kit w/Sportsman | $203,000 |
| Delivery Date | Available Now | 2014 | 2014 | Available Now | **NA** | No longer specified (2014?) | **NA** | 2016 or later | 2013 (maybe) | Prototype by end of 2015 |
| Occupants | 1, open cockpit | 2, enclosed | 2, enclosed | 3, enclosed | 2, open cockpit | 2, enclosed | 2, enclosed | 2, enclosed | 2, enclosed | 4, enclosed |
| Fuel | Premium Auto Gas | Auto Gas | Regular Auto Gas | Regular Auto Gas | Regular Auto Gas | Premium Auto Gas | **NA** | Premium Auto Gas | 100 LL Avgas | Regular Auto Gas |
| Ground Engine Fuel | (has only 1 engine) | (has only 1 engine) | (has only 1 engine) | (has only 1 engine) | (has only 1 engine) | (has only 1 engine) | (has only 1 engine) | (has only 1 engine) | Regular Auto Gas | (has only 1 engine) |
| Max. Road Speed | 55 mph | 112 mph | 90 mph + | 100 mph | 140 mph | 95 mph | 65 mph | 109 mph | 73 mph | 65 mph |
| Highway Fuel Usage | 30 mpg | 28 mpg | 50 mpg | 30 mpg | 37 mpg | 35 mpg | 46 mpg | Zero --> Electric Drive | 25 mpg | **NA** |
| Air Cruise Speed | 70 mph | **NA** | 150 mph | 40 mph | 45 mph | 105 mph | 100 mph (max fuel eff.) | 136 mph | 140 mph 13 gph | **NA** |
| Maximum Air Speed | 80 mph | 112 mph | 200 mph | 40 mph | 65 mph | 115 mph | 200 mph | 138 mph | 150 mph | 150 mph |
| Air Fuel Usage | 5 gph | 9.5 gph | 22 mpg (6 gph) | (Range: 3 hours) | 22 mpg (2 gph) | 5 gph | 42 mpg | 5 gph | 13 gph @ cruise speed | **NA** |
| Fuel Capacity | 7.5 to 17.5 gallons | (Range: 267 miles) | 16 gallons | 15 gallons | 9 gallons | 23 gallons | 18 gallons | 26 gallons | 5 gal road/50 gallons air | **NA** |
| Take-Off Distance | 200 ft | 540 ft | 1600 ft | 300 ft | 650 ft | 1700 ft over 50-ft obstacle | 400 ft | 280 ft ground roll | 400 ft | Vertical Take-Off |
| Landing Distance | 40 ft | 100 ft | 1800 ft | 300 ft | **NA** | **NA** | 400 ft | 330 ft ground roll | 400 ft | and Landing |
| Climb Rate | **NA** | **NA** | 1800 ft/min | 900 ft/min | **NA** | **NA** | **NA** | **NA** | 1000 ft/min | **NA** |
| Air-Road Conversion | Manual, 3 minutes | Auto/Manual, 10 minutes | 3 minutes | Manual, 5-10 minutes | Manual, 3 minutes | Automated, < 30 seconds | **NA** | Automated, 15 seconds | Manual, < 1 hr w/2 people | No Conversion |
| | Rotor Folds | Rotor & Rear Prop Fold | Wings swing under vehicle | Parachute Stows | Parachute Stows | Wings Fold | Wings Stow | Wings swing under vehicle | Wings Fold/Wheels Slide | Required |
| Maximum Altitude | 12,000 feet | **NA** | 10,000 feet | 10,000 feet | 15,000 feet | **NA** | 12,000 feet | 10,000 feet | 15,000 feet | 10,000 feet |
| Maximum Crosswind | 30 mph | **NA** | 17 mph | **NA** | **NA** | **NA** | **NA** | 16 mph | **NA** | **NA** |
| Payload | 300 pounds | **NA** | 500 pounds | 333-700 pounds | **NA** | 460 pounds | **NA** | **NA** | 640 pound useful load | About 2000 pounds |
| NOTES: | | Tilts When Cornering | | Float Compatible | | Auto Safety Features | | | Modified GlasairSportsman | By Lockheed Martin |

## TABLE 2 - CARPLANE EVALUATION

| Evaluation Criteria | Unit | Criteria Weight | Butterfly Aircraft LLC | Pal-V Europe NV | Samson Motorworks | ITEC | Parajet | Terrafugia Inc. | Scaled Composites | German Carplane | Plane Driven | US Army (DARPA) | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **Super Sky Cycle** | **Pal-V One** | **Switchblade** | **Maverick** | **Skycar Mk2** | **Transition** | **BiPod** | **GmbH** | **PD-2** | **Transformer** | |
| Number of Occupants | | | 1 | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 4 | |
| POINTS | | 10 | 1 | 5 | 5 | 7 | 5 | 5 | 5 | 5 | 5 | 10 | |
| WEIGHTED POINTS | | | 10 | 50 | 50 | 70 | 50 | 50 | 50 | 50 | 50 | 100 | **53** |
| | | | | estimated | | | estimated | | estimated | estimated | 640 useful load - (55*6) fuel | | |
| Payload | pounds | | 300 | 500 | 500 | 700 | 500 | 460 | 500 | 500 | 310 | 2000 | 627 |
| POINTS | | 9 | 2.4 | 4.0 | 4.0 | 5.6 | 4.0 | 3.7 | 4.0 | 4.0 | 2.5 | 15.9 | |
| WEIGHTED POINTS | | | 22 | 36 | 36 | 50 | 36 | 33 | 36 | 36 | 22 | 144 | **45** |
| | | | | (assume 90% of max) | | | | | (assume 90% of max) | | | | |
| Air Cruise Speed | miles/hour | | 70 | 100 | 150 | 40 | 45 | 105 | 180 | 135 | 140 | 150 | 112 |
| POINTS | | 8 | 3.1 | 4.5 | 6.7 | 1.8 | 2.0 | 4.7 | 8.1 | 6.1 | 6.3 | 6.7 | |
| WEIGHTED POINTS | | | 25 | 36 | 54 | 14 | 16 | 38 | 65 | 48 | 50 | 54 | **40** |
| | | | 17.5 gal x 70 mph/5gph | 25 gal x 100 mph/9.5gph | 16 gal x 150 mph/6 gph | 15 gal x 40 mph/5 gph | 9 gal x 45 mph/2 gph | 23 gal x 105 mph/5 gph | 18 gal x 42 mpg | 26 gal x 135 mph/5 gph | 50 gal x 140 mph/13 gph | 40 gal x 150 mph/15 gph | |
| RANGE | miles | | 245 | 265 | 400 | 120 | 200 | 475 | 750 | 700 | 540 | 300 | 400 |
| POINTS | | 7 | 3.1 | 3.3 | 5.0 | 1.5 | 2.5 | 5.9 | 9.4 | 8.8 | 6.8 | 3.8 | |
| WEIGHTED POINTS | | | 21 | 23 | 35 | 11 | 18 | 42 | 66 | 61 | 47 | 26 | **35** |
| | | | (75,000 x 1.25) | | (100,000 x 1.25) | | estimated | | estimated | | (270,000 x 1.25) | | |
| Initial Cost | US dollars | | $94,000 | $300,000 | $125,000 | $94,000 | $150,000 | $279,000 | $300,000 | $302,000 | $338,000 | $203,000 | $218,500 |
| POINTS | | 6 | 11.6 | 3.6 | 8.7 | 11.6 | 7.3 | 3.9 | 3.6 | 3.6 | 3.2 | 5.4 | |
| WEIGHTED POINTS | | | 69.7 | 21.9 | 52.4 | 69.7 | 43.7 | 23.5 | 21.9 | 21.7 | 19.4 | 32.3 | **38** |
| Max. Road Speed | miles/hour | | 55 | 112 | 90 | 100 | 140 | 95 | 65 | 109 | 70 | 65 | 90 |
| POINTS | | 4 | 3.1 | 6.2 | 5.0 | 5.5 | 7.8 | 5.3 | 3.6 | 6.0 | 3.9 | 3.6 | |
| WEIGHTED POINTS | | | 12 | 25 | 20 | 22 | 31 | 21 | 14 | 24 | 16 | 14 | **20** |
| | | | | | | | | | estimated | | | | |
| Air-Road Conversion Time | minutes | | 3 | 10 | 3 | 10 | 3 | 0.5 | 15 | 0.25 | 45 | 0 | |
| POINTS | | 3 | 5 | 3 | 5 | 3 | **5** | 7 | 2 | 8 | 1 | 10 | |
| WEIGHTED POINTS | | | 15 | 9 | 15 | 9 | 15 | 21 | 6 | 24 | 3 | 30 | **15** |
| | | | | | | | (650 x 2) | (1700 x 2) | | | | | |
| TakeOff+Landing Distance | feet | | 240 | 640 | 3400 | 600 | 1300 | 3400 | 800 | 610 | 800 | 0 | 1179 |
| POINTS | | 2 | 8 | 6 | 1 | 6 | 3 | 1 | 5 | 6 | 5 | 10 | |
| WEIGHTED POINTS | | | 16 | 12 | 2 | 12 | 6 | 2 | 10 | 12 | 10 | 20 | **10** |
| | | | | | | | | | | Electric Drive | | estimated | |
| Highway Fuel Usage | miles/gallon | | 30 | 28 | 50 | 30 | 37 | 35 | 46 | 60 | 25 | **15** | 36 |
| POINTS | | 1 | 4.2 | 3.9 | 7.0 | 4.2 | 5.2 | 4.9 | 6.5 | 8.4 | 3.5 | 2.1 | |
| WEIGHTED POINTS | | | 4 | 4 | 7 | 4 | 5 | 5 | 6 | 8 | 4 | 2 | **5** |
| TOTAL WEIGHTED POINTS | | | 195.3 | 216.6 | 271.2 | 262.2 | 220.5 | 234.8 | 274.9 | 286.0 | 221.2 | 422.5 | **261** |

**REFERENCES**

(1.) "A Proposed Transportation System for Roadable Aircraft", Jeffrey W. Buckholz, Transportation Research Board, National Research Council, Washington, D.C., 2010 Annual Meeting

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