EIGHT CARPLANES THAT COULD CHANGE EVERYTHING

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ABSTRACT

Six carplanes will reach the market in the near future. Are we ready for them?

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 at either the state or federal level 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 roadable aircraft 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.

THE CURRENT CONTENDERS

Table 1, which is adapted from the http://www.carplanenews.com/ website, summarizes the operational characteristics of seven carplanes that are either available now, will be available by the end of 2011, or

have a prototype vehicle that is actively being tested. The eighth carplane described in the table is a US Army military endeavor that is expected to result in an operational vehicle by 2015.

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 eight current contenders:

1. **The Butterfly Super Sky Cycle** (http://www.thebutterflyllc.com/sscycle/sscycle.htm) - This is really a motorcycle-gyroplane, not a carplane, but I included it because it is available right now in kit form for about $60,000 and it does indeed "drive and fly". In fact, it was "ridden & flown" to the Sturgis motorcycle rally in 2010. The Sky Cycle takes-off and lands in relatively limited space and both its land and air speeds are decent. Only having one seat and being a kit that you have to finish yourself are the major drawbacks. Additional minor drawbacks include having to secure a gyroplane license and a motorcycle license and the rider being exposed to the weather. This type of vehicle is situated within a specialty "carplane" nitch that probably will not result in widespread use.

2. **The ITEC Maverick** (http://mavericklsa.com/) – This is really a car-poweredparachute, not a true carplane, but it has the basic capabilities of a carplane and it only costs $84,000 (completely assembled, not a kit) so it definitely justifies inclusion. 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 fan 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. That's fine if you just want to have fun and cruise over the beach but it keeps the Maverick from being a serious transportation mode 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 is a decent speed.

3. **The Parajet Skycar** (http://www.parajet.com/about/projects/cat/skycar/) – This is also a car-poweredparachute, not a true carplane. It is very similar to the Maverick with an expected price of $80,000. 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 year. The Skycar's major advantage over the Maverick is a purported maximum air speed of 100 mph which, if true, is unbelievably fast for a powered parachute. It does take 4 times the distance to take-off as compared to the Maverick (600 feet versus 150 feet). This could be a very attractive vehicle if they get serious about it and start manufacturing a few.

4. **The Terrifuga Transition** (http://www.terrafugia.com/index.html) – This will be the first true carplane with a 2 person enclosed cockpit and a maximum airspeed of 115 mph. At $210,000 it's a little expensive but this vehicle is probably the most serious long-term contender, being 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 than the other vehicles discussed so far (1700 feet) so a real runway is needed, not a big back yard. You also wouldn't want to drive the Transition off-road like you could the Maverick or the Skycar. Deposits have been taken on the vehicle and the first Transitions are expected to hit the street by the end of 2011.

5. **The Samson Switchblade** (http://www.samsonmotorworks.com/) – This will (sort of) be a carplane but with a 2 person enclosed 3-wheeled motorcycle for the ground vehicle. The expected speeds of this vehicle are outstanding at over 90 mph on the ground at 200 mph in the air and, with a kit price of only $85,000, it would be serious competition for the Transition. The only problem is that, so far, they just have a ground prototype that hasn't flow one nautical mile. But if the Sampson team can pull it off, it could be the game changer that makes carplanes proliferate. As with the Transition, it requires a much longer distance to take-off than the other vehicles (1600 feet) so a runway is needed.

6. **The BiPod** (http://www.scaled.com/) – This carplane is being developed in California by the legendary airplane designer Burt Rutan and his associates at Scaled Composites. It is a 2 person enclosed cockpit vehicle with a hybrid electric-gasoline propulsion system that is expected to deliver an impressive maximum airspeed of 197 mph and surprisingly short take-off and landing distances of only 400 feet. 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 promising low level flight testing. Price and delivery date have not been established as this vehicle still has quite a bit of testing yet to do, but the concept looks very promising and the design team is a good one. If they don't lose interest, this could be a formidable competitor.

7. **The German Carplane** (http://www.carplane.com/) – This 2 person carplane, 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 around $300,000 with a delivery date of 2016 or later, so this vehicle is still quite a few years away from being a reality.

8. **The US Army Transformer**

(http://www.darpa.mil/Our_Work/TTO/Programs/Transformer/Transformer.aspx) – This impressive military carplane will be a 4-person armored off-road vehicle capable of carrying 2000 pounds of people and equipment. The expected speeds of this vehicle are pretty good at 65 mph on the ground and 150 mph in the air - and its expected cost to produce is an extremely surprising $203,000. This will be a vertical take-off and landing vehicle that will use either rotor blades (like a gyroplane) or tilting ducted fan technology. Two design teams are currently competing to win the US Army contract and a vehicle delivery date of 2015 is anticipated. 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 in widespread use before 2020. But this project is being pursued by the military and the 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.

At first these somewhat expensive vehicles will be piloted only by relatively affluent individuals with the proper training and airman certification, much like your typical private plane. Since there are only about ½ million licensed pilots in the United States, this will result in a very small mode shift to carplanes, placing only a slight strain on the current transportation system – mostly associated with a somewhat awkward transition between road and air travel. ("Will somebody please open that gate and let me drive out of this airport?") But as vehicle control systems become more sophisticated and mass-production economies of scale take over, carplanes will become more affordable and the licensing requirements to pilot them more mundane. When your "average Joe" with a valid driver's license and a

bit of specialized training can afford and pilot one (there are more than 200 million licensed drivers in the US), the mode split for carplanes will increase quickly and a very serious strain will be placed on both the current transportation system ("carplane mid-air collisions rise to 5-year high") and the current social environment ("I'm getting tired of Jerry buzzing my house when he lands in his backyard").

INITIAL OPERATIONAL ISSUES

When carplanes first start flying about, I see the major issues being as follows:

1. Take-Offs and Landings – Some of the carplanes have very short take-off and landing distances, so it will be very tempting for pilots to take-off and land in fields, large parking lots, or on back roads. Why drive 10 miles to some airport when you can use that abandoned K-Mart parking lot down the street? And, contrary to what you might expect, in most jurisdictions there aren't any laws prohibiting this if you stay on private land and get the landowner's permission. As it is, helicopters can pretty much take-off and land wherever they want to and most times they don't even bother getting landowner permission until somebody complains. I can see a lot of "innovative" locations being used as carplane runways until we have our first major incident, then the FAA will step in and do something. I have approached the FAA about this and received a nice letter which basically indicates that they are still thinking about the whole issue.

2. Airport Access – If you have a carplane parked in your garage and are a little more conservative, you may want to drive to your local general aviation airport instead of taking-off from a parking lot. (In the future, you may be forced by FAA edict or local ordinance to do this anyway.) Right off the bat you will face the problem of getting access to what is usually a secure facility surrounded by a big fence. Given all the security concerns associated with potential terrorist activity, these days you typically need to arrange "gate access" to the airside (apron, taxiways

and runways) of your local airport in advance. You may need to obtain some sort of gate code or have a transponder-type unit issued to you in order to open the gate or, at many smaller airports, someone might even have to meet you at the gate with a key to open the lock. Arranging this access at your home airport may only be a one-time inconvenience but arranging it at every other airport you fly into is going to be a major hassle! And the fun and convenience of flying a carplane will completely disappear the first time you find yourself "locked in" at some small airport where everyone has gone home for the night.

3. Insurance – There are plenty of companies that will insure your car and quite a few that will insure your airplane. However, at the current time there are effectively zero that will insure your carplane. After considerable research I was able to locate one company that will write a policy for one specific type of carplane (the car-poweredparachute) but the annual premium is about 10 times the cost of insuring the vehicle as either a plane or an automobile – and they can only provide the auto portion of the insurance in certain states. You could choose to fly around without insurance but if you have a catastrophic event that ends up hurting other people, everything you own would be at risk. In addition, in most states it's illegal to drive on public roads without at least basic insurance coverage. The insurance problem is a bit of a chicken-egg situation, you don't want to start operating a carplane without insurance but the insurance carriers don't want to develop an insurance product for carplanes until there is a significant market. I'm sure this problem will eventually solve itself, but premiums could be quite high until some experience is gained. Insurers may also place restrictions on how the vehicle is operated, such as forcing the use of airports for take-offs and landings.

4. Pilot Certification – It's not easy to get access to an airplane without a valid pilot's license. Nobody is going to rent you an airplane without an active license and the FAA does random

airport “ramp checks” to make sure everything is current. You’d be a semi-fool to try and fly an airplane without the knowledge a license represents anyway - that’s a good way to get seriously hurt. The situation is slightly different for carplanes. Some of the carplanes, such as the ITEC Maverick, are very easy to fly and your crazy brother who just bought one might let you do so even though you don’t have the proper license. If you avoid airports and are smart enough to get a sectional map and stay out of restricted and controlled airspace, you might just avoid the long arm of the FAA since they don’t tend to set up shop at abandoned K-Mart parking lots. Rouge carplane pilots could be hard to police.

A FUTURE SYSTEM FOR CARPLANES

As long as the number of carplanes remains relatively low, the current transportation system can probably handle their presence with only a few administrative and operational changes. However, when they become popular and widespread (and I’m convinced this is a “when” question, not an “if” question) the current transportation system will need to change. Carplanes will have to operate within a system where they can get from point A to point B without hitting obstructions, each other, general aviation aircraft, or commercial aircraft - and without entering restricted or prohibited air space.

In a paper I wrote for the 2010 Transportation Research Board Annual Meeting (1) I proposed a transportation system for handling roadable aircraft that centered on low level, under 3000 feet AGL (Above Ground Level) air corridors positioned over the existing interstate highway system. Runways would be constructed at various intervals along the interstate with direct ramp connections to the highway (just like rest areas) for quick and efficient air-to-road and road-to-air transition (see Figure 1). Advanced GPS technology located within each roadable aircraft would be used to guide the vehicle along the desired path and the various air routes would be displayed on each roadable aircraft’s GPS

system as a set of lateral boundaries, allowing for straightforward navigation. The key to safe operation of the system is automated closure of air routes when weather conditions become unfavorable, forcing the vehicles to drive rather than fly under adverse weather conditions. It is also proposed that the vehicle control system eventually become sophisticated enough to eliminate all human intervention in favor of completely automated vehicle control.

Interstate highways often do not travel along a straight path, but curve about to miss development or topographic features. It would be rather inefficient to have the roadable aircraft routes bend about in a similar manner. Consequently, the roadable aircraft corridor would sometimes deviate from its parent interstate route for a short distance to make the trip more direct.

Restricting roadable aircraft to the airspace over the interstate highway system would also result in needlessly circuitous routes in areas where interstate coverage is sparse. In these areas, major non-interstate roadways could also be incorporated into the system. In addition, as the system becomes fully developed, it would be reasonable to introduce what could be called “interstate air routes” to supplement the existing highway system. These interstate air routes would not follow any specific roadway but would instead form direct 4 mile wide air links between existing ground routes. They would generally be oriented over sparsely populated areas and would be particularly valuable where physical obstructions, such as bodies of water or mountains, have precluded the development of a corresponding highway route.

Following the interstate highway system becomes problematic in two instances: 1.) where the interstate highway crosses the airspace of an airport, and 2.) where the interstate highway system passes through a

densely populated urban area. In both cases the problem could be solved by orienting the roadable aircraft route around the airport airspace or around the circumference of the urban area. This would necessitate a deviation from the interstate alignment but, in most cases, the deviation would be relatively minor. If for some reason it is impossible or impractical to orient the route around the area in question then roadable aircraft may be forced to land and drive through the area, returning to the skies on the other side.

Figure 2 shows a proposed set of roadable aircraft routes for the Northeast Florida/Southeast Georgia area.

A PROPOSED SHORT-TERM SYSTEM

The first roadable aircraft transportation system might require that all drivers have at least a sport pilot license with all aspects of flight, including runway selection, take-offs, landings, altitude selection, selection of cruise speed, and spacing selection being carried-out by the pilot in command. Flights are only allowed during daylight hours (from 1 hour before sunrise to 1 hour after sunset) under VFR (Visual Flight Rules) weather conditions. Approaching bad weather, insufficient visibility, or contrary winds result in portions of the system being temporarily shut-down with roadable aircraft forced to land at the next available airstrip where wind and weather conditions are suitable.

Every roadable aircraft is equipped with a modern GPS system that displays the lateral limits of all air routes. The highway itself provides a visual ground reference with roadable aircraft being required to stay to the right of the highway centerline when operating on an overflight segment of the air route.

Roadable aircraft are issued a special ground transponder by the FAA. This transponder communicates with access gates at all interstate airstrips. The transponder is needed to gain access into or out of the airstrip and is used to automatically charge each roadable aircraft every time they use the airstrip via automatic debiting of funds from a pre-established account. This operation is similar to the way transponders are currently used on many US toll roads. As time goes by and experience is gained with the system, roadable aircraft flights are allowed at night and under less-restrictive marginal VFR conditions.

A PROPOSED LONG-TERM SYSTEM

The GPS system will become integrated with the control system of the aircraft, allowing for complete automation of vehicle movement while in the air. Any licensed driver (with a special endorsement) is allowed to operate a roadable aircraft. The driver programs his or her desired departure airstrip and arrival airstrip into the advanced control system and, once the vehicle has been driven onto the departure runway, the system does the rest with the vehicle essentially flying itself. Altitude and spacing are automatically accommodated with all “air passes” and “air merges” coordinated by the system. Fully automated control allows spacing to be reduced and system capacity correspondingly increased, while at the same time freeing the operator to complete other tasks while traveling. Operations are permitted at night and under IFR (Instrument Flight Rule) conditions, but not during severe weather or any other condition that would make travel unsafe. To facilitate trip planning, advanced weather prediction algorithms provide drivers nationwide information on which interstate airstrips are expected to be open and which are expected to be closed during the next 24 hours.

FUTURE TRANSPORTATION ANALYSIS

The 2025 or 2030 Highway Capacity Manual could well include a chapter dealing with carplane systems. Procedures might be developed for calculating the capacity and level of service for carplane air corridors (a mainline analysis) and for carplane take-off and landing locations (a terminal analysis). Increasingly sophisticated vehicle location and control technology, both for carplanes and future surface vehicles, will ultimately result in tighter vehicle headways and higher capacities, both in the air and on the road. The significant potential for drastically reducing system congestion and associated operator delay is evident.

We can also expect that both intercity and metropolitan area transportation planning models will eventually incorporate a carplane mode with appropriately calibrated mode split models.

SUMMARY

Carplanes are on the doorstep and now is the time to start thinking about how they may be integrated into our current transportation system. The system configuration proposed in this paper serves as an initial straw man at which criticisms can be leveled and improvements proposed. As these vehicles make their appearance and begin to fill our skies, a radical change will occur in point-to-point transportation. I don't think it's too grandiose to say that we may be about to witness one of the most significant changes in transportation history.

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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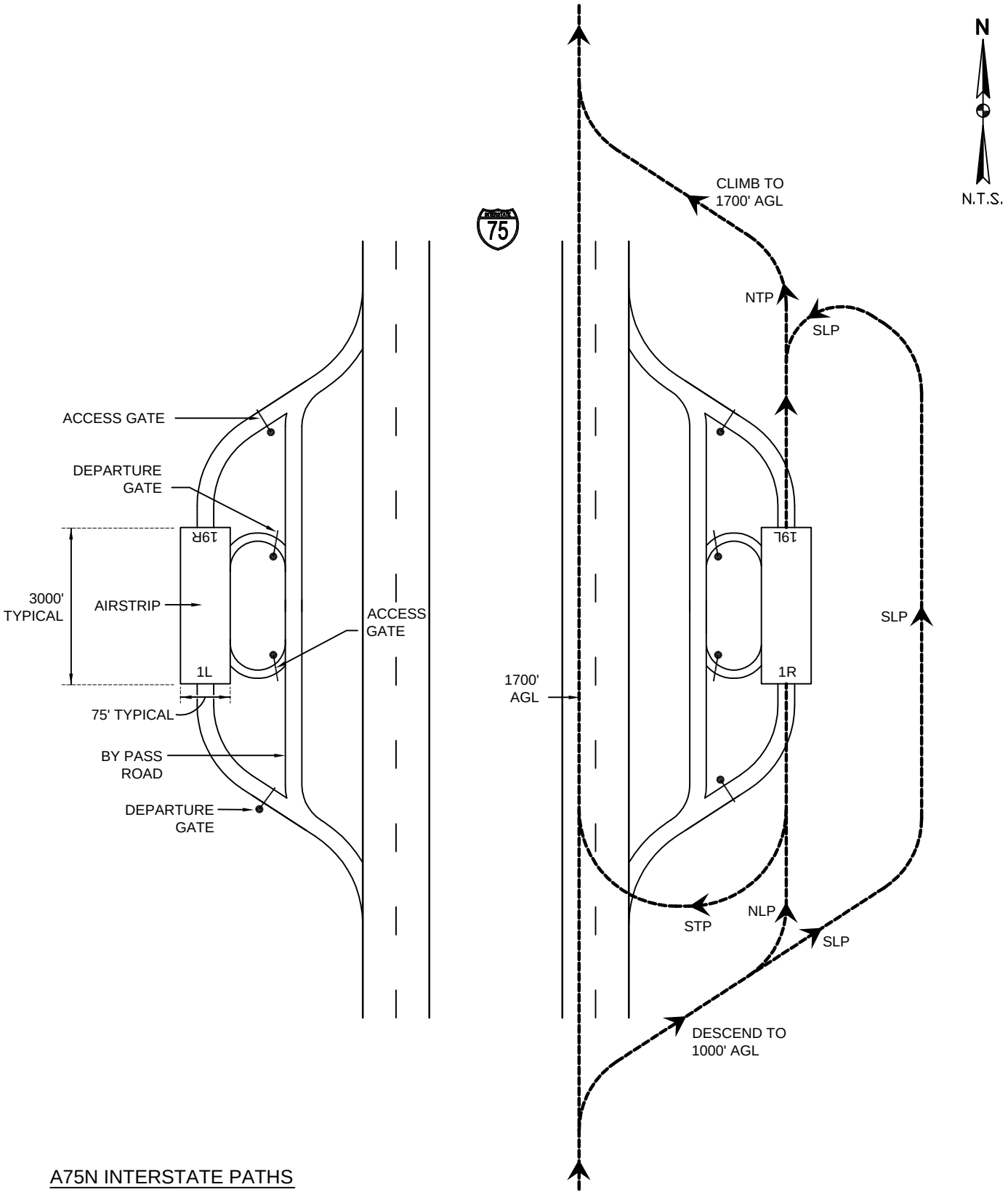
TABLE 1 - SUMMARY OF ROADABLE AIRCRAFT

Company Name	Butterfly Aircraft LLC	ITEC	Parajet	Terrifuga Inc.	Samson Motorworks	Carplane Road/Air Vehicle	Scaled Composites	US Army (DARPA)
Web Address	www.thebutterflyllc.com	www.mavericklsa.com	www.parajet.com	www.terrafugia.com	www.samsonmotorworks.com	www.carplane.com	www.scaled.com	www.darpa.mil
Vehicle Name	**Super Sky Cycle**	**Maverick**	**Skycar Mk2**	**Transition**	**Switchblade**	**Carplane**	**BiPod**	**TRANSFORMER**
Company Location	**Texas**	**Florida**	**England**	**Massachusetts**	**California**	**Germany**	**United States**	**United States**
Air Vehicle Type	**Gyroplane**	**Powered Parachute**	**Powered Parachute**	**Rear Propeller Airplane**	**Rear Propeller Airplane**	**Rear Propeller Airplane**	**Rear Propeller Airplane**	**Ducted Fan OR Rotor**
Air License Required	Rotorcraft or Gyroplane	Sport Pilot/Powered Parachute	Sport Pilot	Sport Pilot	Private Pilot	Sport Pilot	Sport Pilot	None - Military Use
Ground Vehicle Type	3 Wheel Motorcycle	4 Wheel Car	4 Wheel Car	4 Wheel Car	3 Wheel Motorcycle	4 Wheel Car	4 Wheel Car	4 Wheel Armored Car
Ground License Required	Motorcycle	Automobile	Automobile	Automobile	Motorcycle	Automobile	Automobile	None - Military Use
Expected Price (US $)	$59,000 Kit	$84,000	$80,000	$210,000	$85,000 Kit	$310,000	NA	$203,000
Anticipated Delivery Date	Available Now	July 2011	July 2012	Late 2011	NA	2016 or later	NA	2015
Occupants	1, open cockpit	3, enclosed	2, open cockpit	2, enclosed	2, enclosed	2, enclosed	2, enclosed	4, enclosed
Fuel	Premium Auto Gas	Regular Auto Gas	Regular Auto Gas	Premium Auto Gas	Regular Auto Gas	Premium Auto Gas	NA	Regular Auto Gas
Maximum Road Speed	55 mph	90 mph	140 mph	95 mph	90 mph +	109 mph	65 mph	65 mph
Highway Fuel Usage	30 mpg	25 mpg	37 mpg	35 mpg	50 mpg	Zero --> Electric Drive	46 mpg	NA
Air Cruise Speed	70 mph	40 mph	82 mph	105 mph	150 mph	136 mph	100 mph (max fuel eff.)	NA
Maximum Air Speed	100 mph	40 mph	100 mph	115 mph	200 mph	138 mph	197 mph	150 mph
Air Fuel Usage	5 gph	NA	NA	5 gph	22 mpg (6 gph)	5 gph	42 mpg	NA
Fuel Capacity	12.5 gallons	15 gallons	20 gallons	23 gallons	16 gallons	26 gallons	18 gallons	NA
Take-Off Distance	200 ft	150 ft	650 ft	1700 ft over 50-ft obstacle	1600 ft	280 feet	400 ft	Vertical Take-Off
Landing Distance	40 ft	150 ft	NA	NA	1800 ft	330 feet	400 ft	and Landing
Air-Road Conversion	Manual, 3 minutes	Manual, 5-10 minutes	Manual, 3 minutes	Automated, 15 seconds	3 minutes	Automated, 15 seconds	NA	No Conversion OR
	Rotor Folds	Parachute Stows	Parachute Stows	Wings Fold	Wings Rotate	Wings Fold	Wings Stow	Rotor Folds
Maximum Altitude	12,000 feet	10,000 feet	15,000 feet	NA	10,000 feet	10,000 feet	12,000 feet	10,000 feet
Maximum Crosswind	30 mph	NA	NA	NA	17 mph	16 mph	NA	NA
Useful Load	300 pounds	333-700 pounds	NA	460 pounds	500 pounds	NA	NA	About 2000 pounds

NA = Not Available

See **www.carplanenews.com** for more information on roadable aircraft



A75N INTERSTATE PATHS

NLP = NORTHBOUND LANDING PATH
SLP = SOUTHBOUND LANDING PATH
NTP = NORTHBOUND TAKE-OFF PATH
STP = SOUTHBOUND TAKE-OFF PATH

FIGURE 1 - TYPICAL INTERSTATE RUNWAY LAYOUT

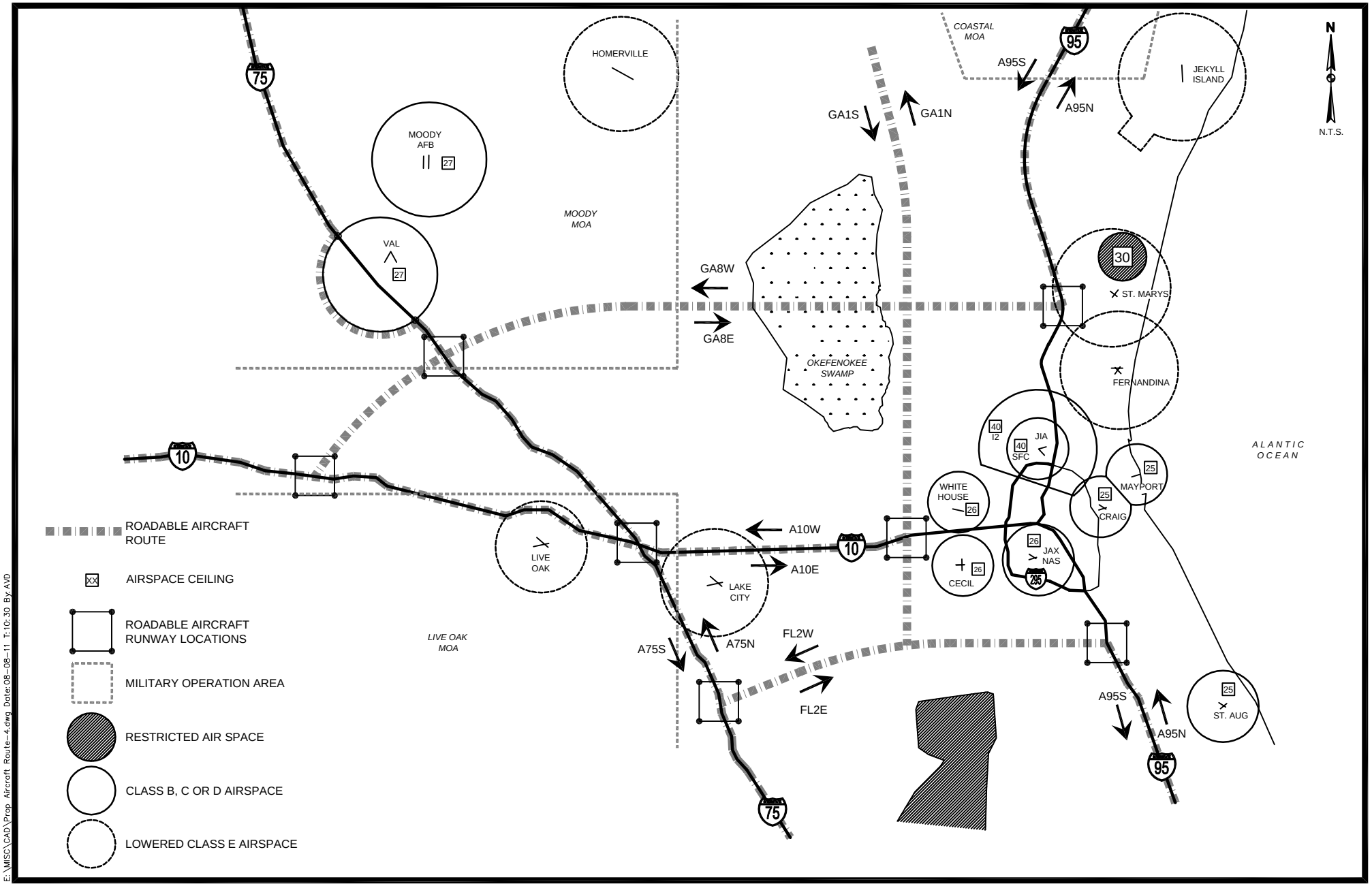


FIGURE 2- PROPOSED ROADABLE AIRCRAFT ROUTES (NORTHEAST FLORIDA / SOUTHEAST GEORGIA)