

# **PAVE** “*Futures*”

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“The roads to support Autos cost as much as a small War and the casualties are on the same scale”

Arthur C. Clark, 1984

# “Futures Context” - 1

- IT,Bio,NANO,Energetics Technology  
“Revolutions”
- ✓ Computing-E7 on Silicon since ‘59,E8-E12 to go  
on Bio,Optical,quantum,Nano,Molec.
- ✓ Comms-wide-band RF,Optical Freespace [Gbits-  
to-Tbits]
- ✓ Nav-GPS,Optical GPS,”atom Optics” INS
- ✓ Manuf.-Free Form Fab.,Brilliant materials,CNTs
- ✓ Sensors-micronano,exquisite sensitivity &  
resolution,swarms

# Enabled Future “Capabilities”

- “Tele-Everything” [commuting,shopping,commerce,education,entertainment,travel,medicine,politics,socialization]
- Inexpensive systems
- Robotics/Machine Intelligence
- “Digital Air Space”
- Automatic Air Ops /Nav/ATC
- Flow Control”Bird-like Flight”

# Flying Cars/Roadable Aircraft [AKA Personal Air Vehicle/PAVE]

- A Recurrent Dream for over 80 Years, obviously a real desirement.....
- Revisited every 20 years or so, technology not/never ready, Much closer now.....
- For “Convenience”, Both Fly/Drive AND Airport-Independent

**“Any form of transportation that offers the lowest door-to-door travel time will always drive out lower speed competing modes unless the economics of the higher speed system are grossly unfavorable”**

William Seifert, 1968

# Future PAVE Characteristics

- Automatic Ops/NAV/ATC
- Super STOL [Driveway/Street TO], runway indep.
- Safe [sport ‘chutes],”All Weather”
- Quiet [has to be]
- ~ \$50K/each [Quantity Production]
- Fly/Drive
- 3 “Flavors” [increasing capability-size/speed/  
range]
  - ✓ Commuter
  - ✓ Delivery
  - ✓ Rural Regional

# Future PAVE Functionality

- Robotic Package Delivery
- “Commuting” [could allow 300mi “commute”]
- Could largely Supplant domestic airline service [“faster” in terms of total travel time, far less expensive, far more “destinations”]
- Sport
- Suitable for use by the aged, the infirm, the young and the inebriated
- PAVE, plus railroads, constitutes a complete [physical] domestic transportation system



# Future PAVE ‘Enablements’

- ~ 1 \$T/yr Aero Industry, Revolutionizes Aero
- Huge “cost avoidance” for roads/bridges & “time wasted in traffic”
- Tremendous increase in Personal Mobility
- Tremendous changes in Land Use, enables low population density ,electronic/largely self-sufficient cottages
- [Along with “Tele-everything”] will enable depopulation of current built-up areas [currently some 80% of population within 200 Miles of a “coastline”],
- Note ,These vehicles will NOT go “downtown”, will “drive” in extremely built-up areas..

# How it will happen.....

- Automatic Air ops/ATC/NAV, developed by DOD, applied/allowed in controlled air space for Homeland defense and Military ops-
- [Modified] militaryUCAVs applied to robotic civilian package delivery
- Inexpensive/limited capability initial commuter versions developed, hugely successful [motorcycle/ultra-light regulations]
- Larger/more capable [cadillac/SUV] versions developed for “Rich People” and “service” markets, eventually going mainstream
- Major markets include areas without intercity roads [Indonesia, Siberia, Northern Canada/Alaska etc.]

# Why it will Happen.....

- Because it can [FINALLY] - Will be enabled by the on-going tech revolutions
- Cost Avoidance - Infrastructure vastly less expensive than the current ground alternative
- Increasing trip times/congestion of current travel modes
- The HUGE markets/economic benefits
- Because the People want the associated freedom/convenience/time savings/cost reductions

# Why Not Before This.....

- Absolute requirement for a “pilot”, few in the population with the time/health/treasure to be pilots - therefore market remained small, vehicles expensive
- The technologies were not “ready”.....

**PAVE is the “PC” Version of  
[Civilian] Aeronautics**

# Interesting [Applicable] Technologies....

- A 3rd approach [beyond rotary wing and powered lift] for super STOL [VTOL?] functionality [channel wings/nacelles with circulation control]
- Brilliant/multi-functional materials for IVHM, Flow Control [Fly Through Weather],
- Fuel Cells/H<sub>2</sub> fuel using thermal diode/direct conversion as a “bottoming cycle” and Casimir force-optimized CNT H<sub>2</sub> storage [MANY emerging H<sub>2</sub> Sources - photocatalysis, biomass using seawater irrigation on “wastelands, e.g. the Sahara, Algae/plants, bacteria, Nano PV,.....]
- SMES/CNT Magnets, several times Chem. Fuel En. Density
- [DOD] “Swarm Technologies”, CNT’s
- Electron Beam Robotic Free Form Fab, IVHM

From an FAA Brief on  
“Transforming Air Transportation  
2020 and Beyond” Given to OSTP  
[Rediess]

- Create Infrastructure for Airport - Independent Operations
- Automated, Airport independent Roadable vehicles
- Fully Automatic Flight and [associated] ATM
- Automated air cargo-UAV’s operated out of Industrial Parks not airports

# Comments-Status /Outlook

- Several factors converging to “make this happen’ [road cost/congestion,IT Revolution/UAV’s,Technology advances,Homeland Defense]
- THE Metrics are Cost,Safety,’Convenience” and “neighborliness”
- In General and from a 3 year study, Rotary Wing machines are too expensive, too heavy, too slow [except for commuter version[s]] and generally not “stylish’, CRW is a possibility.....
- Powered lift variants could provide true VTOL and good forward speed, channel wings/nacelles with circulation control are a “newbee” for superSTOL, possibly better...



# Transportation Mode and Influence Upon Land Use

- 1700's - Water Transport, Development of Ports and Riverine Commerce
- 1800's- Railroads, Development of inland railhubs, enabled "Sea-to-Sea" population of U.S.
- 1900's - Automobile, development of extensive suburbs around 1700's seaports and 1800's railheads
- 2000's - Connextcar, Will allow reduction of population density, improved ecology [red. Flooding/Heat Islands, Pollution, Crime]

There is a strong incentive for personal aircraft in the steady growth of road congestion and all are agreed that the small VTOL Aircraft is not much more complicated than the modern Automobile and can be mass produced at comparable prices given sufficient demand .The real difficulty is the requirement for a Complete Revolution in air traffic control. We cannot accept much longer the personal control of individual aircraft, it must convert to a fully automatic system.

The great deterrent in the past has been the expense and uncertain Reliability of electronic equipment. This situation is rapidly changing and the magnitude of the task of tracking [and controlling] thousands of vehicles should not dismay us.....

Ronald Smelt,1970