

Aeronautics Into the Virtual Age

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The (Economic) Ages of Humankind

- **Hunter/Killer groups (~1 Million - ~10K BC)**
- **Agriculture (~10K BC - ~1850 AD)**
- **Industrial (~1850 AD - ~1950 AD)**
- **Information/BIO/NANO(~1950 AD - ~2030 AD)**
- **Virtual (~2030 - ?)**

- Hunter-Gatherer - “Nature Provided”
- Agriculture - Controlled Nature (Plants/Animals), enabled civilization
- Industrial - Mechanized Agriculture
[1800-97% Farmers, Now-2%]
- IT/BIO/Nano - Automating Industry/Agriculture [1950-60%, Now-11%, heading to 2%]
- Virtual - Robotization of IT/Bio/Nano/Industry/Agriculture [TBD]
- **Technology MATTERS** - For Both Good and ill.....

There are now seven major and simultaneous Societal Existential Issues, Any one of which will Change Society as we know it MUCH. The impacts of all seven, including potential synergisms, is approaching the unfathomable.....

[Simultaneous] Existential Societal Issues

- **Climate Change/ Energy**
- **Massive Debt [AKA “The Great Correction”]**
- **Water/ Food shortages/Environmental issues**
- **5 Simultaneous game-changing Tech Revolutions, Tele-Everything**
- **Luddites/ Individual Destructive Power**
- **Robotics/ Machine Intelligence/ Employment**
- **Humans merging with the Machines**

Suggested Green Energy Best Bets/“Ways Forward”

- **Halophyte and Cyanobacteria Biofuels, to replace Petroleum for transportation**
- **Drilled Geothermal, Biomass, Solar Thermal, Nano Plastic PV and Wind to replace coal**
- **Distributed Generation [200,000 off-grid homes NOW]**
- **Emerging Wild Card - LENR**

LENR [Low Energy Nuclear Reactions]

- Originally dubbed “Cold Fusion”, an experimental discovery with replication issues and no acceptable theory
- Now, Almost 2 decades of massive world-wide data collection/experiments indicate is “real”, Produces both transmutations and heat
- Now, an interesting Theory [Widom/Larsen]
- Not “Hot Fusion”/ strong force/ particle physics, is electroweak interactions/ collective effects explicable via the “Standard Model” of Quantum Theory on Surfaces
- Economics/Utility TBD.....

Just a goodly portion of the Sahara capable of providing [using halophytes, seawater Irrig.] sufficient Biomass to replace ALL of the Fossil Carbon, provide petrochemical feedstock and all the requisite food whilst returning some of the 68% of the fresh water now used for Conventional Agric. to direct human use. Overall – “Solves” land, water, food, energy & warming...

The Ecosystem appears to be “Crashing”

- Fresh Water Shortages
- Species Extinctions, Emergence of Fragile Mono-culture Biomes
- CO2 etc. induced “Climate Change”
- “Pollution” of all manner
- Deforestation
- Losses of Topsoil & Wildlife Habitat
- Overall, Humans Practicing “Anti-Terraforming”

Water/Food

- Current food production based on Fresh Water Plants
- We are “running out” of Fresh Water
- The Ecosystem is “Crashing”, the “code word” is “Sustainability”

Engendered by Population Growth and standards of living,~
50% too many of us for the Ecosystem to support NOW [why
is crashing], if/as ROW attains U.S. Consumption rate will
need 4 more planets...NOT AVAILABLE

- Resulting in “PEAK EVERYTHING”.....

Standards of Living will drop, economic mantra built around
“Growth” no longer sustainable, will have to live within the
Ecosystem strictures.....

THE KEY TECHNOLOGIES

(highly synergistic / at the frontiers of the small / in a “feeding frenzy” off each other)

- **IT** (comms/computing/sensors/electronics/machine intelligence)
- **Bio** (genomics/molecular biology/designer life forms)
- **Nano** (coatings/barriers/computers/sensors/materials/“assemblers”)
- **Energetics** (HEDM (various)/revol. solar/biomass/explosives/propellants/storage)
- **Quantum**
[crypto/computing/sensors/optics/Electronics]
- **Societal Technological Systems** (motivational asynchronous “distance learning,” immersive/virtual presence, “tele-everything,” “robotic everything,”]

Worldwide IT Revolution

- **Comms/Computing/Sensors/Electronics**
- **Factor of E08 since '59 [Moore's Law]**
- **Factor of E08 to E12 further improvement
[Silicon,Molecular/CNT, Quantum, Bio, Optical]**
- **Quantum computing is potentially E44 better
for some-to-many applications**
- **Beyond Human Machine Intelligence?**
- **Automatics/Robotics “in the large”**
- **Immersive multi-sensory VR/”Holodecks”**
- **Ubiquitous multi physics/hyperspectral sensors
[land/sea/air/space]**

IMPACTS OF ONGOING IT REVOLUTION UPON SOCIETY

- **Work (at home telecommuting, reduced local/corporal travel)**
- **Shopping (at home web based, (robotic?) delivery)**
- **Entertainment/leisure (at home immersive 3-D interactive/multi-sensory via VR/holographic projection)**
- **Travel (3-D/interactive/multi-sensory tele-travel)**
- **Education (at home low cost asynchronous, web based on-demand, highly motivational, life-long distance learning, .edu)**
- **Health (at home interactive tele-medicine)**
- **Politics (increased real-time virtual involvement of the body politic)**
- **Commerce (tele-commerce already ubiquitous)**
- **Tele-Socialization, Tele -[onsite] Manufacturing**

“It will be routine to meet in full-immersion virtual reality for business meetings and casual conversations in 5 to 7 years”

Ray Kurzweil, Author, “Age of Spiritual Machines” and “The Singularity is Near”

Tele-Everything

- Beyond the current IT age is the Virtual Age
- Tele Everything – Work, shopping, travel, medicine, politics, socialization, education, commerce, manufacturing, ...
- Rise of the individual “Prosumer”, Electronic, off-all-the-grids [energy, food, water, sewage] cottages
- 5 senses virtual reality [commercially demonstrated in the U.K.], holographic projection
- “Virtual Worlds”, 2nd Life and all that, [Many] millions are spending more time in virtual worlds than in the “real” world, this before widespread superb 5 senses virtual reality, which will make such “better than real”, and not limited to reality

“In 30 Years,The Universities of
America,as we have Traditionally
known them,will be Barren
Wastelands”

Peter Drucker

Existence Proofs - Distance/ Virtual Ed.

- Some 85% of College Students taking online courses
- Some 820,000 courses available from 20,000 Web Sites
- Largest University in the World is the Indira Gandhi National Open [Virtual] University, 2.5 Million Students
- K-12 Online enrollment projected to 10 million by 2014, growing at 30%/year

Major Ongoing Revol. Tech Advancements that Could Change “Everything”

- Structural BNNTs, CNT's, factor of 5 to 8 dry weight red.
- LENR
- 5 Senses Virtual Reality, Tele-everything, The Virtual Age
- Molecular Manufacturing
- CNT/Graphene & Quantum Computing
- Seawater Agric., Halophytes, cyanobacteria [Food, energy, land, water, warming]

“Rise of the Machines”

- Machine Intelligence approaching Human via Biomimetics and perhaps emergence
- Autonomous Robotics
- Creating increasing unemployment [manufacturing , now service, soon Intellectual]
- Humans becoming Cyborgs [Retinas, hearts, limbs, brain chips, ...]
- Emergence of a Global Sensor Grid and a “Global Mind” [Web 3.0++]

Machine Intelligence

- **Approaches:**
 - **Experiential - Behavior Based/'learning'** (neural nets/other "Soft Computing" - genetic algorithms, fuzzy logic,etc..)
 - **Nano-section/replicate brain in Silicon**
 - **"Emergence"**
- **Should produce Artificial/Cyber "life" which will possibly-to-probably be sentient but will not be anthropomorphic**

[Un]Employment.....

- We are in a “Jobless” Economic recovery, Large numbers of jobs “missing”
- Some 1/3rd of the “missing jobs” went out of the country [Globalization/outourcing of WHITE COLLAR/”Service” jobs]
- Rest of the jobs “Disappeared” due to ever-improving Automation/”Robotics/IT. Then year very few-to-no jobs the machines cannot do.....
- The machines create “wealth”, cost of goods on a rapid downward spiral

The OUTLOOK -Continuing rapid erosion of high level employment, No “Human Unique” jobs in the offing, “What the people will do all day” a serious issue.....

“Productivity Improvements”, Impacts of Automation, Robotization and Machine Intelligence upon Human Employment

- Already largely Automated - Manufacturing, Bank Tellers, Gas Station Attendants, Telephone Operators, Software, Billing Clerks
- Next-in-line - Check Out Clerks, Pilots & Air Controllers, Health Workers, Teachers, Soldiers, Attorneys, Accountants, Engineers
- Beyond/Emerging - “Invention”/Creative Activities

[Example] - Automated Invention

- Steve Thalers' Creativity Machine AKA Imagination Engine
- A trained neural net is deprived of all rational input
- “Dreams”, apparently as people dream, producing multitudinous new combinations/“ideas”
- A “critic” neural net evaluates these ideas for various problems/metrics
- Quite successful, good “Track Record”, many other such.....NOW

“When Industrialization first occurred there were fears of massive unemployment which never happened, Why will the integration of robots into the workforce be any different?”

“We didn’t create a second intelligent species 150 years ago, now we are doing that with intelligence that will get better and better.....”

Marshall Brain, Author ‘Robotic Nation’

“In Thirty Years it is likely that virtually all of the intellectual work that is now done by trained human beings such as Doctors, Lawyers, Scientists, or programmers can be done by computers for pennies an hour. Artificial General Intelligence is likely to eliminate almost all of today’s decently paying jobs.”

AGI-09, Washington D.C., ‘09

The truth is not only are people now surplus, but a liability. People make mistakes, Machines do not. People get tired and cranky, machines do not. People are erratic and unreliable, machines are not. People think and act slowly, machines do not. People have very definite limitations of endurance and concentration, machines do not. These human shortcomings mean that every modern system is designed to minimize or exclude human intervention; so just as horses became obsolete and were phased out of the workplace, so have people. No human can compete with the relentless, accurate, speed of the robot.

PHILIP ATKINSON, 2010

Machines taking the Jobs – Suggested Readings

- Martin Ford “The Lights in the Tunnel”
- Federico Pistono “Robots Will Steal Your Job But That’s OK”
- Hans Moravec ‘Robot’
- James Albus “The Economics of the Robot Revolution”
- Erik Brynjolfsson and Andrew McAfee “Race Against the Machine”

Humans Becoming Cyborgs

- Cochlear Implants
- Artificial Retinas
- Artificial Hearts
- Direct brain-to-prosthetic limb communication
- Brain Chips – To fix defective Brains now, brain augmentation being worked, then year probably cannot compete without the latest Brain Chip Installed

Emerging Sit-Rep

- Three Major Issues driving Down Standard of Living worldwide/ increasing ‘Unrest’
 - The Debt Problems, will result in much greater taxes, inflation and Interest Rates
 - Ecosystem Crashing, short 50% of a Planet now, As Asians try to attain Western Living Standards, will be short 4 Planets
 - The Machines are taking over employment RAPIDLY, outlook is GRIM

“Interesting Times” Projected Within Some 30 years-

- Increases in human life span approaching 1 year/year...
- Machine Intelligence approaching-to-beyond human, Networked Global Sensor Grid/Global “Mind”
- Individual [Bio, IO, Nano] capability to take down the species, “Warming” [CO₂, Methane, Albedo, land use]
- Machines/Robotics take-over “Employment”, produce wealth for EVERYONE, Molecular Manufacturing
- Humans become Cyborgs far more than today [Brain and Body]
- Revolutionary Energy Sources/Storage

[Nearly] everything goes VIRTUAL

Over the Million plus years of Human Evolution as the Dominant Animal on the Planet we have had to “work” to feed ourselves.....It now appears that we will create/develop machines that will be MUCH more productive than us and create Massive Wealth, relieving us of the need to “work”- this will be a MASSIVE “Sea Change” in the Human Existence Theorem

Suggested ‘Ways Forward’

- Halophyte/ Saline water AG to solve land, water, food, energy and climate
- Population control-to-depopulation to reduce ecosystem pressures, “Sustainability” WRIT LARGE
- Highly motivational and inexpensive virtual TELE-ED, educate everyone
- FAR MORE STRATEGIC/ longer term, planning wrt machines replacing humans wrt “employment, Distribution of the wealth produced by the machines

Going Forward, What will change Aero MUCH.....

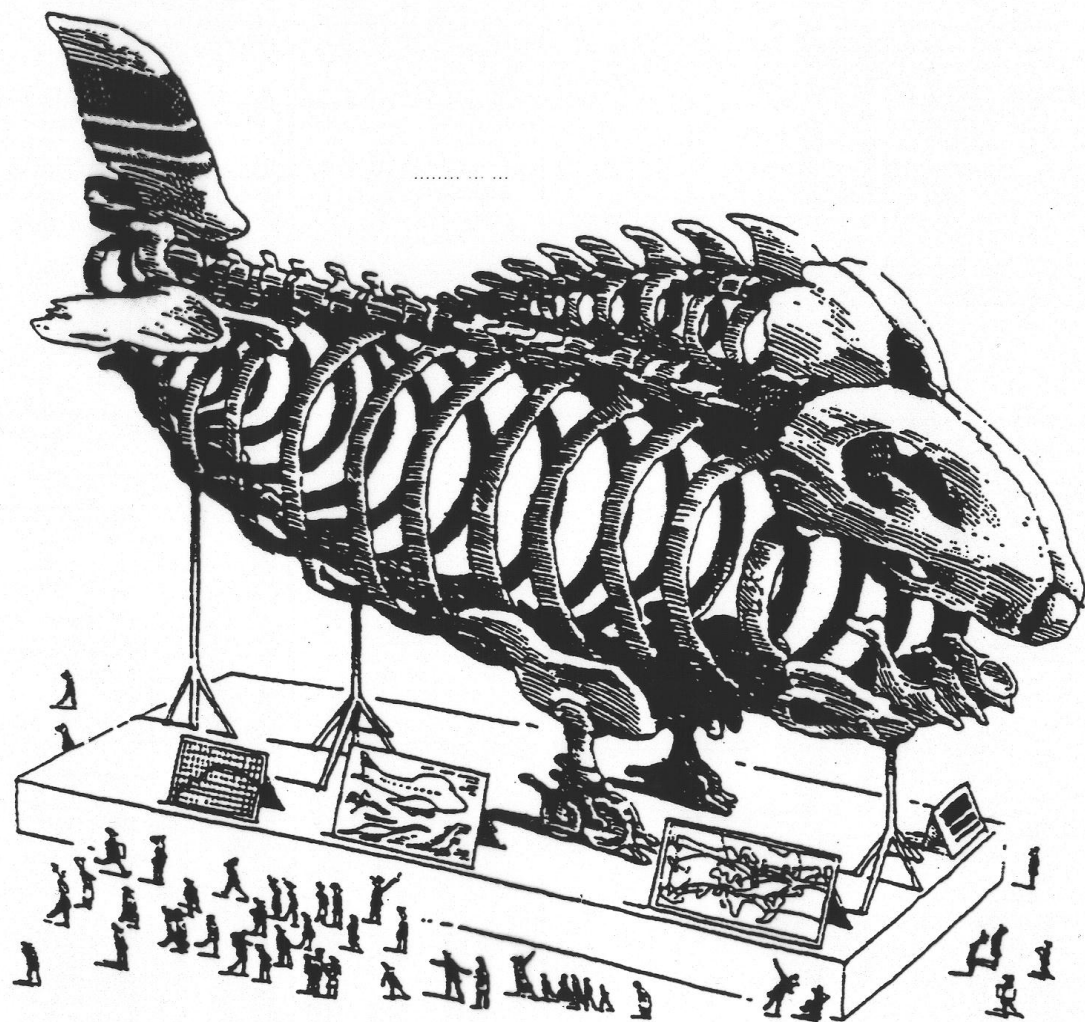
- 5 senses VR, Tele-Everything, Virtual Age, **Tele-Travel, - Reduced PAX utilization/demand**
[ongoing....]
- On site Manuf./ Fab Labs/ Molecular Manufacturing - **Reduced Cargo demand**
- Human level Machine Intelligence/ autonomous robotics - **Autonomous ATC and Air Ops**
- Toffler independent “Prosumers”, Distributed Everything-“**PC version of Aero, PAV**”

“Entering The Age of the
Small, The Fast, The Smart and the
Many....”

[And the Inexpensive and
Ubiquitous]

Aeronautical Industry Status

- **Global opportunities and competition**
- **High on (existing/deployed) technology s-curve**
- **Focused on incremental change**
- **Becoming appliers versus developers of technology**



Since 1940

- Long range train/ship passenger transport replaced by aviation
- Aviation and space assumed dominant role in warfare
- Satellites revolutionized communications and geopolitics

Aerodynamics

- Large, swept wing, near sonic aircraft
- Supersonic cruise and fighter aircraft
- Helicopters
- Bluff entry bodies
- Lifting entry bodies
- Long range missiles

Propulsion

- Turbojets
- Fanjets
- Ramjets
- Scramjets
- H₂-O₂ rockets

Materials

- High strength aluminums
- Composites
- Titanium
- Ablators
- Ceramics

Controls /Electronics

- Radar
- ILS, MLS
- ATC
- Fly-by-wire
- Digital controls
- Automatic pilot
- Automatic load alleviation/SAS/active controls

**Going Forward – Need to
Anticipate the impacts of the
ongoing Technological
Revolutions upon
Aeronautical Economics,
Missions, and Technologies**

Aeronautical “CHANGE AGENTS”

- **IT, Nano, Quantum, Energetics Tech revolution(s)**
- **Environmental “marching orders”/concerns**
- **“Competition” from 5 senses virtual reality
Tele-Travel, “Tele Everything”, the VIRTUAL AGE**
- **Competition from [local] Free Form Fab on way to Molecular Manufacturing**
- **Personal Autonomous Air Vehicles operated from the local streets**

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

Arthur C. Clark, 1984

Also, HUGE COSTS of Roads/ Bridges,
Infrastructures for current ground
transportation

PAV Enablers

- Massive capacity UAS-capable ATC, NAV, Automatic Flight System
- As close to Autonomous flight as feasible to avoid the errors and latencies of human “pilots”
- Affordable Vehicles [costs are rapidly decreasing due to “printing” manufacturing, The IT revolution, Etc....
- STOL vehicle capability to obviate need for “airports”

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

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

Available NOW from the Canadian Company RAF

- **RAF-2000, Kit Gyrocopter, ~ \$25,000**
- **70'-150' T.O. Distance, 10' Landing Roll**
- **Heated, Enclosed Cockpit**
- **140 MPH, 340 Mi Range, 20+ MPG**
- **14K ft Altitude, 740 lbs payload, 1500#GW**
- **Unleaded Gasoline, Safe engine out autorotation descent**
- **A Netherlands Firm working on a Roadable Version.....**

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 - Connextion, Will allow reduction of population density, improved ecology [red. Flooding/Heat Islands, Pollution, Crime]

The Payoffs from an “Electronic” ATC system are MASSIVE - New \$1 T/ year Aero Market, vast increases in personal mobility, satisfactory National Defense/ Security, Major Cost Reductions and increases in safety and capacity

³¹ 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

Suggested Comparisons Between Horse to Auto and Auto to VTOL Converticar “Transitions”

- **In Common:**
 - Occurs in the early years of the century
 - Provokes/enables major changes in land use and ecology (population dispersal)
 - Leads to atrophy of concentrated population centers
 - Revolutionizes Nation’s economy/builds on Country’s technological strengths
 - Equivalent percentage increase in speed
 - Increases personal “action radius”/“elbow room”/ “freedom of action”/privacy
- **Differences, VTOL Converticar**
 - “Infrastructure” far less expensive and will be/is largely “in place”
 - Improves safety

PAV Comments-Status /Outlook

- **Several factors converging to “make this [PAVs, Autonomous flight/ ATC] happen’ [road cost/congestion,IT Revolution/UAV’s, Technology advances, Homeland/ National Defense]**
- **THE Metrics are Cost,Safety,’Convenience” and “neighborliness”**
- **Powered lift variants could provide true VTOL and good forward speed, channel wings/nacelles with circulation control are a “newbee” for superSTOL, possibly better...**

Current/Emerging (Major) Issues Driving Re-Invention of Long Haul CTOL Transports

- **Safety/Security**
- **Acoustics**
- **(Water & CO2) Emissions**
- **IT (VR/immersive presence) competition**
- **International competition**
- **Fuel Price[s]**

Green Aircraft Problem Space[s]

- **The Emissions Issues:**

- NOX
- CO2
- Water/Cirrus

- **Fuel Burn**

- Reducing fuel burn A LONG TERM , Expensive, PARTIAL [only] Approach/solution
- Therefore primarily a cost reduction/ fuel cost issue

NOx Reduction[s]

- NOx can be reduced MUCH via clever combustor design. In HSR we worked such as “lean Burn, quick quench” etc and reduced NOx significantly. That was then, before we had the combustor physics/codes we now have [Thanx to CTR etc.].....Serious [replaceable/”drop-in”] combustor [re]Design, research ongoing.

Water/Cirrus Reductions

- Water addition above the Tropopause [above some 27K-30K ft] is warming/reflective of outgoing radiation. Water below 27K ft is cooling, reflects incident solar radiation
- Therefore - Fly/Cruise Below 27K ft. Not a major advanced ATC issue, just “Different.” If design the A/C for this little-to-no fuel burn impacts [downsize the wing]
- Utilize Circulation Control for takeoff to downsize wing & Greatly increase Airport Productivity [multiple takeoffs on same runway], utilize at cruise for ride quality “In the Weather”

CO2 Reduction

- Use of [Already flown/demonstrated] “Drop-in” Biofuels sourced from Halophytes, Algae and Cyanobacteria [utilize waste lands, waste/saline/salt water, MASSIVE Capacity] SOLVES CO2. The plants take up the CO2, some is sequestered, rest goes back into atmosphere, better than a closed cycle. NREL estimates Biofuel cost by 2020 ish at \$1.00/Gal.

From Bioengineering.....

- Engineered Microbes which utilize CO₂, sunlight and waste water to produce [projected] 20,000 gals of fuel/ acre-year, with Economics competitive with Petroleum at some \$50/bbl. [Petroleum now over \$90/bbl]
- “Joule Biotechnologies” , Nascent Technology, A potential MAJOR transportation fuels breakthrough.

What is “Different” About SST’s (wrt CTOL)

- **WAVE DRAG**
- **Higher Temperatures**
 - **Both Causing higher fuel fraction, higher costs, greater weights**
- **Ozone Issue (Higher Altitude), Emissions**
- **Radiation**
- **Sonic Boom, Much Higher Take-off Noise**
 - **Causing “anti-SST Legislation”**

OVERALL - An “uphill battle,” including several “failed campaigns” and perception that SBJ would only be for “Rich People”

H₂O Injection for Takeoff Noise Reduction

- **Method of “staging aircraft,” minimal cruise penalty**
- **Thus far order of 5% of engine flow rate provides 10db reduction, NOT OPTIMIZED**
- **H₂O droplets kill turbulent noise sources**
- **(Easily) pressurized H₂O injection INCREASES THRUST**

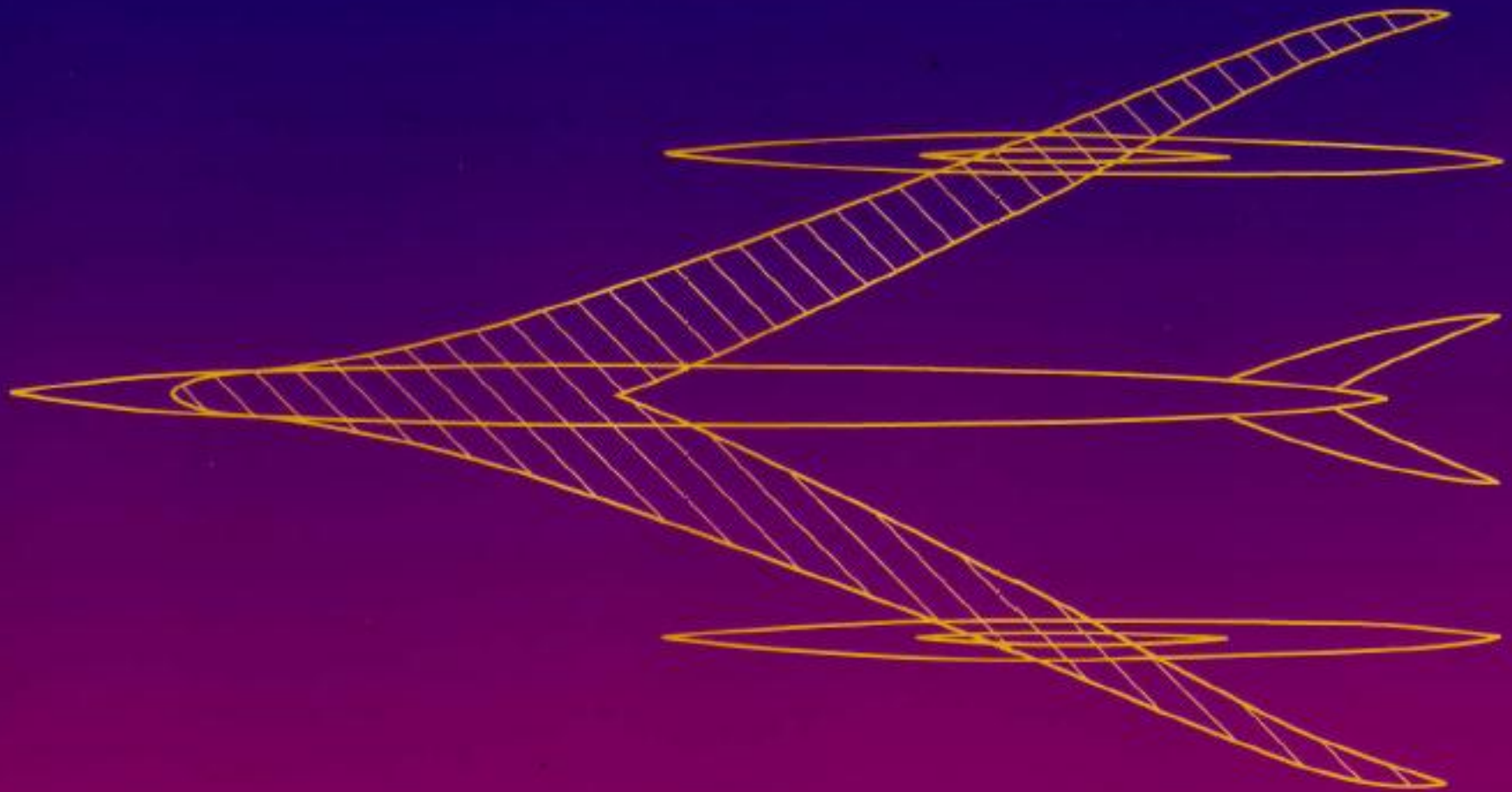
“Extreme Machine” Class
Aerodynamics required to
ameliorate
economic/environmental
Problems, provide “Margin[s]”

1. Favorable Interference/ Parasol
Wing +30% L/D

2. Strut-Braced/Extreme Arrow +
100% L/D

STRUT-BRACED HIGH ASPECT RATIO

LFC Wing, Cruise Mach # = 2



Features/Advantages

Pfenninger Strut-braced Extreme Arrow

- Minimal Wave drag-due-to-lift
- Increased Aspect Ratio
- Mid-wing fuel Canisters for Favorable Interference & load alleviation
- Low wing Re No - Extensive Laminar Flow
- ‘Natural’ Laminar Flow on fuselage and mid-wing cannisters, $L/D \sim 18$ [Vs. 9.5]

Example Advanced SST Research

- Pfenninger strut-braced/extreme Arrow Config.
- Propulsion that does not emit H₂O
- Suction LFC
- Thrust Vectoring for control, Bleedless inlets, Gear weight Reduction via “automatic landing[s] and chutes for refused takeoffs, H₂O droplets for noise reduction, Circulation control for high lift, riblets, C-wing tips...

Comments WRT Sonic Boom

- Can Double due to Atmospheric Conditions/ Caustics
- Can Double due to Maneuvering
- The Low Frequency, Building Structural Impacts extremely difficult to reduce
- Ongoing research trying to reduce Human perception levels to something tolerable to acceptable, For SMALL MACHINES
- The Oblique Wing is nearly Boomless up to an interesting speed that is much greater than usual CTOL.
- Overall, An uphill battle , whose outcome is TBD [allowable overland supersonic civilian cruise]

Current Air Transportation Status

- Serious Safety & Security Concerns
- Increasingly serious emission and noise concerns and restrictions, increasing fuel costs
- Seasonal increasing flight delays
- Capacity overload at major airports
- DHS, DOD requirements to operate UAVs in controlled airspace
- Personal aviation restricted to the rich
- Transoceanic travel times excessive

The Tasks Before Us.....

- **Safe, affordable, fast, convenient personal air mobility (door to door)**
 - **Huge societal/ government infrastructure cost avoidance (Roads, bridges, airports, etc., \$1T/Year Market)**
- **Aircraft Emissions addressed via seawater Biofuels, Flight below 27K ft for water and advanced Combustors**
- **Advanced Electronic ATC enabling UAV's in controlled Air Space for National Security and PAV**

(Example) “Usual” CTOL Transport Advanced Concepts

- **Strut-braced/Tip engines (C-C, NLFC, etc.)**
- **Adv, BWB (Goldschmeid integ., HLFC etc.)**
- **Ring Wing (Distributed/anti-DDL Propul.)**
- **Dbl. Fuselage-midwing**
- **Biplane**

What could we do if we “Took
The Gloves Off?”, Went back to a
“Frontiers of Flight “ Mentality?
[The following is the result of
such a mental exercise, an
attempt to establish/explore the
“Frontiers”, Art of the Possible]

Going in Considerations

- Are After Aero, Structural AND Propulsive Frontiers in a SYNERGISTIC DESIGN
- Important, once make major drag-due-to-lift reductions, need to re-establish a “balanced design” by making similar reductions in skin friction drag . This is the reason behind the need to “do it all” from an Aero prospective

Overall Approach[es]

- Pfenninger – Started with Suction LFC and then went to strut-braced wings to reduce DDL correspondingly
- This Effort – Started with TRUSS-Braced wings/ HUGE DDL reduction and then worked/ added techs/approaches to reduce viscous drag to rebalance performance
- Note – We have NO IDEA what an Optimal Wing Truss looks like! We have NEVER Been Here Before. Some obvious options include pre-stressing, laminar elements, arching, “Y” wing intersections, optimizing number/position[s] of truss elements.....ALL “Forward Work”, we have little real idea of what the performance is/could be until we do this. Active controls]/ load alleviation required.

Technology to Double CTOL L/D [$\sim 40++$] Incorporating Weight/Propulsion/Emissions/Acoustics/Vortex Hazard Solutions

- **The basic Enabler is full span Truss-Braced Wings, courtesy of CFD**
- **Major wing weight Red.**
- **Thin wing and unsweep, Natural Laminar Flow, wing Cf Red.**
- **DDL red. Via either Wing-Tip Engines, C-Tips or Wing-grid [$\sim 30\%+$ DDL red.]**
- **Alternative DDL red. Is Folding Span extensions, double Span, 75% DDL red.,,large span/small chord wing, even more Laminar Flow [$\sim 37\%$ VDR]**

Double CTOL L/D - Cont.

- **Fuselage Cf Red. Via red. Length, greater height [red. Wetted area, height for Truss attachment], riblets, Marlin nose to age boundary layer**
- **Engines Buried in Fuselage Base/boundary layer inlets and Goldschmied Shrouds, ~ 15% in “Propulsion Efficiency”, thrust vectoring for control/no Empannage or wing nacelles, major acoustics benefits, - ~ 30% Fuselage Drag via static pressure thrust [total VDR now ~ 75%]**
- **Chutes and Automatic Landing Sys. for gear weight Red. , BNNT structural/skin material[s]**
- **Also, red. Wake vortex via DDL, red. Weight and enabled control vortex generation/vortex systems**
- **Circulation Control for takeoff [200ft TO roll] and cruise ride quality to solve emissions [fly below 27k ft. for H2O] – or use trim tabs , Biofuels**

Thus Far [technology option[s] and effort-wise] ,
the L/D is in the mid-high 40's

IF add Fuselage re-laminarization just
downstream of the forward door [due to
radome, pitot tubes, windshield wipers etc. nose
of fuselage is turbulent] and use the ingested air
for turbulent slot injection D.R. in the
Fuselage/wing Interference wedge can attain L/D
in the high 50's to 60's.....

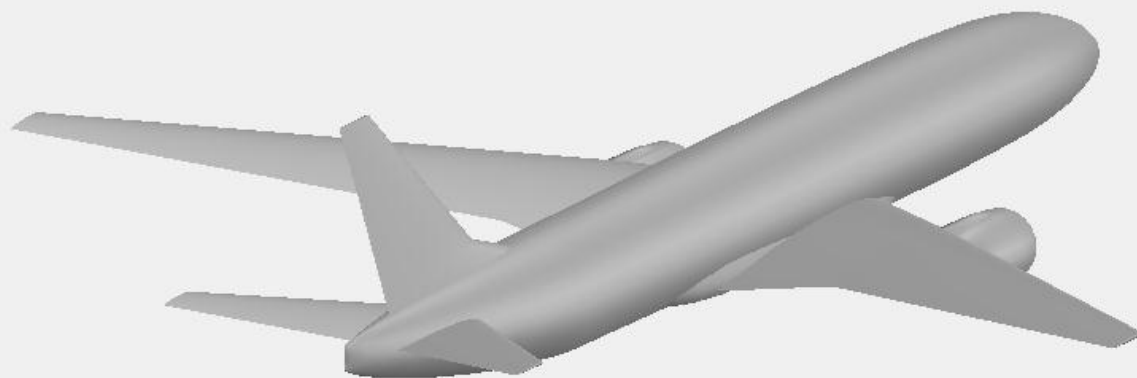
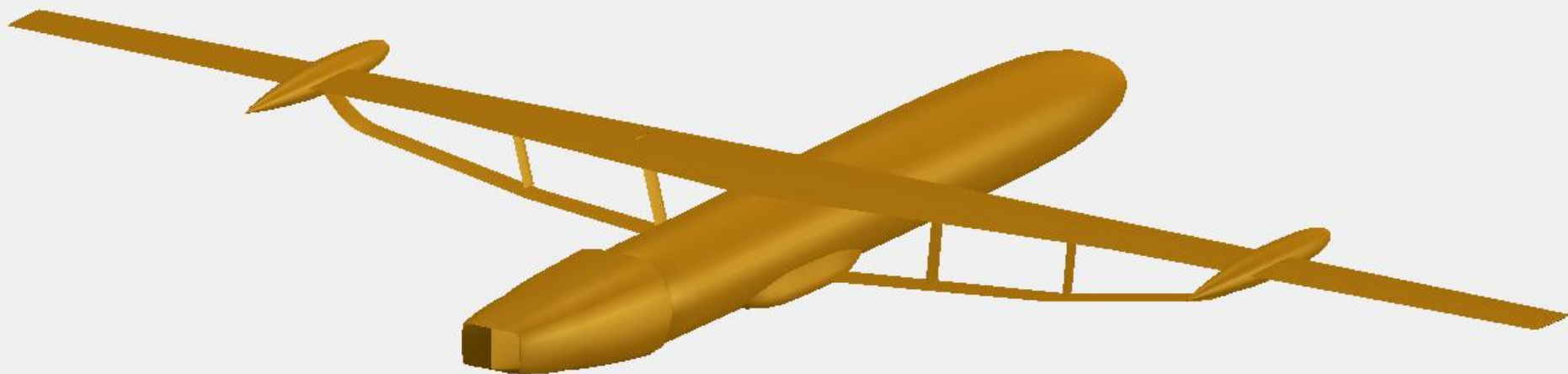
- Pfenniger, Laminar Fuselage Design, 700 Pax,
L/D ~ 100! Range 200,000 Km.

Double CTOL L/D - Concluded

- Advanced Engines - Aspirated Compressors, Wave Rotors [25%], Endothermic Fuel Cooling, Recuperators/tion [25%]
- Conops - Wing Tips [half the span] fold for Gate [“80 M. Box”], deploy/Lock outer & inner region Trusses before takeoff
- Serious “Load Alleviation”, “VPI Truss Joints”

WAG Performance Benefits

- $L/D > 40$ [into the 60's]
- $70\% < \text{Fuel Burn}$ [up to 85%+ reductions]
- $\sim 15\%$ [up to 65%] Propulsion Efficiency
- $\sim 30\%$ DRY WEIGHT REDUCTION [$\sim 70\%$ + for BNNT's]
- $\sim 250'$ TAKE OFF ROLL [with Circ. Control.]
- EMISSIONS "SOLVED" [BIOFUELS, FLY BELOW 27K FT]



Futures of Civilian Aero

- Wholly Electronic triply redundant ATC enabling UAV's in controlled air space, SWARMS of them [Civ. & Mil.]
- PAVE for the Masses, \$1T/ yr. market
- Truss-Braced Wing Tech Suite for long haul, “solving” emissions and fuel burn
- IF an SST propulsion cycle with zero water emissions is developed then SST's using Extreme Arrow approach are feasible [subsonic overland]

Aero Futures.....

- Large transports for over the Ponds only, ultra Long Haul, Red. PAX demand due to tele-travel
- Personal Aircraft, Autonomous/ robotic ops, wholly robotic ATC, Airport independent, Domestic Scheduled airlines largely atrophy
- Reduced Cargo demand due to onsite manuf.
- Biofuels sourced from saline AG, electrics, LENR[?]
- “Gloves Off” long haul machine, 85% fuel burn red.