

ENVIRONMENTALLY CHALLENGED

1. How does consumer influence ...?

- Low travel cost e.g.. people packer plane
- Methane/H₂ fuel
- Highly taxed, inefficient convenient travel
- Internet & other communications are a substitute if travel becomes more expensive

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2. Nature of general business . . . ?

- Just in time mfg.
- Low inventory
- Growth of mini-mill reprocessing scrap
- Small firms decline
- Decrease in business travel
- Low cost assembly may return to US

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3. Role of regulatory authorities . . . ?

- Certification may be in terms of efficiency
- Local CO2 landing fees
- European regulations make Europe the enemy
- Use tax for dedicated environmental improvement research
- Balkanization of regulatory regime

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4. How global civilian aero industry operates

- All searching for loopholes
- Two airframers
- Larger market for US subsystems & components than airframes
 - Including entertainment systems
- Two world engine mfg.
- Commercially derived avionics packages
- Largest portion of business is upgrades
- Large premium for ATM improvement
- Major market for sensors technology

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5. Military security environment?

- Proliferation of monitoring systems
- Increase in ASATs by CO2 target violators
- RPVs for tactical application
- Microvehicles

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6. Needs and opportunities for US aero . . . ?

- Hydrogen airplane
- People packer airplane
- Impacts on NASA facilities
- R&D on extraction of H₂ without CO₂ in process
- Restructuring aviation industry
 - Gets highest priority for CO₂ emissions?
- Change travel behavior
- Major innovation in flight simulation
- Military applications - greater emphasis on RPV and simulators
- Small aircraft
 - Efficiency
 - Bypass ground transportation CO₂ discharges
 - Many small airports
- Systems analysis modeling capability for transportation system
- Stealth aircraft for both military and civil applications
- Low fuel burn technologies, e.g., light weight composite structures, low drag, high-lift, efficient engines (reduced power/idle descent)
- Low carbon fuel technologies, e.g. methane, H₂, fuel infrastructure
- Alternate sources of propulsion for alternate vehicles
- Upgrade or replace older engines
- Aviation system improvements
 - ATM
 - Unpiloted civil aircraft
- Space based laser for sanctions
- ASATs for violators
- Short-takeoff and landing
- Micro vehicles
- Monitoring systems

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6. Technological implications?

- Hydrogen airplane
 - Low weight cryo tankage materials
 - Safety in ground handling, e.g., leak detection and mitigation
 - CO₂ efficient slush H₂ production and handling
 - Airplane configuration
 - H₂ engine development
- Low fuel burn technologies
 - Engineered and smart materials
 - New A/C config for high lift/low drag
 - Efficient engines
 - MEMS
- Improved security for civil aircraft
 - Low observable
 - Blast resistance
 - Airplane integrated detection system
- ATM for fuel efficiency
 - Highly accurate on-board weather prediction and monitoring
 - Sensors for more accurate positioning
 - System integration
- Uninhabited aircraft
 - Secure wideband data links
 - Non human centered automated decision making
 - Sensor technologies
 - System integration technologies
- Mini launch vehicles for micro payloads - civil and military reconnaissance

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Robust Elements in Our World

- Hydrogen airplane
 - Low weight cryo tankage materials
 - Safety in ground handling, e.g., leak detection and mitigation
 - CO₂ efficient slush H₂ production and handling
 - Airplane configuration
 - H₂ engine development
- Low fuel burn technologies
 - Engineered and smart materials
 - New A/C config for high lift/low drag
 - Efficient engines
 - MEMS
- Improved security for civil aircraft
 - Low observable/countermeasures
 - Bomb/blast resistance
 - Airplane integrated contraband detection system

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Robust Elements in Our World

- ATM for fuel efficient routing
 - Highly accurate on-board weather information and monitoring
 - Sensors for more accurate positioning
 - System security and integrity
- Uninhabited aircraft - military/cargo/passenger
 - Secure wideband data links
 - Automated decision making
 - Sensor technologies
- Mini launch vehicles for micro payloads, i.e. tens of pounds - civil and military reconnaissance
 - Reduced payload size with constant functionality reduces cost
- Totally quiet airplane

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7. Look beyond time horizon and speculate

- Micro aircraft based on MEMS
 - Sensors
 - Munitions
- Mini launch vehicles for micro payloads
- Exoatmospheric travel

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8. R&D activities that could address
technological implications

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Opportunities and Needs Technology Implications

1

- Description: Hydrogen powered large commercial aircraft
- Rationale: Visible carbon free airplane
- Problems:
 - Infrastructure, i.e. cost of producing H₂
 - Safety - real and perceived

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Opportunities and Needs

Technology Implications

2

- Description: Carbon based fuel aircraft technologies for minimizing CO2 emissions
- Rationale: May be best solutions for stopgap; refit potential
- Problems: Not a complete solution, competitive with other modes

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Opportunities and Needs Technology Implications

3

- Description: Improved security for civil aircraft to combat terrorism
- Rationale: Need to counter other countries' threats in this scenario
- Problems: Adds weight, complexity increased price

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Opportunities and Needs Technology Implications

4

- Description: ATM for fuel efficiency through shorter routes, reduced holding, and meteorological optimization of flight paths
- Rationale: Minimize fuel, minimize CO₂

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Opportunities and Needs Technology Implications

5

- Description: Uninhabited aircraft, smaller and thus reduced weight and fuel consumption
- Rationale: Reduced weight, fuel consumption, less CO2 output
- Problems: Acceptance by public

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Opportunities and Needs Technology Implications

6

- Description: Mini launchers for micro payloads - civil and military reconnaissance
- Rationale: Tensions, places we can't fly over, "cheaters," industrial intelligence, int'l science groups
- Problems: Everybody (e.g. terrorists) can have one!

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Robust Elements Across Worlds

- Low fuel burn technologies
- ATM technologies
- Low cost LEO launch capability (under 1000 lb payloads)
- Totally quiet aircraft
- Uninhabited aircraft
 - Reconnaissance
 - Combat
 - Cargo
- Highly survivable aircraft
- Integrated modeling and simulation vehicle design

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Breakthrough Points of Intervention

- Any new energy source which does not omit CO₂, e.g., fusion to make H₂
- Alternate solutions for CO₂ problem, e.g.,
 - Bioengineered carbon eaters
 - Airborne CO₂ “catalytic converter”
- Silent aircraft and rotorcraft
- Power MEMS
 - Each “powerplant” is 100 watts
 - Power on surface of aircraft
- Materials to reduce structural weight fraction by 2
- “Boomless” supersonic aircraft
- High subsonic VTOL and/or tiltrotor aircraft
- Pilotless civil aircraft
- Low cost tunneling technology
- Low cost exoatmospheric travel

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Agenda

- Robust elements across worlds
- Robust elements in our world
- Breakthrough points of intervention