

# Prior NASA General Aviation Research

## Oshkosh Airventure 2015

Dr. Bruce J. Holmes  
Holmes Consulting, LLC  
NextGen AeroSciences Inc  
AirMarkets Corporation



# Topics

- A Retrospective View of What Worked and What ...mmm... not so much (2003-2006)
  - AGATE
  - ERAST
  - GAP
  - SATS
- The Evolution of Mobility Demand and Supply
- Current Needs
- Approaches to Government – Industry Collaboration
- Summary Remarks

This presentation provides my views through the lens of past NASA experiences and startup entrepreneurial endeavors - aiming at game-changing innovations in air mobility.



# RETROSPECTIVE ON DISTRIBUTED, DEMOCRATIZED AIR MOBILITY

From three industry CEO's shared perspective...





# Strategic Innovation Premise

- A large underserved market opportunity exists for personal on-demand (mobility) air transportation (ODM)
- ODM is “strategic” or “blue ocean” in the sense that it stimulates new demand, previously unreachable and unfulfilled
- The lessons of the first-to-market have been learned (e.g., DayJet, SATSair)
- Many past barriers to market success have been lowered
- New barriers will require attention (e.g., cost, automation)
- The market is in need of new solutions
- The solutions generate significant value for our nation





# A \$2+ Billion Bottom Line

## Premise

A portfolio of integrated national technology development projects spanning the late 1980's to 2005, with industrial and governmental investments exceeding \$2 billion, was implemented on the **premise that the results would lead to significant market uptick** in the use of community airports and advanced technology smaller transportation aircraft for public transportation.

## Outcome

The evidence of the recent ten years, following completion of these investments, reveals an absence of intended effect; the **premise failed to reach fruition, to date.**

## Today

Why?

What is the relevance of the premise today?

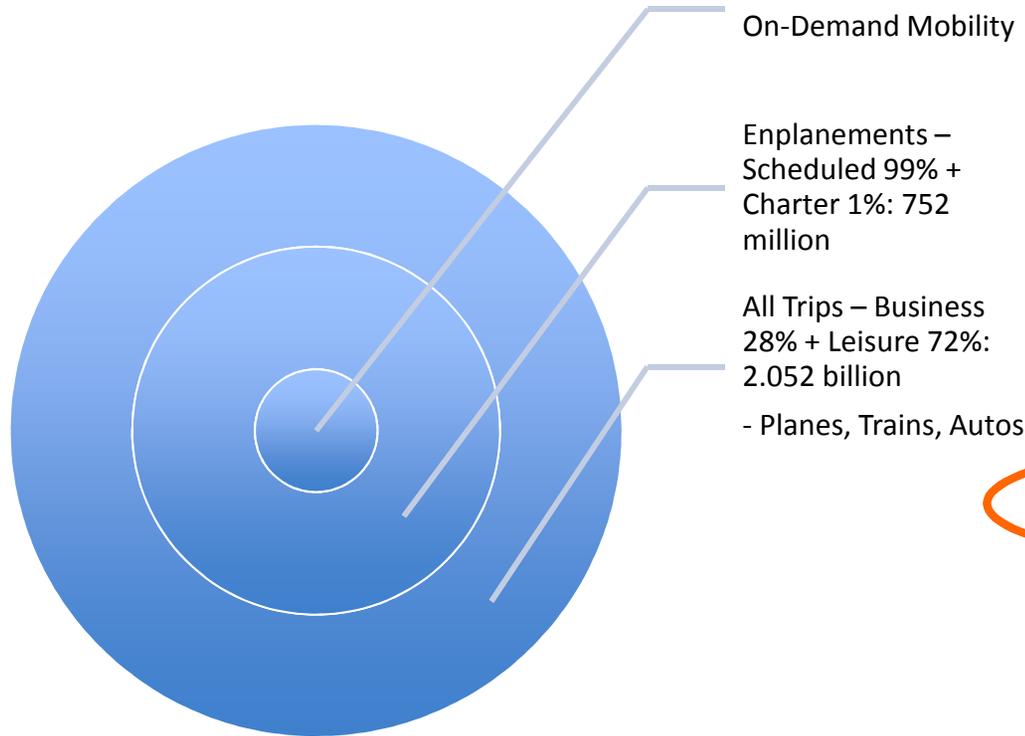
What good came of the investments?

What technology strategies are relevant now?



# Context: Total US Travel, All Modes

(Charter flying is a small fraction of the potential demand)



| Travel Categories                            | 2013 Trips    |
|--|---------------|
| All Trips<br>- Planes, Trains, Autos         | 2,052 million |
| Leisure Travel Person-<br>trips – All modes  | 1,600 million |
| Business Travel Person-<br>trips – All modes | 452 million   |
| Scheduled Carrier<br>Enplanements 5/13-4/14  | 747 million   |
| Non-Scheduled/Charter<br>Enplanements        | 5 million     |
| Business Travel Person-<br>trips by Air      | 150 million   |
| Leisure Travel Person-<br>trips by Air       | 597 million   |

[http://www.ustravel.org/sites/default/files/page/2009/09/US\\_Travel\\_AnswerSheet\\_June\\_2014.pdf](http://www.ustravel.org/sites/default/files/page/2009/09/US_Travel_AnswerSheet_June_2014.pdf)

[https://2bts.rita.dot.gov/xml/air\\_traffic/src/index.xml](https://2bts.rita.dot.gov/xml/air_traffic/src/index.xml)

<http://www.ustravel.org/news/press-kit/travel-facts-and-statistics>

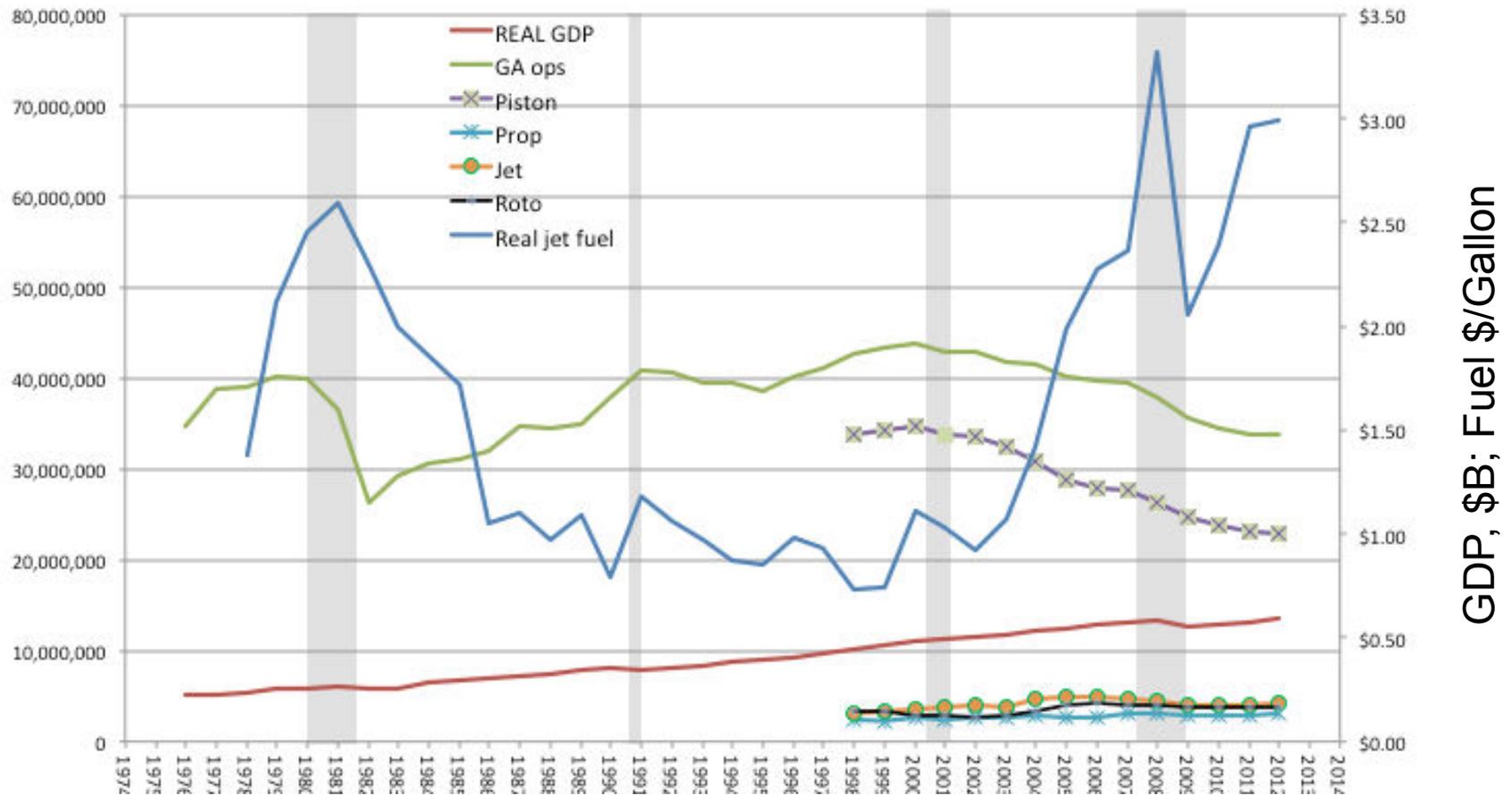
[http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/america\\_on\\_the\\_go/us\\_business\\_travel/html/entire.html](http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/america_on_the_go/us_business_travel/html/entire.html)

<http://www.businesstravelnews.com/Business-Travel/Business-Travel-To-Grow,-But-Slowly,-U-S--Travel-Association-Forecasts/?a=mqmt>



# Legacy GA Not Growing With GDP

GA Towered Airport Operations



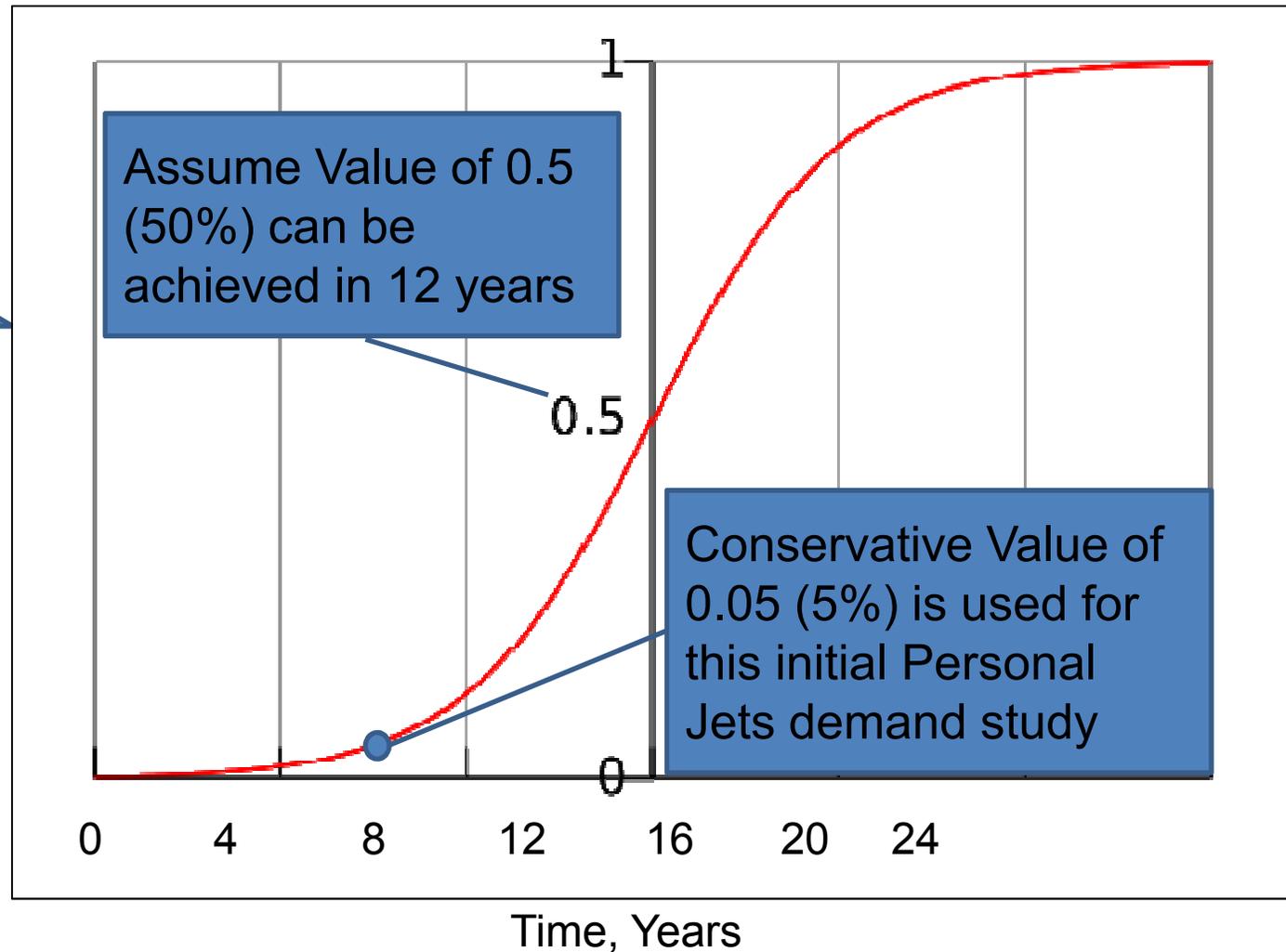
Data reveal weak coupling of GA demand with GDP, indicating that **new strategies are required** to move this market's needle.



# Market Penetration

AirMarkets uses “Consumer Awareness” as a measure of Market Penetration to account for passenger knowledge, comfort, confidence, and access to the Personal Jet mode.

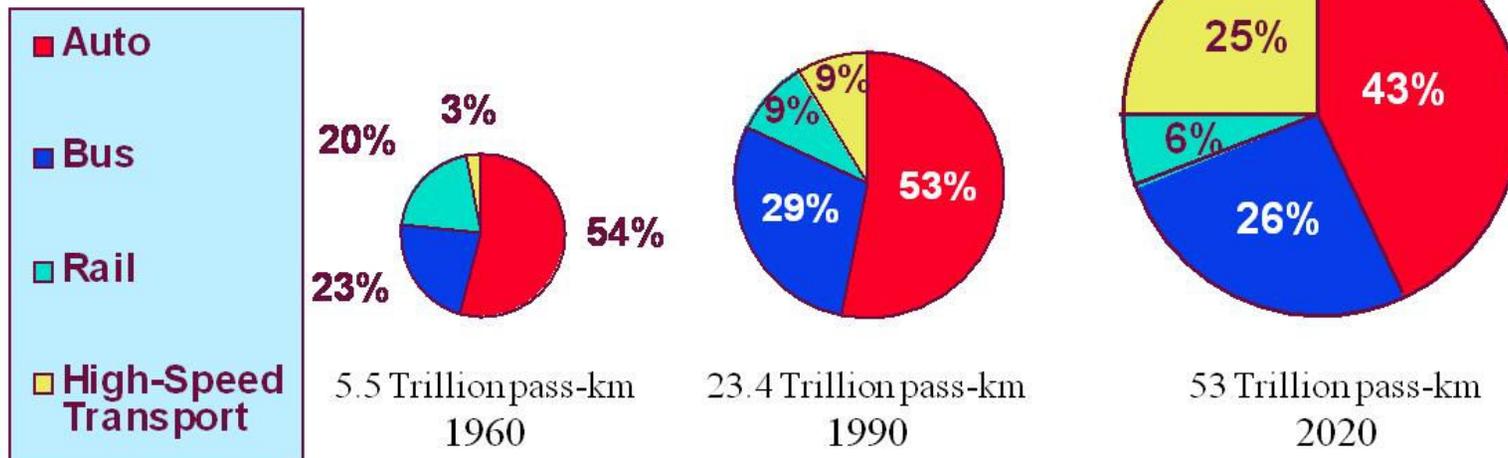
*Cumulative Consumption or Market Penetration, “Awareness Factor”*





# Evolution of Transportation Demand

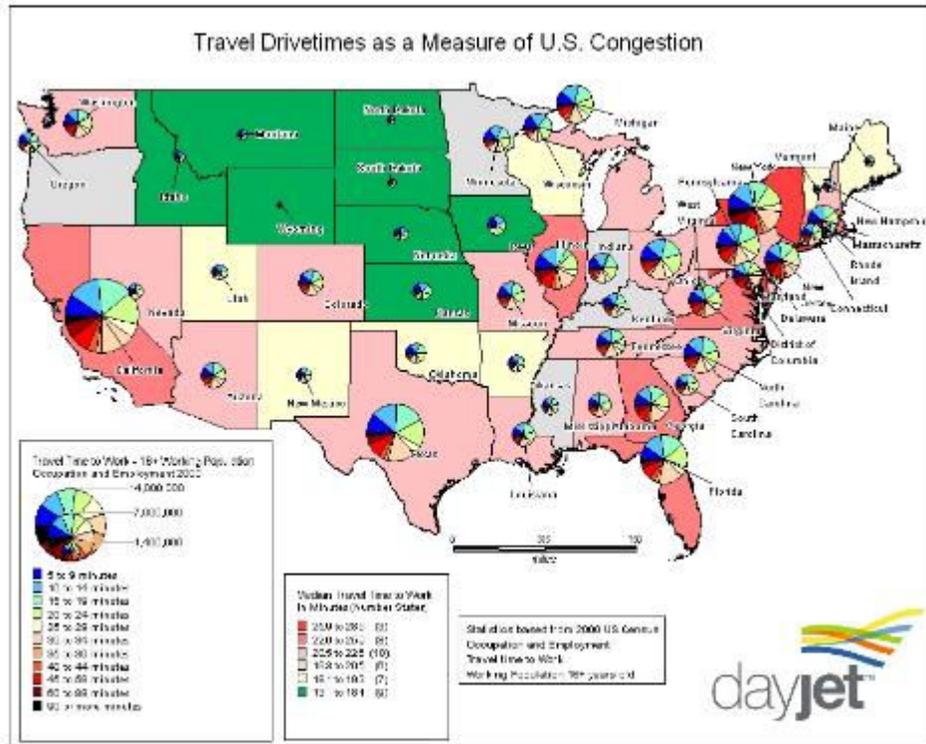
As per capita income rises,  
per capita annual travel rises,  
personal daily travel time budgets remain constant,  
and  
high-speed modes gain market share  
(Schafer and Victor, *Sci. Amer.*, Oct. 1997)



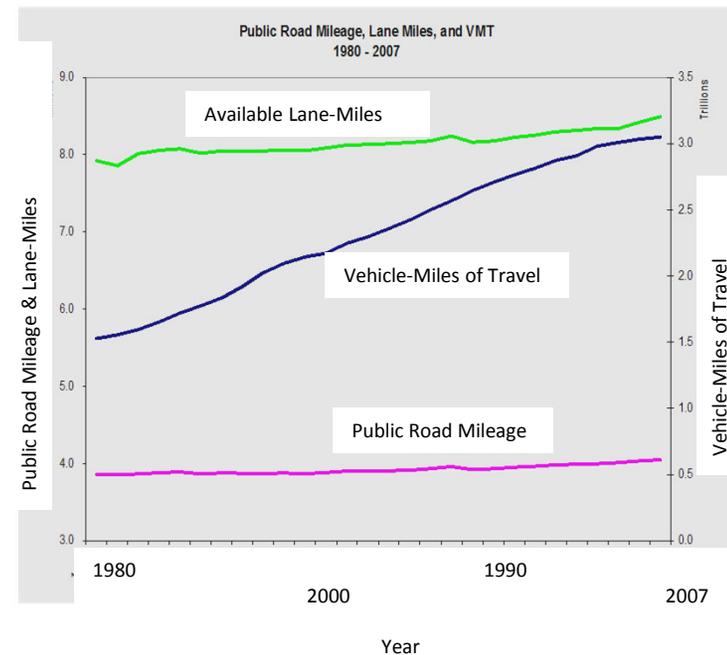
High-Speed Transport in 2020 – as large as all transport in 1960 and as all auto transport in 1990



# The Interstate Highway Challenge



- For 30 US states, road congestion is a serious issue for more than 1/3<sup>rd</sup> of the population.

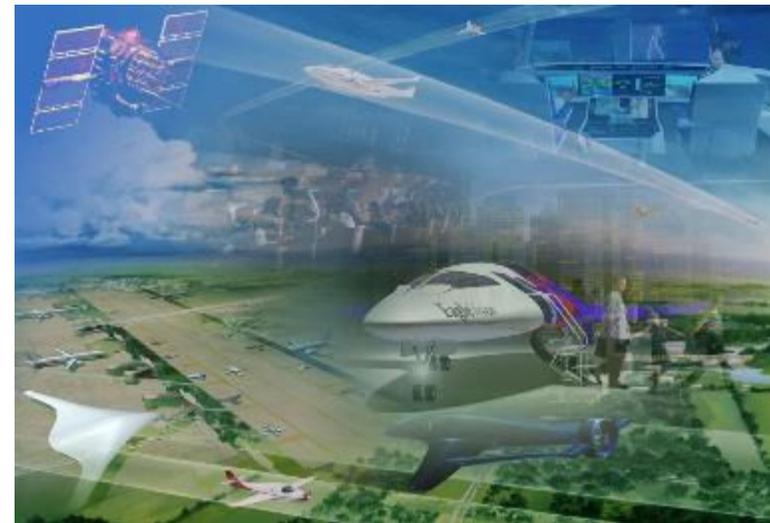


- For the Nation, the Interstate Highway System is completed, while demand grows.



# Industry and Government Motivations

- Evolution of Transportation Demand
- Constellation of NASA-Industry-FAA Investments
- Industrial Response
- Outcomes
- Opportunities





# Constellation of NASA-Industry-FAA Investments



AGATE Alliance  
1994-2001

GAP Project  
1995-2000

SATS Project  
2001-2005

**Outcome:** Technology, Regulatory Policy, Infrastructure Investment supporting expanded use of community airports and smaller aircraft for public transportation; however, we did not go far enough



# AGATE Mid-Term Progress Report



# Industrial Response



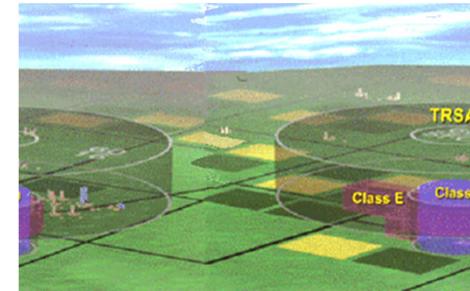
And  
Several  
Others



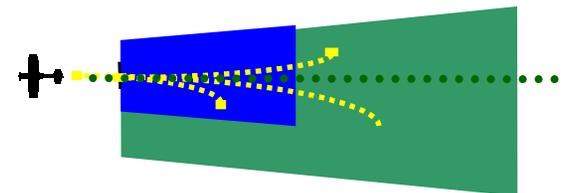
# NASA

## Small Aircraft Transportation System Program

Expanded use of community airports and smaller aircraft for public transportation



Higher Volume Operations



Lower Landing Minima



Single Pilot Performance

**Result:** Significant Infrastructure Advancements

- e.g., Virginia airports, AWOS III
- Nationally, LPV-WAAS >> ILS



# SATS Assessment

(From 2005 NASA Review)

- Deployed new transportation system demand analytical modeling.
- Conducted Business Case studies for:
  - North Carolina
  - Ohio
  - Upper Great Plains
  - Virginia
  - Michigan
  - Northeast Corridor & the Southeast
- Conclusions from 2005 reports
  - Profitability between \$1.50 – \$2.00 psm
  - Demand exists to support new aircraft
  - Costs still too high



**However:** Purpose-designed aircraft are needed to achieve fares  $\sim < \$1/\text{seat-mile}$



# A DayJet Lesson on Aircraft

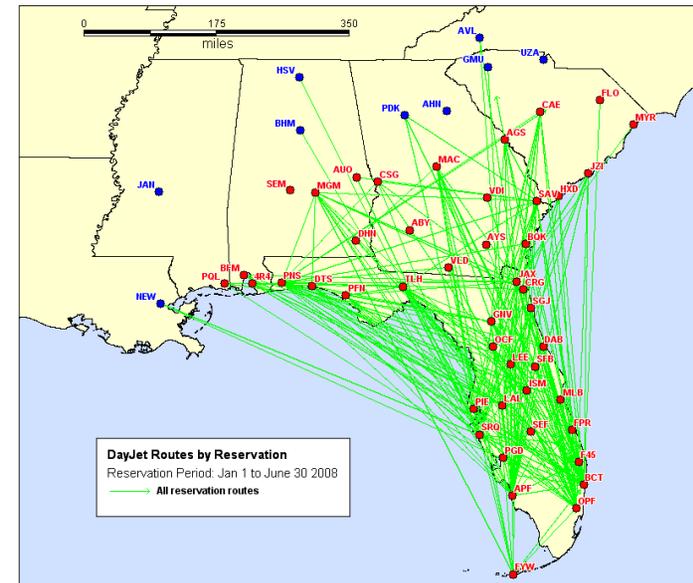
11 months of revenue service

- Average Trip Length = 252 nm
- Shortest leg – 97 nm
- Longest leg – 450 nm
- Typical Altitude – FL 180-210
- \$1.25/psm < Fares < \$4/psm

Eclipse 500

- Max Range – 1,100 nm
- Optimum Cruise Altitudes – FL 350-410

SATSAir Story Very Similar  
(Cirrus SR 22, 4 years service)



- At 1.5% of market, 6 million legs flown requires 1500-2000 aircraft flying 10 legs per day per aircraft.

Revenue Inefficiencies = Aircraft Mismatch + Airspace Inefficiencies + Two-Crew Operation: **More than 40% “loss”**



# On-Demand Air Carrier Sector



2002-2008



2002-Present



+ Others

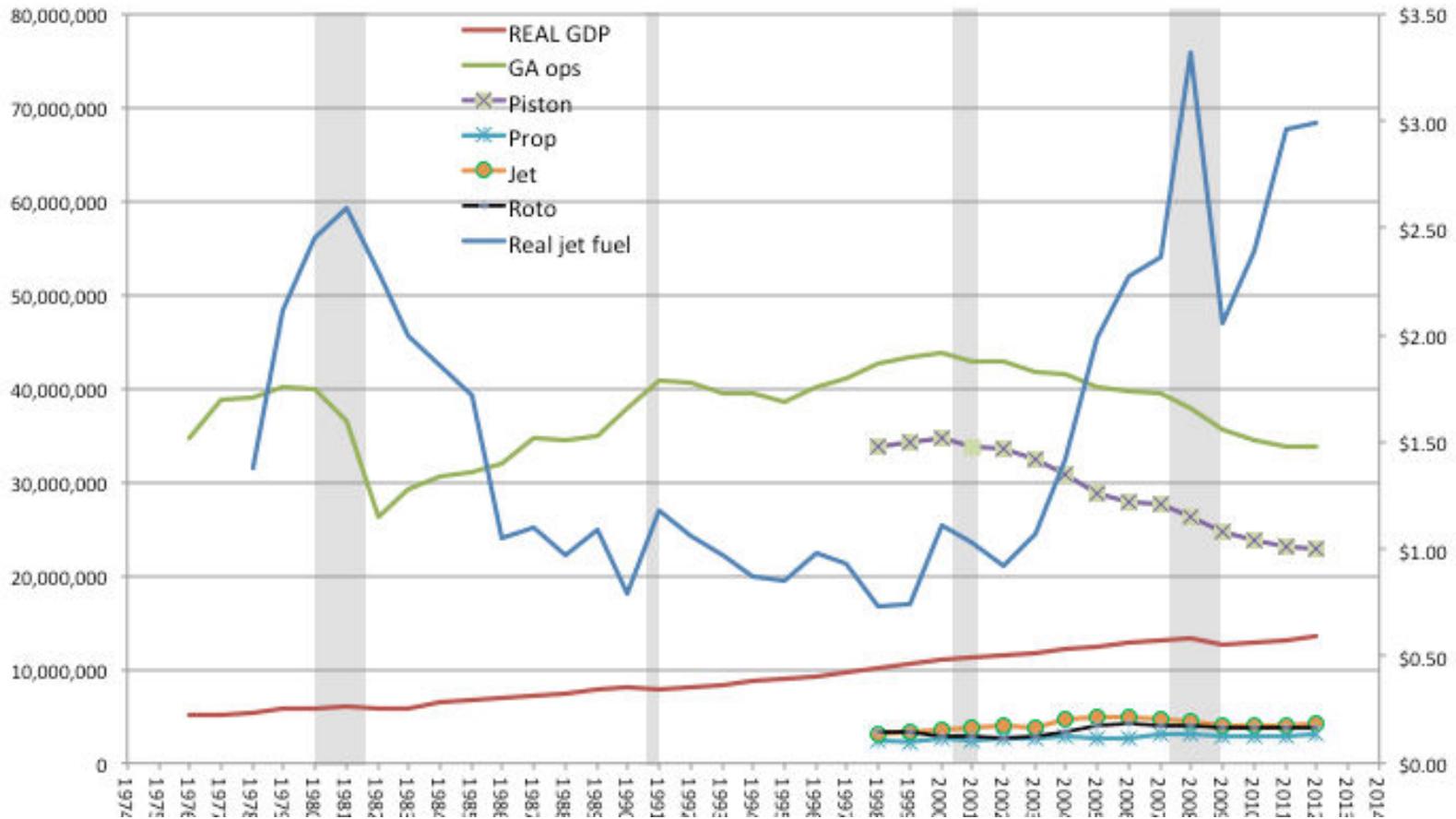
## Business Models (Parts 91K, 125, 121, 135)

- Branded Charter
- Brokered Charter
- Fractional
- Subscription Transport
- Jet Card
- Leasing
- Networked Air Taxi, per-seat
- Prop Card
- Pure Charter
- Corporate Shuttle
- Ride Sharing



# GA Not Growing With GDP

GA Towered Airport Operations



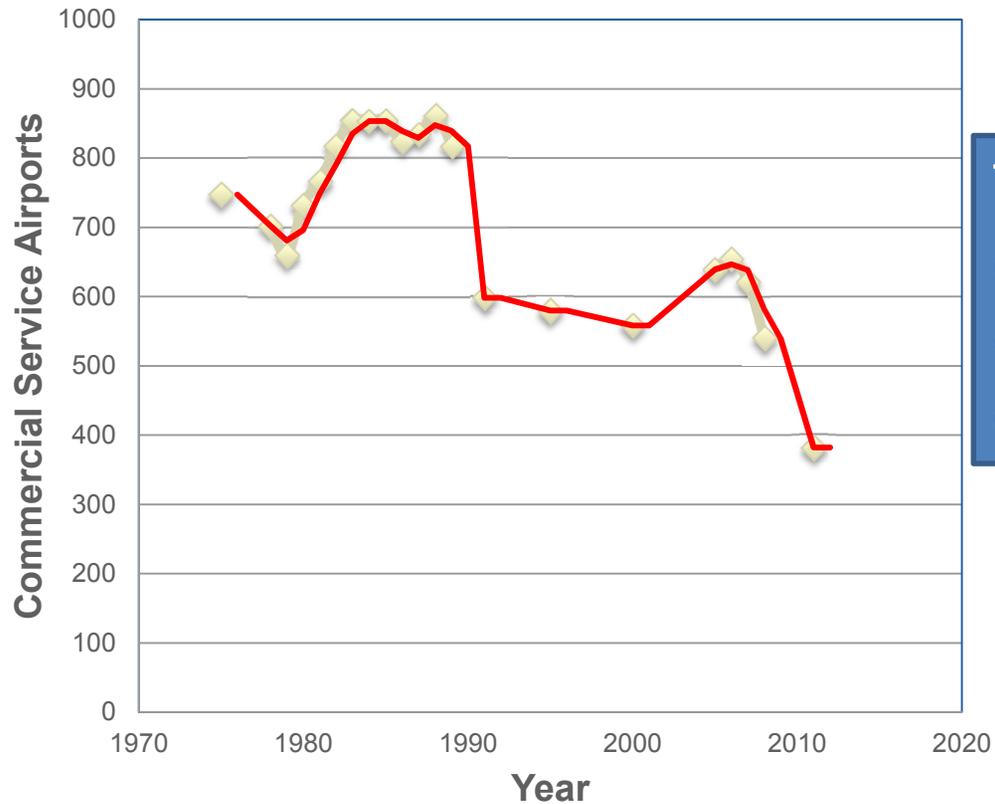
GDP, \$B; Fuel \$/Gallon

Data illustrate decoupling of demand from GDP, indicating that **new strategies are required to move this market's needle.**



# Medium Term Market Driver: Scheduled Air Service Contraction

## U.S. Commercial Service Airports



The continuing contraction of the scheduled air carriers creates a **market vacuum** as communities lose service

Based on data from the US Department of Transportation, Bureau of Transportation Statistics..



# Enablers for Innovation in On-Demand Air Mobility Service



## The “Right” Airplane

A higher-volume, purpose-built aircraft for thin-haul, networked, on-demand service reduces operating costs by >15%



## Real-time Logistics

Demand-Supply satisfaction and scheduling software enables per-seat fares with 2-4X reduction in fares



## Small World Networks

Autonomy reduces crew costs by about 25%



## Autonomy and NextGen

NextGen reduces fuel costs by 5 – 15% (estimates during FAA Test Bed project)

The regulatory, technical, and operational needs converge between UAS and On-Demand air service



# On-Demand Personal Air Travel Consumer Value Proposition

## On-Demand Network Performance

- Point-to-Point efficiencies
- Reduced network fragility

## Quality of Service

- Individualized preferences
- Door-to-door speed
- Value of Time, Command of time

## Community Access

- Air access and economic development
- Quality of life



# Lessons and Opportunities

- Airplane Requirements
- On-Demand Transport Market Size and Nature
- Logistics Capability Requirements
- Small World Network Design
- Effects of NextGen (TBO, ADS-B, DataComm, ...)
- Prospects for and path to Autonomy

We have lived through one of the largest industrial-governmental “experiments” in air mobility innovations, learned the lessons, and see the prospects for overcoming remaining barriers



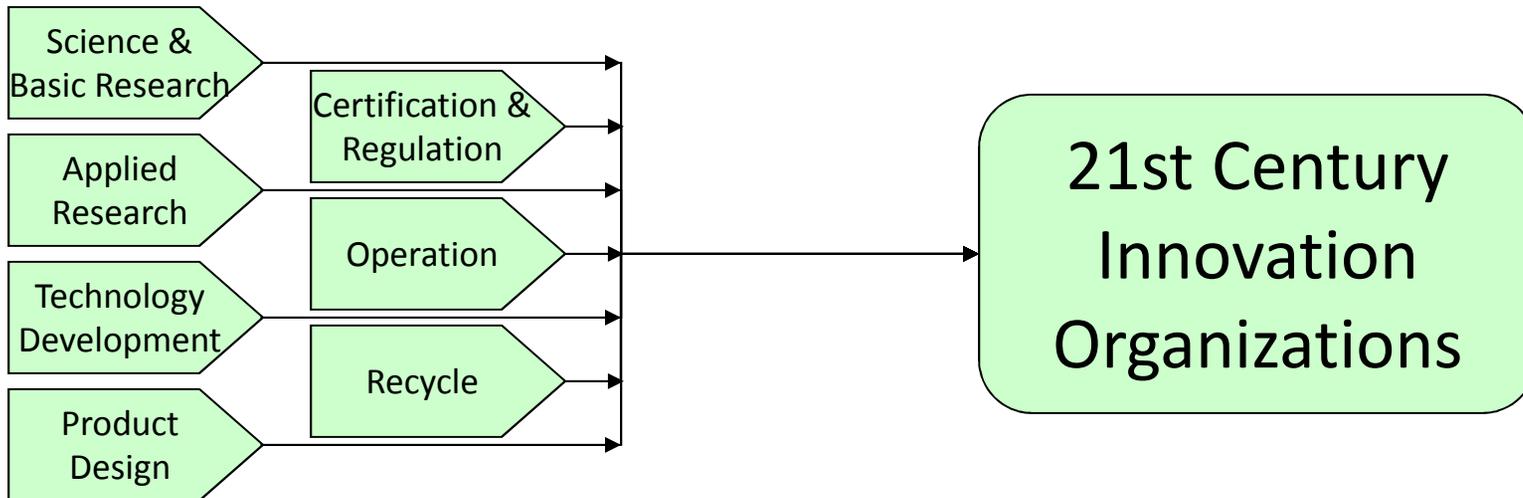
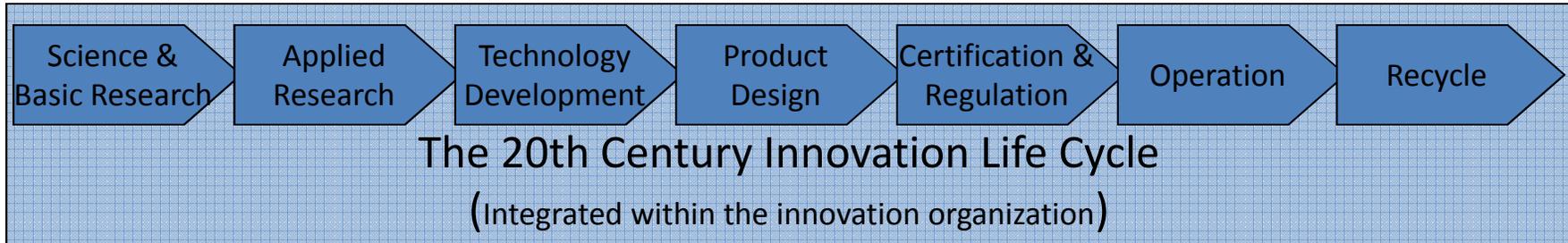
## Necessary Advancements

- Airspace with highway-equivalent operating simplicity
- Air Portals with seamless interconnectivity between roads and airspace
- Autonomous air vehicles with car-equivalent operating costs
- Outcomes that are beyond the ROI time horizon for the private sector (10-15 years)
  - Pre-competitive standards, guidelines, certs
  - Trust in autonomy
  - Host culture change in century-old industry

Create Blue Ocean strategic innovations



# 21st Century Labs and Alliance Strategies

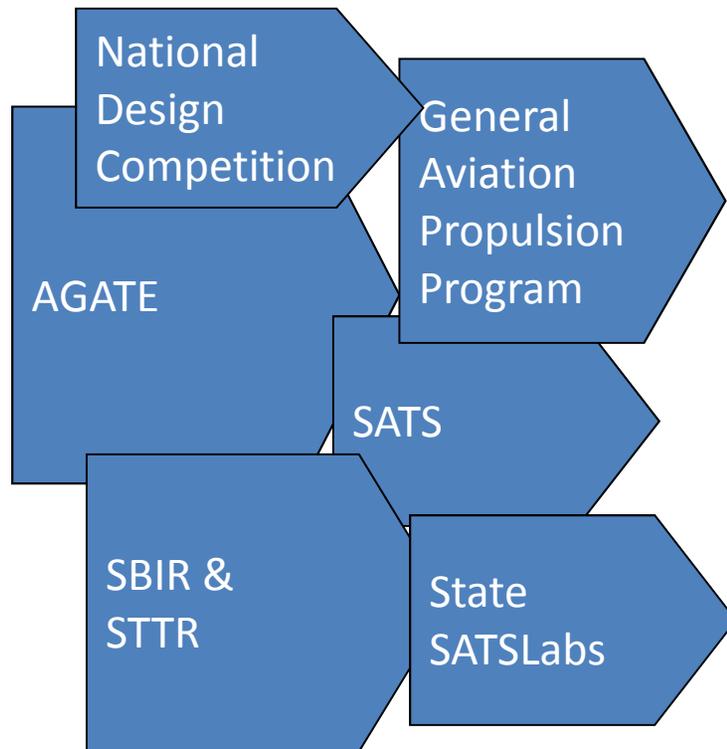


The 21st Century model for innovation requires new organizational processes.



# Alliance Strategy

(An Historical Example)



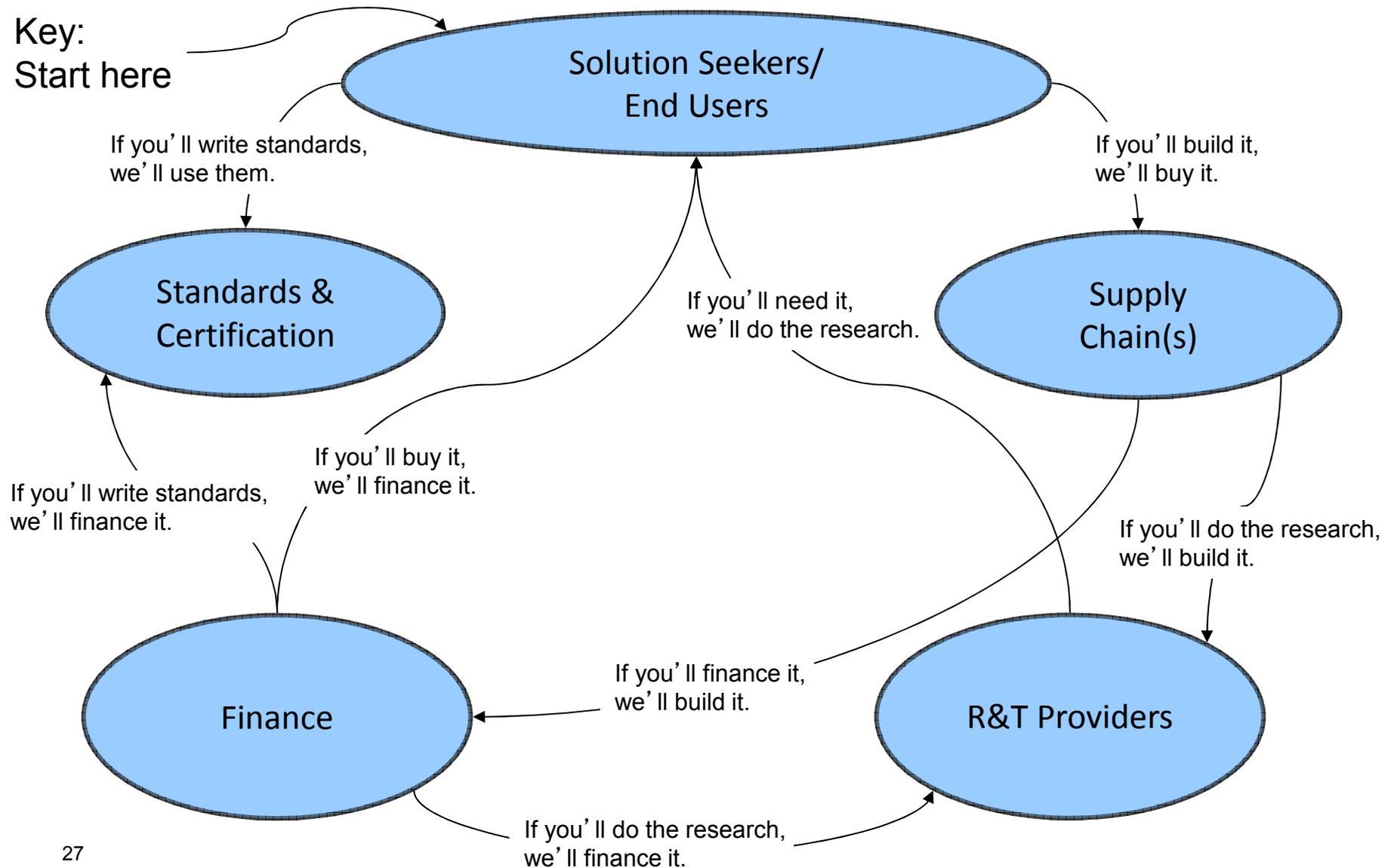
A Constellation of Alliances led to the public good outcome sought by NASA and new industrial capacity deployed by industry



# Innovation Alliance Strategies

## Design Architecture

Key:  
Start here





## Bottom Lines

- We have lived through one of the largest industrial-governmental air mobility innovation experiences, learned the lessons, and see the prospects for overcoming remaining barriers
- U.S. NextGen and E.U. SESAR programs are favorable to infrastructure for ODM operating capabilities.
- Modern market demand modeling tools, based on Agent-Based Models, provide improved and deeper insight into market opportunities and design decisions.
- Current aircraft are challenged to meet the cost and quality of service needed to make a breakthrough in air charter for On-Demand Mobility.
- The potential exists to achieve market fares that could drive demand to reach consumers and markets not served today
- The global demand for democratized personal air mobility vastly exceeds the supply.

*Thank You!*



# Bibliography

- "Annual Energy Outlook 2011 - With Projections to 2035, Table 12." U.S. Energy Information Administration, Washington DC, 2011, p. 246.
- "U.S. 2010 Census; Revised January 30, 2013." Washington DC, 2012.
- Blair, P., and Hauser, R. "Aging and the Macroeconomy - Long-Term Implications of an Older Population." Washington DC, 2012.
- Chester, M., and Horvath, A. "Life-cycle assessment of high-speed rail: the case of California," *Environmental Research Letters* Vol. 5, 2010.
- Borshchev, A., and Filippov, A. "From System Dynamics and Discrete Event to Practical Agent Based Modeling: Reasons, Techniques, Tools," *The 22nd International Conference of the System Dynamics Society*. Systems Dynamics Society, Oxford, England, 2004.
- Consultancy, S. D. G. "Air and Rail Competition and Complementarity, Final Report." 2006.
- Contrino, H., and McGuckin, N. "An Exploration of the Internet's Effect on Travel," 2006.  
doi: 10.2514/1.C031452
- FAA. "2013-2017 National Plan of Integrated Airport Systems (NPIAS)." Washington DC, 2012.
- Fallows, J. "Taxis in the Sky, How tiny jets, Soviet math prodigies, American "ant farmers," and dot-com refugees are revolutionizing air travel," *The Atlantic*. The Atlantic Monthly Group, Washington DC, 2008.
- Fischer, L., and al., e. "Who Rides Curbside Buses?." Chaddick Institute for Metropolitan Development, 2011.
- GAO. "High Speed Passenger Rail: Future Development Will Depend on Addressing Financial and Other Challenges and Establishing a Clear Federal Role." GAO, Washington DC, 2009.
- Gawdiak, Y. "Net Present Value Challenges for NextGen 2025 and Beyond," *11th AIAA ATIO Conference, AIAA Centennial of Naval Aviation Forum*. AIAA, Virginia Beach, VA, USA, 2011, p. 31.
- Gawdiak, Y., Holmes, B. J., Sawhill, B. K., Herriot, J., Ballard, D., Eckhause, J., Long, D., Hasan, S., Creedon, J., Murphy, C., Thompson, T., Wieland, F., Marcolini, M., Moore, M., and Alcabin, M. "Modeling of Demand and Supply for Air Transportation in the U.S., 2025 – 2040," *AIAA Aircraft Technology Integration and Operations Conference*. Indianapolis, IN, 2012.
- Gawdiak, Y., Holmes, B. J., Sawhill, B. K., Herriot, J., Ballard, D., Eckhaus, J., Long, D., Hemm, R., Creedon, J., Murphy, C., Thompson, T., Wieland, F., Marcolini, M., Moore, M., and Alcabin, M. "Air Transportation Strategic Trade Space Modeling and Assessment Through Analysis of On-Demand Air Mobility with Electric Aircraft," *AIAA ATIO Conference*. Indianapolis, IN, 2012.
- Yuri Gawdiak, James Herriot, Bruce J. Holmes, Bruce K. Sawhill, Jeremiah Creedon, Jeremy Eckhause, Dou Long, David Ballard: Modal Preference Modeling of Transportation Demand and Supply for Strategy Portfolio Analyses - Results and Future Plans. AIAA 2013-4361, 2013 Aviation Technology, Integration, and Operations Conference
- Haas, J. "Bright Idea, Ready When You Are, Dayjet's air taxi service is taking off," *Stanford Magazine*. Stanford Alumni Association, Stanford, CA, 2008.
- Hamilton, B. A. "Dynamic Impact Macro-Economic (DIME) Modeling." Vol. 2013, Washington DC, 2013.
- Holmes, B. J., Durham, M. H., and Tarry, S. E. "Small Aircraft Transportation System Concept and Technologies," *Journal of Aircraft* Vol. 41, No. 1, 2004, p. 10.

Continued



# Bibliography, Concluded

Joseph P. Schwieterman, e. a. "The return of the Intercity Bus: the Decline and Recovery of Scheduled Service to American Cities, 1960 - 2007." Chaddick Institute for Metropolitan Development, 2007.

Kieckhäfer, K., Walther, G., Axmann, J., and Spengler, T. "Integrating Agent-Based Simulation and System Dynamics to Support Product Strategy Decisions in the Automotive Industry," *Winter Simulation Conference*. Austin, TX, 2009.

Kitou, E., Masanet, E., and Horvath, A. "Web-Based Tool for Estimating the Environmental Impacts of Telework," *2001 IEEE International Symposium on Electronics and the Environment*,. IEEE, Denver, CO, 2001, p. 4.

Long, D., and Hasan, S. "Improved Prediction of Flight Delays Using the LMINET2 System-Wide Simulation Model," *9th AIAA Aviation Technology, Integration, and Operations Conference (ATIO)*. AIAA, Hilton Head, SC, 2009, p. 10.

Mane, M., and Crossley, W. A. "Allocation and Design of Aircraft for On-Demand Air Transportation with Uncertain Operations," *Journal of Aircraft* Vol. 49, No. 1, 2012, p. 10.

Nuic, A. "User Manual for the Base of Aircraft Data (BADA) Revision 3.6." Brétigny-sur-Orge CEDEX FRANCE, 2004, p. 103.

O'Toole, R. "Intercity Buses – The Forgotten Mode." Cato Institute, 2011.

Parker, R. A. "Virtual Markets: The Application of Agent-Based Modeling to Marketing Science," *School of Marketing, Faculty of Business*. Vol. PhD, University of Technology Sydney, Sydney, Australia, 2010.

Peisen, D. J., Schulz, C. L., Golaszewski, R. S., Ballard, B. D., and Smith, J. J. "Case Studies: Time Required to Mature Aeronautic Technologies to Operational Readiness." SAIC, 1999, p. 40.

RITA, D. "American Travel Survey (ATS) 1995." 1995 ed., DOT, RITA, BTS, Washington DC, 1995.

Schafer, A., and Victor, D. "The Past and Future of Global Mobility," *Scientific American*. Vol. Vol. 277, No. 4, Scientific American, Inc., New York, NY, 1997, p. 4.

Schafer, A., and Victor, D. G. "The future mobility of the world population," *Transportation Research Part A* Vol. 34, 2000, p. 34.

Subatra, S. "Video Telepresence." Vol. 2012, Network World, 2009.

Taylor, P., and Keeter, S. "Millennials: A Portrait of Generation Next," <http://www.pewresearch.org/millennials>, 2011.

Todorovich, P., and Hagler, Y. "High Speed Rail In America." Lincoln Institute of Land Policy, 2011.

Trani, A. A., Baik, H., Hinze, N., Ashiabor, S., Viken, J. K., and Dollyhigh, S. "Nationwide Impacts of Very Light Jet Traffic in the Future Next Generation Air Transportation System (NGATS)," *6th AIAA Aviation Technology, Integration and Operations Conference (ATIO)*. AIAA, Wichita, Kansas, 2006.

Walsh, M. "The Bus Industry in the United States," *EH.Net Encyclopedia*. Vol. 2012, EH.Net, 2010.