Transition Management, Sustainable Systems Innovation, and the Challenge of Countervailing Trends: The Case of Personal Aeromobility

Maurie J. Cohen
Graduate Program in Environmental Policy Studies
New Jersey Institute of Technology
University Heights
Newark, NJ 07102 USA
E-mail: mcohen@adm.njit.edu

ABSTRACT

Mobility research in transition management and sustainable systems innovation has tended to concentrate on battery electric vehicles, urban “smart” cars, fuel-cell powered transport modes, and power-assisted bicycles. While these studies have demonstrated the complex dynamics governing sociotechnical change, emergent developments outside the purview of sustainability have been excluded from the analytic frame. A critical area of neglect concerns the growth in aeromobility that has occurred in recent years. Passenger dissatisfaction with commercial airlines, public concerns about terrorism, increasing affluence on the part of wealthy travelers, and creative marketing by sponsors have led to expanded commercial interest in private aviation. In many regions of the United States, individually customized air travel is becoming a relatively simple and affordable transport alternative. This discussion documents the mounting popularity of four segments of the market: business/personal airplane ownership, fractional aircraft ownership, flight-time cards, and air taxis. It also describes the catalyzing role that the Small Aircraft Transportation System (SATS), a working group within the National Aeronautic and Space Administration (NASA), has had in addressing the technological and logistical obstacles to more pervasive personal aeromobility. The concluding portion of the paper examines the ramifications of these trends on current efforts to foster sustainable mobility.

1. Introduction

During the past decade, transition management has gained prominence among scholars and policymakers interested in sustainable systems innovation. This field of applied research has coalesced around awareness that the most prevalent sustainability tools and strategies are geared largely toward fostering incremental improvements in materials and energy-intensive practices over relatively short time intervals. Proponents of transition management have sought to address this problem by cultivating a more expansive planning horizon—typically one or two generations in length—that allows for more imaginative consideration of how to ambitiously transform entire sociotechnical systems for producing and consuming food, for generating energy, and for meeting societal needs for mobility (see, e.g., Rotmans et al 2001; Martens & Rotmans 2002; Smith 2005).

The literature on transitions toward more sustainable systems of mobility emphasizes the need to conduct niche experiments with small-scale technologies such as battery electric vehicles, urban “smart” cars, fuel-cell powered transport modes, and power-assisted bicycles (Brown et al 2003; Brown & Carbone 2004; Elzen et al 2004; Hekkert & van den Hoed 2004; Truffer et al 2002; van den Hoed and Vergragt 2004; Vergragt 2004; Kemp &
Rotmans 2004; van den Bosch et al 2005; Geels 2005a, 2005b; see also Dearing 2000; Hård and Knie 2001; Cohen 2006; Rajan 2006). The tendency is emphasize motive designs that are highly compact, lightweight, and able to function without the direct input of fossil fuels. There is furthermore stress on the importance of alternative legal titling arrangements with pride of place occupied by various cooperative or shared-ownership schemes.

Most nascent ventures to nurture more sustainable systems of mobility have to date failed to challenge the current transport paradigm due to insufficient capitalization, marketing entrepreneurship, supporting infrastructure, or government facilitation. Analysts of sustainable mobility have moreover been largely preoccupied with surface transport—focusing primarily on substitutes for the internal combustion engine—and have turned their gaze away from growing patterns of aeromobility as well as the interface between air and surface transport. A separate group of scholars with interest primarily in the sustainability implications of global tourism has begun to explore the implications of the expanding availability of low cost air travel (Janic 1999; Høyer 2000; Gössling 2002; Frändberg & Vilhelson 2003; Shaw & Thomas 2006). The intent of this paper is to draw attention to several dynamic developments within the aviation market that, because of their potential for rapid diffusion, are likely to have profound ramifications on efforts to foster more sustainable mobility systems. A secondary objective is to illustrate the essential inseparability of surface and air transport in discussions of the future movement of people and goods.

The next section provides an overview of the literature on mobility transitions. This discussion is followed by a description of the expanding range of increasingly affordable options for personal aeromobility and reviews a specific ongoing planning initiative in the United States under the aegis of the National Aeronautics and Space Administration (NASA) to develop a Small Aircraft Transportation System (SATS). The concluding section considers the implications of these developments on efforts to foster sustainable mobility.

2. Transition Management and Mobility

Mobility specialists working within the ambit of transition management emphasize that the creation of more sustainable transport systems is only partly dependent on the design of more energy-efficient vehicles. To achieve the multifold reductions in fuel use and greenhouse emissions currently deemed necessary, while simultaneously expanding global access to affordable mobility services, one must also be attentive to the laws, rules, norms, market and regulatory incentives, and social practices that define the contemporary mobility system. Interventions must, therefore, be predicated upon a sophisticated understanding of the full range of political, cultural, and technological factors responsible for the inertia in the prevailing setup and that have in the past stymied the uptake of innovations that threaten dominant designs.

The literature on transition management and mobility that has accumulated over the past decade can be divided into four categories. The first approach is retrospective and seeks to identify the historical factors responsible for driving the sociotechnical evolution of mobility systems in earlier eras. A second strand is more pragmatic and focuses on the diffusion of innovations occurring at the interface between automotive engineering and public policy, most notably battery electric vehicles, alternative fuels, and fuel cells. A third, less prosaic thread of work considers a number of more esoteric developments taking place outside of mainstream public view. A final strand of inquiry employs foresighting and backcasting techniques to chart plausible transitions through which prospective mobility innovation might progress over the next several decades.1

The first perspective on sustainable system innovation with respect to mobility has been developed in large part by Frank Geels (2005a; 2005b) and is grounded in historical studies of the evolution of transport technologies over the last two centuries. The aim of constructing detailed retrospective research on past transitions such as the displacement of sailing ships by steam vessels and the replacement of horse-drawn carriages by
automobiles is to give credence to the mutuality between the social and technical dimensions of important societal services. While dominant sociotechnical systems are often deemed to be invincible at the peak of their success, these detailed views backward shed light on how accreting, multi-level changes can accumulate over time to produce potent alternatives with the capacity to rapidly supplant more powerful rivals.

The second approach is more overtly purposeful and examines the relative tradeoffs and future prospects of battery-electric vehicles, gas-electric hybrids, fuel cells, and other technologies presently foremost on the policy agenda (Truffer et al 2002; Hekkert & van den Hoed 2004; van den Hoed & Vergragt 2004; Vergragt 2004; van den Bosch et al 2005; see also Kemp & Rotmans 2004). Scholars of transition management observe that current public enthusiasm for gas-electric hybrids stems from the fact that these vehicles (most notably the Toyota Prius) offer a strategy to achieve modest improvements in fuel economy without having to resolve any of the politically divisive contradictions embodied in the contemporary surface transport system. A major concern in this regard is that hybridization has the potential to lock in suboptimal outcomes as this technology relieves the sense of urgency for systemic adjustments, dampens opportunities for useful social learning, and ultimately delays the timeframe for the commercial-scale implementation of more radical design changes. This perspective also highlights how, from the standpoint of powerful institutional actors, gas-electric hybrids have already yielded significant benefits. For instance, by postponing into the indefinite future fundamental change regarding automotive fuel requirements, it has proved possible to successfully diffuse the challenges posed by battery-electric vehicles during the 1990s (see also Dyerson & Pilkington 2005).

The third perspective focuses on a range of entrepreneurial activities being pursued by small groups of highly creative individuals who are committed to engendering expansive new conceptions of mobility. For example, Brown & Carbone (2004) assess the engineering and promotional strategies behind two small electric cars respectively named Sparrow and Gizmo by their manufacturers. Researchers working within this perspective have also examined the potential of an innovative three-wheel electric bicycle called Mitka developed during the 1990s at the Delft University of Technology in the Netherlands (Berchicci & Vergragt 2002; Brown et al 2003). Common to all of these imaginative vehicles is the diffident organizational circumstances under which their particular design projects evolved and the obstacles that the sponsors now face in securing market viability. Despite the long odds of achieving financial success, these intriguing mobility technologies have the potential to inspire extreme innovation in personal mobility.

A final example of work on mobility transitions is represented by the work of Boelie Elzen and his colleagues (2004) to develop a series of stepwise innovations that could provide possible evolutionary paths over the next fifty years. One of their envisioned trajectories consists of four successive periods. An initial decade-long phase (2000-2010) begins with partial uptake of small electric cars and hybrid electric vehicles as automobile usage costs increase due to higher taxes, tolls, and congestion charges. These changes provide the basis in the subsequent period (2010-2020) and the introduction of fuel cell buses, the expanded use of biofuels, and the further market penetration of small electric cars. In the third phase, climate change continues to impose escalating costs on society and in response a new type of long-distance vehicle powered by a fuel cell begins to gain popularity and, in tandem with this development, opportunities start to emerge to integrate automatic vehicle guidance systems (AVG) into the overall surface transport system. Finally, in the final phase of the anticipated transition, AVG becomes more widespread and its growing use leads to less congestion. This situation prompts an increase in vehicle ownership after an extended period during which sales had stagnated or declined. However, because the automobile fleet is comprised of small electric cars, hybrids, and hydrogen-powered long-distance vehicles there is little additional burden in terms of greenhouse gas emissions.
3. The Growth of Personal Aeromobility

While a century ago the possibility of jetting at 35,000 feet was still a distant dream, we have in the present day come to experience such journeys as mundane and—hopefully—uneventful. For most travelers, the impressive grandeur and stateliness of Pan Am’s Clippers gave way long ago to the discomfort and petty aggravation of economy class. The monotony of the experience is at least partly attributable to the fact that commercial airplanes provide a relatively safe, affordable, and accessible form of long-distance transport. Thousands of passengers now board scheduled aircraft everyday with nary a thought of the enormous organizational and technological challenges that are daily overcome to make mass air travel a practicable and reasonably reliable mobility service. The normalization of this mode of transport is marked by exponential increases in both passenger volumes and travel distances (Figures 1 and 2).

This growth in air travel has taken place in the face of protracted financial distress on the part of the airline industry. Beset by a litany of problems including aging equipment, high labor costs and high fuel prices, weather delays, ever-changing security protocols, discount startups, customer-friendly reservation systems, and persnickety passengers, besieged managers have had to confront one disabling dilemma after another. Amidst this upheaval and disarray, savvier travelers have begun to defect in expanding numbers from the mainstay commercial companies and to opt instead for novel forms of service to satisfy their air-travel needs (see, e.g., Gottdiener 2001; Fallows 2002).

To some extent, these developments do not represent anything new. Private airplanes have been of course, a staple form of transport for a select crowd of jet-set celebrities, corporate executives, and political figures for decades. Business and personal aircraft have long enabled these individuals to preserve their luminous public personae while concurrently conferring protection from the indignities of commercial flights. However, a combination of technological innovation, marketing inventiveness, and opportunistic circumstances is eroding the elitism typically associated with personal aeromobility and on-demand air travel is now on the verge of becoming a more mainstream mode of transport.

First, aircraft manufacturers are now mass producing smaller airplanes and selling them at affordable prices. Models such as the Cessna Mustang and Eclipse 500 can be purchased for as little as US$1 million and this price is making private aviation a reality for a growing number of travelers. The Brazilian company Embraer, long shut out of the large-aircraft market by Boeing and Airbus, has been aggressively exploiting this interest in small- and medium-sized aircraft and is now gaining a formidable position in this market.

Second, pioneers in the field of personal aviation have developed a number of novel marketing strategies that have the effect of spreading the acquisition and operating costs of customized flight services across small groups of passengers without compromising the convenience, expediency, or status of individual, on-demand air travel. Despite prices that are typically higher than a first-class seat on a scheduled airline, most travelers deem the superior experience, especially in terms of time savings, to be more than sufficient to compensate for a modest premium.

Finally, the expanding popularity of personal aviation is attributable to a series of opportunistic circumstances. Swelling corporate profitability during the last few years and anxieties about terrorism, have given affluent travelers license to upgrade from the mainstay commercial carriers. It is simultaneously important not to disregard the status striving that has long been associated with transport choice and, in its current manifestation, personal aviation has become the new “ultimate toy.” One beleaguered executive who had grown quite attached to this mode of travel was recently quoted as saying, “You can fool around with my stock options all you want, but don’t fool around with my airplane” (Fabrikant 2006).

The market for personal aeromobility services is currently organized into four primary segments: business/personal airplane ownership, fractional aircraft ownership,
flight-time cards, and air taxis. Because an expanding number of companies offer multiple services and travelers tend to upgrade to higher (and more expensive) alternatives over time, there is necessarily some overlap in these categories.

**Business/personal airplane ownership**

Fueled by the economic exuberance of the mid-1990s, there was an appreciable increase in sales of private airplanes as personal aeromobility became financially accessible to a new cadre of entrepreneurs, corporate managers, and other frequent travelers. Spurred by the introduction of more affordable entry-level aircraft and robust demand for larger and more lavish jets, the market for business airplanes has been growing at an annual rate of approximately 15 percent (Figure 3). In the United States alone, the number of firms with their own flight operations has increased from 9,504 in 1991 to 15,879 in 2003 (Figure 4). Europe occupies second position in terms of business aircraft operations and number of airplanes (Figure 5).

The extent to which personal airplane ownership has grown is more elusive to ascertain because of data and definitional disparities, the greater demands for confidentiality maintained by this facet of the market, and the difficulties of disaggregating business and personal travel. Nonetheless, by one measure the number of hours flown by private individuals traveling for non-business purposes is twice as large as it is for business-only travel.

This growing fleet of private aircraft does not for the most part utilize commercial airports, but rather relies on the extensive network of small public use general aviation facilities that exists outside of the major air-traffic system. For instance, in the United States there are approximately 5,400 of these landing fields situated in diverse geographic locations: adjacent to major metropolitan cities, in suburban communities, and in rural areas (Figure 6). These airports have typically been used by recreational pilots, flight schools, and agricultural service companies and they afford a tremendous amount of latent and underutilized capacity outside of the major airports. Moreover, access to these facilities does not generally entail time-consuming travel to the periphery of a major metropolitan city or multiple connections from a secondary or tertiary commercial origin/destination. Point-to-point (or “doorstep to destination” in expert parlance) travel between two general aviation airports via a business or personal airplane is often quicker and more convenient than the scheduled alternative.

**Fractional airplane ownership**

The concept of fractional airplane ownership is roughly analogous to a car-sharing cooperative or a holiday timeshare and provides a scheme that allows several travelers to jointly own an aircraft (Rolf 2001). Launched in 1986, this segment of the personal aeromobility market has also experienced exponential growth and as of 2003 there were more than 6,000 fractional shares outstanding (Figure 7).

The largest company selling fractional shares, with control of approximately half of the existing market, is NetJets based in Woodbridge, New Jersey. Owner-passengers typically purchase a 1/8 share and then pay a monthly maintenance fee and an hourly flight-time charge. The company has its fleet of 550 planes positioned around the world to provide clients with on-demand air travel. With six hours advance notice, NetJets will deliver a fully outfitted aircraft to a proximate airport and fly its owner-pasengers to a chosen destination.

To ensure high service quality and continued success in the face of rapid growth firms in the fractional airplane ownership industry have developed very sophisticated operational software that enables managers to employ aircraft and personnel in a cost-effective manner (see e.g., Martin et al 2003). Because owner-passengers are apt to provide very narrow call windows for prospective trips, management companies must continuously and accurately anticipate where their airplanes and crews will be needed—or
be prepared to provide expensive charter replacements in cases where they are unable to meet their contractual obligations.

**Flight-time cards**

Pioneered by a company called Marquis Jet, one of the most recent innovations in personal aeromobility entails the sale of flight-time cards that allow travelers to purchase a preset number of on-demand flight hours without having to incur the expenses of aircraft ownership and maintenance. The cost of a flight-time card can be as low as $100,000 for 25 hours on a Cessna Citation V Ultra—an amount that translates into about $4,000 for a one-hour flight between New York and Chicago. While this “fare” is certainly expensive in comparison to the $1,000 it would normally cost for an immediate-purchase first-class seat on a commercial airline, the enhanced travel comfort, the personalized service, the lack of cumbersome security procedures, and the ability to utilize convenient general aviation airports has made flight-time cards a sensible option for an expanding number of travelers. The fact that pricing is predicated not on the number of passengers, but rather on the length of the trip means that the effective per-person cost is reduced when a family or small group travels together. On this basis, personal aeromobility increasingly becomes less of a luxury and more of an unquestioned and reasonable means of transport.

**Air taxis**

There are indications that a market for on-demand flying taxi service (also known as personal or executive jet service) is beginning to emerge and the Federal Aviation Administration in the United States forecasts that more than 1,650 very light jets (VLJs) will be in the air by 2010 (Wald 2006; see also http://airtaxiflights.com/index.html). The essential idea is to use small, relatively inexpensive microjets to provide customized flights for short-distance trips. One new company, the Florida-based DayJet, outlines the rationale behind its point-to-point flights in the following terms:

> What is DayJet all about? It’s about flexibility, convenience and control. But most of all, it’s about time. Your time. DayJet gives you back the valuable time you need to become more productive in business, while enjoying a better balance between work and your personal life. With DayJet, more timely and efficient business travel is just on the horizon (italics in original) (see http://www.dayjet.com).

With an initial investor-based capitalization of US$18.5 million, DayJet has developed a network of so-called “DayPorts™” that link together the cities of Boca Raton, Gainesville, Lakeland, Pensacola, and Tallahassee. These airports are deemed underserved by commercial airlines and the aim is to provide up to six passengers with the opportunity to travel between them on an on-demand basis (Johnson 2005). The company’s current plans call for expanding its services to nearly 100 cities over the next couple of years and to meet this objective 239 Eclipse 500 jets have been ordered (Asker 2005).

DayJet’s pricing is projected to be about 25 percent higher than regularly scheduled commercial flights and will be determined through the use of a complex computer algorithm that allows passengers to identify their origin, destination, and departure time via the company website. The system will search its inventory of aircraft, assess its already-scheduled commitments in seconds, and provide prospective travelers with a bone fide fare. Passengers with some flexibility in their travel plans—for instance a four-hour departure window—will be rewarded with a lower price.

Another air-taxi company, SATSair, is based in Danville, Virginia and Greenville, South Carolina and offers on-demand flights across a nine-state region stretching from Pennsylvania to Georgia. For US$395 per flying hour (equal to approximately 220 flight miles or US$1.80 per flight mile), one of the company’s planes will pick up to four
passengers from a departing airport and transport them anywhere within its service area (Fallows 2005). Another entrant into the air-taxi market in the United States is Connecticut-based POGO Jet operating under the direction of ex-American Airlines CEO Robert Crandall. Other startups are located in the Midwest and Plains states.

Developments in Europe have been more hesitant, but a new Swiss-based company, JetBird, has recently announced that it plans to provide similar on-demand air service from its headquarters in Zurich beginning in 2009 with a fleet of fifteen Embraer Phenom 100 VLFs. The company’s business plan calls for the annual addition of 20 aircraft and to eventually serve 800 European destinations (Wall and Taverna 2006; see also Taverna and Flottau 2003).

It is notable that small companies are not the only firms seeking to develop the market for on-demand personal aeromobility. The mainstay commercial airlines are also beginning to take an active interest and in some instances are forming partnerships with the forerunners in the field. For instance, NetJets has entered into a collaborative arrangement with Lufthansa Private Jet, a subsidiary of the large German airline. The joint venture will be based in Munich and provide service to a 1,000 European airports. A flight from Munich to Lugano is set to cost between €4,550 and €5,650 depending on the aircraft type and a flight from Dublin to Billund in the west of Denmark will be priced at €9,530 (Baker 2005).

4. NASA’s Small Aircraft Transportation System

The growth in personal aeromobility is often deemed to be the result of the status-and convenience-seeking behavior of affluent travelers for whom the out-of-pocket price is a minimal consideration. However, many of the developments outlined in the prior section have been undergirded directly or indirectly by the Small Aircraft Transportation System Project (SATS), a US$69 million five-year NASA initiative that ended in 2005 (Bowen & Hansen 2000; Tarry & Bowen 2001; McGrath & Young 2002; Young 2002; El-Kasaby et al 2003; Moussavi and Vargas 2003; Holmes et al 2004; Trani et al 2003; see also Transportation Research Board 2002).

SATS evolved out of a predecessor program, the Advanced General Aviation Transport Experiments (AGATE), and was conducted as a public-private partnership involving NASA, the Federal Aviation Administration, and the National Consortium for Aviation Mobility. The aims of the proof-of-concept project were to demonstrate the capacity of a new generation of aviation technologies (principally related to safety at airports without control towers and ground-based radar systems), to substantially expand the national air-transport system, and to relieve both highway and airport congestion through the more extensive utilization of public use general aviation airports. Based on single-pilot aircraft with the capacity for 4-10 passengers, the SATS project sought to advance the goal of making point-to-point air travel safe, affordable, and accessible.

To their considerable credit, the SATS project managers have not approached this task exclusively as a technical engineering exercise (see, in particular, El-Kasaby et al 2003 and Holmes et al 2004). Though there is no indication that they have had any systematic exposure to the literature on transition management, these aviation specialists nevertheless come treat air travel as a configuration of complex sociotechnical arrangements. The published work on SATS recognizes that efforts to build space in the existing range of travel alternatives for air taxis and other related modes will depend on a broad array of heavily interlinked and interdependent factors. Moreover, the project managers tacitly recognize that implementation will not depend merely on overcoming technological challenges, but that planners will need to be cognizant of regulatory frameworks, insurance and liability arrangements, operational safety (real and perceived), cost competitiveness, and economic and social geography of affected locales. There seems to be stark realization that the viability of a small aircraft system (at least one of any consequential size and scope) will ultimately depend not only on the design of new guidance and control systems, but also on
the effectuation of tedious and expansive changes in the broader operational landscape that makes air travel possible.

5. Discussion

The agonizing demise of iconic automobile manufacturers and the continual financial struggles of the major passenger airlines are overt indications that the current mobility system is being reshaped following decades of relative stability. After an extended period of dependence on combustion-powered automobiles and hub-and-spoke air travel, a remarkably large number of novel ideas are "in the air" including electric-powered urban "smart" cars, shared-ownership schemes, improved intermodal coordination, and personal aeromobility. To get a full view of these changes, however, one must not be singularly preoccupied by activities captured only within the frame of "sustainable mobility." Though sustainability (and its analog, livability) has become embedded in conventional planning practice in many places, the pursuit of outcomes that are consistent with this ideal is fraught with profound conflicts (Godeschalk 2004). Numerous dynamic and often crosscutting forces are at work and current public sentiments surrounding sustainability will remain equivocal and ambiguous. The developments pertaining to personal aeromobility described here represent an instance in which sustainability objectives have not been a foremost part of the planning equation. Proponents have instead displayed a commitment to customary transport objectives such as time savings, capacity management, and traditional notions of economic development. Such a situation is a reminder of the need to be analytically attentive to other prominent drivers—most notably the quest for greater comfort, convenience, and distinction (see, e.g., Shove 2004). Foresight exercises that privilege one of these dimensions over others run the risk of generating overdetermined scenarios.

It also merits observing that prevailing patterns of globalization and transnationalization give the trend toward increasing personal aeromobility a strong sense of inexorability and this is reflected in many of the forecasts of future demand. Continued growth in air travel seems inevitable despite public concern in some quarters about the unsustainability of current and emergent lifestyle practices (Lassen 2006; see also Hoyer 2000; Gott diener 2001). Optimistic analysts have suggested that new information and communication technologies will make "virtual mobility" a realistic alternative and stem the seemingly relentless expansion of transport by airplane (for a detailed discussion see Arnfalk 2002; Berkhout and Hertin 2004). However, there is little evidence to date to support these claims and the historical record suggests that the obverse outcome is more likely to hold.

Nevertheless, before we presage a mobility future characterized by pervasive personal aeromobility it is necessary to recognize some of the significant obstacles that still must be overcome. The SATS team has already voiced concern that recent growth in business and personal aircraft is leading to congestion in the aviation system and one NASA study forecasts that a 25 percent increase in traffic could lead to paralysis. There are a variety of other issues that will likely pose problems for the continued growth of private aviation. For instance, some skeptics point to a shortage of trained pilots to fly the growing number of small airplanes and the cost and complex logistics of ensuring adequate aircraft maintenance. Other observers point out that at present existing air taxis, despite the use of sophisticated operational software as discussed above, fly empty more than 50 percent of the time because of continued inability to effectively coordinate drop-offs and pick-ups (Wald 2006).

Even in the face of these challenges, the incontrovertible fact remains that point-to-point air transport has long held a tight grip on the public imagination and this mode of travel remains a cornerstone of popular visions of the future. While the evolving likelihood of personal aeromobility may be discomfiting from a sustainability standpoint, it is important to be realistic about the pending prospect of this mode of transport. A major outstanding
question is therefore whether private aviation can be reconciled with efforts to foster a more sustainable future. One plausible scenario might be built around the idea of using power-assisted bicycles and other “sustainable use” vehicles to provide local mobility while travel to more distant locales is based on small aircraft. There is even the prospect that these airplanes could be equipped with fuel cells or other alternative sources of energy such as biodiesel (see e.g., Wardle 2003; Oman 2004). It might even prove feasible to create the next generation of airports as comprehensive intermodal transfer stations that provide seamless and convenient interchange from air to ground transport. One could also consider the possibility of encouraging a prior, forgotten practice of designing aviation facilities that serve as dual-use park-airports (Bednarek 2005). The expanding use of smaller, local airports will likely allow landing fields to become reembedded into the fabric of communities instead of perpetuating the contemporary practice of treating them as objectionable land uses situated at the distant reaches of metropolitan areas.

This possible future suggests a need to begin to consider how affordable and readily accessible personal aeromobility will alter work routines and future settlement patterns (Marshall 2003). These implications have thus far been sketched out only in the most superficial ways, often simply in terms of their potential to economically catalyze lagging non-metropolitan regions with poor connectivity to existing transport services. Little consideration has been devoted to the likelihood, for instance, that unchecked forms of personal aeromobility could bring to these locales unprecedented patterns of sprawling low-density development. It is for these reasons that scholars and policymakers interested in transition management and sustainable systems innovation resist the impulse to disregard countervailing trends such as private aviation that clash with their overarching aims.

6. Bibliography


World Passenger Air Travel by Volume, 1950–2004

Source: ICAO

Figure 1

Figure 2

World Air Travel by Distance, 1950–2004

Source: ICAO

Figure 3

WORLDWIDE BUSINESS JET FLEET, 1987-2003

Figure 4

U.S. COMPANIES OPERATING FIXED-WING TURBINE BUSINESS AIRCRAFT AND NUMBER OF AIRCRAFT, 1999–2003

Source: National Business Aviation Book, 2004
(http://www.nbaa.org)

(15)
Figure 5

WORLDWIDE FIXED-WING TURBINE BUSINESS AIRCRAFT FLEET BY REGION, 2003

Source: Aviationweek, May 19, 2003

North America
Operations: 969

Central America
Operations: 453

South America
Operations: 293

Europe
Operations: 275

Asia & Middle East
Operations: 212

Oceania
Operations: 112

Total Flights/Operations = 23,621
Total Operations = 14,991
<table>
<thead>
<tr>
<th>FACILITY NAME/T D</th>
<th>STATE</th>
<th>TOTAL AIRPORT OPS</th>
<th>ITINERANT GA OPS</th>
<th>AIR CARRIER OPS</th>
<th>A/R QUALITY %</th>
<th>TOTAL AIRPORT OPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Van Nuys (WNA)</td>
<td>CA</td>
<td>410,656</td>
<td>289,438</td>
<td>0</td>
<td>0.0%</td>
<td>1,090,114</td>
</tr>
<tr>
<td>Tampa Brecardo Int (TBO)</td>
<td>FL</td>
<td>336,169</td>
<td>268,196</td>
<td>4,906</td>
<td>1.2%</td>
<td>1,055,664</td>
</tr>
<tr>
<td>Orlando Sanford (SFB)</td>
<td>FL</td>
<td>365,303</td>
<td>167,684</td>
<td>7,391</td>
<td>2.2%</td>
<td>1,054,828</td>
</tr>
<tr>
<td>Fort Lauderdale Executive (FXE)</td>
<td>FL</td>
<td>216,499</td>
<td>166,107</td>
<td>0</td>
<td>0.0%</td>
<td>3,093,860</td>
</tr>
<tr>
<td>Phoenix Deer Valley (DVT)</td>
<td>AZ</td>
<td>319,599</td>
<td>151,594</td>
<td>0</td>
<td>0.0%</td>
<td>2,917,333</td>
</tr>
<tr>
<td>Seattle Boeing Field (BFI)</td>
<td>WA</td>
<td>310,851</td>
<td>151,045</td>
<td>9,801</td>
<td>2.7%</td>
<td>9,199,324</td>
</tr>
<tr>
<td>Atlantic City Intl (ACY)</td>
<td>NJ</td>
<td>210,329</td>
<td>142,940</td>
<td>24</td>
<td>0.1%</td>
<td>8,415,650</td>
</tr>
<tr>
<td>Long Bane Int Airport Field (LEB)</td>
<td>CA</td>
<td>318,167</td>
<td>142,640</td>
<td>20,410</td>
<td>0.7%</td>
<td>6,313,030</td>
</tr>
<tr>
<td>Teterboro (TEB)</td>
<td>NJ</td>
<td>216,153</td>
<td>141,741</td>
<td>125</td>
<td>0.6%</td>
<td>6,313,030</td>
</tr>
<tr>
<td>Bermuda Executive (BMA)</td>
<td>PU</td>
<td>311,459</td>
<td>143,623</td>
<td>125</td>
<td>0.6%</td>
<td>3,082,000</td>
</tr>
<tr>
<td>Santa Ana John Wayne (SMA)</td>
<td>CA</td>
<td>357,369</td>
<td>172,558</td>
<td>84,961</td>
<td>23.3%</td>
<td>5,414,584</td>
</tr>
<tr>
<td>Tulsa Riverside (ROS)</td>
<td>OK</td>
<td>211,750</td>
<td>126,700</td>
<td>0</td>
<td>0.0%</td>
<td>8,363,610</td>
</tr>
<tr>
<td>Mesa Folsom Field (FMS)</td>
<td>AZ</td>
<td>211,742</td>
<td>120,232</td>
<td>308</td>
<td>0.1%</td>
<td>8,415,650</td>
</tr>
<tr>
<td>Montgomery (MAG)</td>
<td>AL</td>
<td>215,164</td>
<td>121,777</td>
<td>0</td>
<td>0.0%</td>
<td>4,410,860</td>
</tr>
<tr>
<td>San Diego Montgomery Field (XIV)</td>
<td>CA</td>
<td>216,371</td>
<td>121,645</td>
<td>0</td>
<td>0.0%</td>
<td>2,917,333</td>
</tr>
<tr>
<td>La Verne Municipal Field (LVN)</td>
<td>CA</td>
<td>221,623</td>
<td>122,256</td>
<td>0</td>
<td>0.0%</td>
<td>3,024,411</td>
</tr>
<tr>
<td>Coral Gables (GCK)</td>
<td>CA</td>
<td>113,356</td>
<td>121,026</td>
<td>0</td>
<td>0.0%</td>
<td>2,917,333</td>
</tr>
<tr>
<td>Chino Privat (WNR)</td>
<td>CA</td>
<td>112,951</td>
<td>111,985</td>
<td>0</td>
<td>0.0%</td>
<td>3,082,000</td>
</tr>
<tr>
<td>San Antonio Int (SAT)</td>
<td>TX</td>
<td>211,751</td>
<td>117,645</td>
<td>63,344</td>
<td>24.3%</td>
<td>8,363,610</td>
</tr>
<tr>
<td>Dallas Love Field (DAL)</td>
<td>TX</td>
<td>213,112</td>
<td>114,205</td>
<td>63,344</td>
<td>31.7%</td>
<td>2,917,333</td>
</tr>
<tr>
<td>Dallas Int Airport (DFW)</td>
<td>TX</td>
<td>110,038</td>
<td>111,767</td>
<td>113</td>
<td>0.8%</td>
<td>3,082,000</td>
</tr>
<tr>
<td>McAllen (McL)</td>
<td>TX</td>
<td>104,139</td>
<td>111,767</td>
<td>4</td>
<td>0.0%</td>
<td>3,082,000</td>
</tr>
<tr>
<td>Fort Worth-Branch Field (FRR)</td>
<td>TX</td>
<td>215,049</td>
<td>111,767</td>
<td>4</td>
<td>0.0%</td>
<td>2,917,333</td>
</tr>
<tr>
<td>Orlando Executive (ORL)</td>
<td>FL</td>
<td>110,038</td>
<td>107,256</td>
<td>1</td>
<td>0.0%</td>
<td>3,082,000</td>
</tr>
<tr>
<td>Fort Pierce (FPC)</td>
<td>FL</td>
<td>113,356</td>
<td>103,639</td>
<td>0</td>
<td>0.0%</td>
<td>3,082,000</td>
</tr>
<tr>
<td>Concord (CON)</td>
<td>CA</td>
<td>112,898</td>
<td>100,784</td>
<td>0</td>
<td>0.0%</td>
<td>2,917,333</td>
</tr>
<tr>
<td>Hackett Presbyterian Field (HGR)</td>
<td>MA</td>
<td>174,987</td>
<td>101,514</td>
<td>296</td>
<td>0.2%</td>
<td>8,363,610</td>
</tr>
<tr>
<td>Palm Beach Int (PBI)</td>
<td>FL</td>
<td>117,976</td>
<td>99,753</td>
<td>16,695</td>
<td>24.7%</td>
<td>5,414,584</td>
</tr>
<tr>
<td>Chicago O'Hare (ORD)</td>
<td>IL</td>
<td>112,384</td>
<td>99,021</td>
<td>11</td>
<td>0.1%</td>
<td>3,024,411</td>
</tr>
<tr>
<td>Northwest Philadelphia (NTS)</td>
<td>PA</td>
<td>111,346</td>
<td>99,433</td>
<td>0</td>
<td>0.0%</td>
<td>3,082,000</td>
</tr>
<tr>
<td>Porte Rossy (JBD)</td>
<td>BQ</td>
<td>179,453</td>
<td>97,036</td>
<td>1</td>
<td>0.0%</td>
<td>8,363,610</td>
</tr>
<tr>
<td>Grand Saline Field (GSH)</td>
<td>TX</td>
<td>218,657</td>
<td>97,036</td>
<td>4,312</td>
<td>1.9%</td>
<td>8,363,610</td>
</tr>
<tr>
<td>White Plains Westchester (WHP)</td>
<td>NY</td>
<td>118,875</td>
<td>96,323</td>
<td>2,625</td>
<td>2.8%</td>
<td>2,917,333</td>
</tr>
<tr>
<td>Sacramento Executive (SCC)</td>
<td>CA</td>
<td>114,954</td>
<td>94,971</td>
<td>6</td>
<td>0.0%</td>
<td>3,082,000</td>
</tr>
<tr>
<td>Prescott-Lake A. Lane Field (PRL)</td>
<td>AZ</td>
<td>213,422</td>
<td>92,548</td>
<td>4</td>
<td>0.0%</td>
<td>3,082,000</td>
</tr>
<tr>
<td>Morehead Intenerate Field int (MDE)</td>
<td>CA</td>
<td>312,161</td>
<td>93,311</td>
<td>1,392</td>
<td>0.1%</td>
<td>4,410,860</td>
</tr>
<tr>
<td>St. Petersburg-Clearwater (TLE)</td>
<td>FL</td>
<td>212,785</td>
<td>93,311</td>
<td>5,687</td>
<td>4.5%</td>
<td>2,917,333</td>
</tr>
<tr>
<td>Monrocco Regional (ME)</td>
<td>NY</td>
<td>128,044</td>
<td>92,548</td>
<td>0</td>
<td>0.0%</td>
<td>2,917,333</td>
</tr>
<tr>
<td>Farmingdale Republic (FDR)</td>
<td>NY</td>
<td>119,589</td>
<td>91,283</td>
<td>165</td>
<td>0.9%</td>
<td>8,363,610</td>
</tr>
<tr>
<td>Firenze Yosemite Int (IFY)</td>
<td>CA</td>
<td>171,391</td>
<td>88,391</td>
<td>6,253</td>
<td>3.8%</td>
<td>1,054,864</td>
</tr>
<tr>
<td>Shasta Lake Int (SHL)</td>
<td>WA</td>
<td>171,391</td>
<td>88,391</td>
<td>6,253</td>
<td>3.8%</td>
<td>1,054,864</td>
</tr>
<tr>
<td>Erie Lackawanna Int (EAY)</td>
<td>NY</td>
<td>119,589</td>
<td>91,283</td>
<td>165</td>
<td>0.9%</td>
<td>8,363,610</td>
</tr>
<tr>
<td>Johnstown (JNY)</td>
<td>PA</td>
<td>128,044</td>
<td>92,548</td>
<td>0</td>
<td>0.0%</td>
<td>2,917,333</td>
</tr>
<tr>
<td>Lehigh Valley (Lv)</td>
<td>PA</td>
<td>128,044</td>
<td>92,548</td>
<td>0</td>
<td>0.0%</td>
<td>2,917,333</td>
</tr>
<tr>
<td>El Reno (El)</td>
<td>OK</td>
<td>112,768</td>
<td>84,304</td>
<td>17</td>
<td>0.1%</td>
<td>2,917,333</td>
</tr>
<tr>
<td>Austin-Bergstrom Int (AUS)</td>
<td>TX</td>
<td>212,160</td>
<td>82,849</td>
<td>53,597</td>
<td>46.1%</td>
<td>2,917,333</td>
</tr>
</tbody>
</table>

TOTAL | 11,736,557 | 872,957 | 7.46% |

*Ranked by itinerant general aviation U.S. operators. An itinerant flight operation originates at one airport and terminates at another airport located at least 25 miles from the original port.
Figure 7

TOTAL NUMBER OF FRACTIONAL SHARES, 1986 – 2003

7. Notes

1 While the taxonomy presented here is outlined in terms of explicit typological categories, it merits observing that the contributing authors display considerable versatility and a notable tendency to contribute to more than one perspective.

2 The Sparrow was manufactured by Corbin Motors (acquired in 2004 by Myers Motors) and the company designed a related model dubbed the Merlin that never went into production. Images of both vehicles are available at http://www.3wheelers.com/corbin.html. Gizmo is produced by the Oregon-based Neighborhood Electric Vehicle Company (NEVCO). Images of Gizmo are available at http://www.nevco-ev.com.

3 MITKA (an acronym from the Dutch name Mobiliteitsconcept voor individueel transport op de korte) was conceived as part of a collaborative project involving the Design for Sustainability Group at the Delft University of Technology, TNO, and others. Images of MITKA are available at http://www.kathalys.com.

4 Upright electric scooters such as the Segway Human Transporter have also begun to attract considerable interest as urban mobility vehicles (Schrage 2003; Marshall 2003; Shaheen et al 2005). The firm has also recently publicized the Centaur, a concept prototype that is roughly akin to a miniature off-road four-wheeler (see http://www.segway.com/products/centaur). Also germane in this regard is Toyota’s i-swing, a personal mobility machine that company officials describe as a “wearable vehicle” (see http://www.toyota.co.jp/en/news/05/1011_1.html). Some observers may see a certain similarity between these novel designs and the star-crossed Sinclair C5 that was produced briefly on a commercial basis during the mid-1980s (Thisdell 2005; see also http://www.sinclairc5.com).

5 A related form of mobility currently undergoing rapid expansion involves the use of helicopters for intraurban transport. Owing to a variety of local factors including unmanageable congestion, fear of crime, and status seeking by affluent business executives, helicopter travel has become a quite prevalent way to move around in São Paulo (Cwerner 2006).

6 This observation is gleaned from data reported by the National Business Aviation Association (6.5 million flight hours for business purposes vs 11.0 million flight hours for personal purposes in 2002). At slight variation, the General Aviation Manufacturers Association (GAMA) claims that 70 percent of the flight hours on general aviation aircraft are for business and commercial purposes (see http://web.nbaa.org/public/news/stats/factbook/2004/section4.php#01). Another estimate is offered by Trebey (2006) who recently reported that 80 percent of private aviation is for leisure purposes.

7 Other companies selling fractional airplane ownership include FlexJet (a subsidiary of Bombardier), Flight Options (a subsidiary of Raytheon), and CitationShares (a jointly owned subsidiary of Textron and TAG Aviation) (Fabrikant 2006).

8 The successor organization to SATS is the Consortium for Aviation System Advancement based in Daytona Beach, Florida (see http://www.casa.aero). A larger scale-coordinating role is being played by the Federal Department of Transportation’s Joint Planning and Development Office under the auspices of its program on the Next Generation Air Transportation System (see http://www.jpdo.aero).
NASA reports that 98 percent of the American population lives within 20 miles of an existing general aviation facility (see http://www.asc.nasa.gov/factsheet/SATS_Fact_Sheet.htm).

The identification of trends that challenge efforts to foster sustainability is not in and of itself a particularly interesting observation as evidence of countervailing trends is widespread. For instance, despite unprecedented discussion and negotiation, greenhouse gas emissions in most countries have increased rather than decreased over the past decade.

Each subsequent advance in long-distance communication capability over the past century—from the telegraph to the telephone to the Internet—has paradoxically induced demand for travel rather than dampened or substituted for it.

Some scenarios of future personal aeromobility are predicated upon technologies that would eliminate the need for a dedicated pilot—a development for which there is obvious precedent. With the streamlining of operational systems, the organization of affordable training programs, and the design of more sophisticated control equipment, aircraft pilots will likely become obsolete in much the same way as the automobile chauffeurs of an earlier era. Progress in this direction obviously brings us closer to the prospect of individualized flying machines, long a staple of popular science fiction. See also Robb (2005).

It bears observing in this regard that the most significant advances in fuel-cell technology have been achieved in research programs associated with the space shuttle.