

Paper Trail: Research and Reflections Related to the Environmental Effects of Aviation

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### **Research Statement**

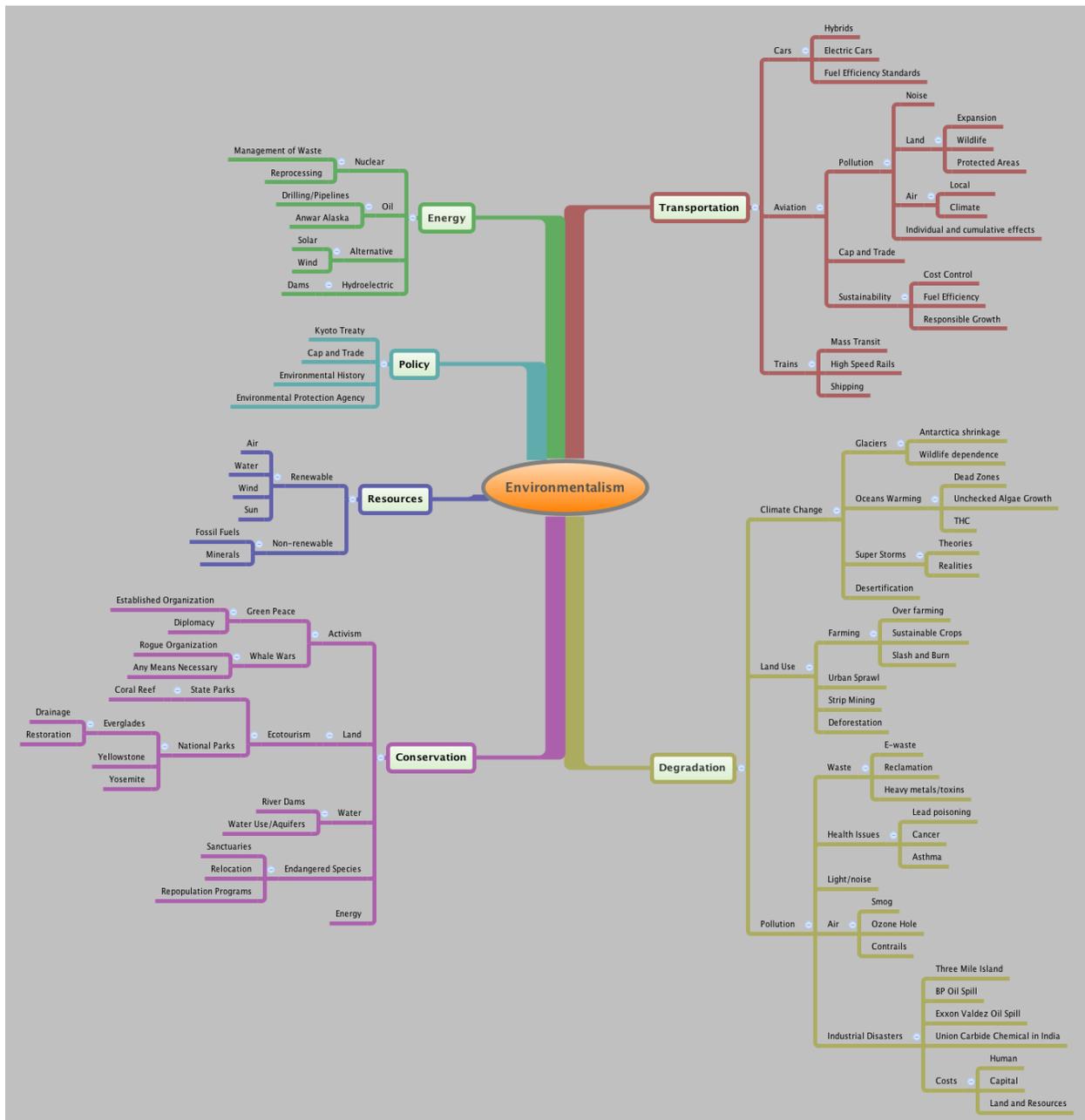
Mitigating the effects of aviation-related environmental issues is a serious concern in an industry that has the potential to add significant levels of noise and air pollution into the atmosphere. Even more difficult to measure, however, are the actual effects of aviation pollution on global climate change. This difficulty had led to disagreement on local and national levels about how to set and enforce environmental regulations—and for that matter, on who should oversee these issues. As it stands, the FAA, EPA, and a host of private organizations work together to set loose standards. Research into reducing environmental impacts, on the other hand, displays a more collaborative and productive approach; in selecting this topic for study it became clear that while some progress has been made in this area in the last ten years, it is insufficient to maintain sustainable growth over time. I found this to be a fascinating and timely topic given the attention that industrial pollution has received lately.

I originally began with the intention of including airports and aircraft in the definition of aviation; both have serious impacts on their surroundings. However, I found such large volumes of information on the topic of aircraft emissions and noise alone that it made sense to narrow the scope of my research. Additionally, while I found information on airport pollution issues, there was not enough detailed information to answer my research needs fully. For instance, wildlife encroachment was treated more as a safety issue and nuisance for the airport than a habitat problem; water pollution from deicing liquids was covered as well, but almost in a peripheral nature. Noise and air quality, however, were covered in detail. Since these are largely related to the actual aircraft I decided to examine these effects and the associated regulations, standards, and actions designed to mitigate them. Technological research and development, as well as collaboration among industry participants, was an important part of answering my research

question. I found that the willingness of airlines and governments to cooperate was an important driving force in effecting necessary changes to reduce environmental impacts while maintaining profitability—both keys in achieving longevity within the field.

### Research Question

How can environmental effects from aviation be mitigated on local and national levels in ways that are both sustainable and cost-effective?



*Figure 1.* Concept map showing brainstorming process leading to identification of environmental concerns in aviation as a subtopic of environmentalism. Connections between broad ideas identified through mapping lead to the development of a research question on the subtopic.

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## Research Paper Outline

### I. Introduction

#### A. Summary of topic and statement of the issue

1. Technological developments/teamwork from all sectors of aviation
2. Safe, cost-effective, environmentally responsible, sustainable air travel

#### B. Identification of aviation impacts on the environment—Waitz, et al., 2004

1. Climate change
2. Energy use
3. Noise level

#### C. Current and future issues—Gossling and Upham, 2009

1. Costs
2. Regulations
3. Traffic

### II. Literature Review

#### A. Organizations and oversight—United States General Accounting Office, 2000;

Pfander, et al., 2009

#### B. Environmental impacts—Burlinson and Maurice, 2003; Committee on Transportation and Infrastructure, 2007; Mahashabde, et al., 2010

- C. Research—Rachami, Liming Zhou, Royce Bassarab, 2009; Noppel and Singh, 2008; Brand, Sampath, and Shum, 2003

### III. Environmental issues and research

- A. Climate change—International Civil Aviation Organization, 2010; Rachami, Zhou, Bassarab, 2009
- B. Energy use—Aerospace Industries Association, 2010
- C. Noise level—Mahashabde, et al., 2010; Dallara and Kroo, 2011

### III. Technological solutions

- A. New vehicle design—Hall, 2009; Noppel and Singh, 2008
  - 1. Next generation materials
  - 2. Aerodynamic improvements
  - 3. Improved propulsion systems
- B. Alternative fuels—Boeing, 2010; Hendricks, 2007; Brand, Sampath, and Shum, 2003
  - 1. Biofuels
  - 2. Hydrogen fuel-cell

### IV. Sustainability and Operating costs

- A. Critical issues/teamwork—National Research Council Committee on Aeronautics Research and Technology for Environmental Compatibility, 2002
- B. Growth—Thompson, 2006
- C. Teamwork and standards—Transportation Research Board, 2009

### V. Conclusion

- A. Still a need for increased research in aircraft design and fuel
- B. Sustainability requires teamwork and standards

C. Challenges must be met through cooperation on local and national levels

### **Annotated Bibliography of Relevant and Useful Sources**

Brand, J., Sampath, S., Shum, F. (2003). *Potential use of hydrogen in air propulsion* (Report No. AIAA 2003-2827). Retrieved from American Institute of Aeronautics and Astronautics database.

This article provides an excellent overview of alternative fuels that could potentially be used in aviation to decrease carbon emission levels. Of these fuels alternatives, the authors describe the use of hydrogen as an alternative to traditional aviation gas. An important part of this analysis is the fact that hydrogen can be utilized with relatively few changes to the existing aircraft structure. This is a significant advantage over other alternative fuels, many of which would require complete redesigns of the aircraft engine. This is obviously not a possibility for commercial aviation since the costs would be unrealistic. The potential of any alternative fuel to lower the carbon footprint is significant, and the authors suggest that hydrogen fuel research is close to providing a viable alternative. This report for the AIAA captures and synthesizes current research in the field. It presents sufficient data to back up the authors' conclusions and provides a necessary look at technological advancement designed to mitigate environmental effects. This, paired with design research, answers a necessary part of my research inquiry regarding how the pollutions' effects can be mitigated in a realistic and

cost-effective manner.

Mahashabde, A., Wolfe, P., Ashok, A., Dorbian, C., He, Q., Fan A. . . . Waitz, I. A. (2011).

Assessing the environmental impacts of aircraft noise and emissions. *Progress in Aerospace Sciences*, 47, 15–52. doi:10.1016/j.paerosci.2010.04.003

This article provides excellent information on aspects of pollution that were not covered in other sources on the topic. It details issues with water vapor as an agent of climate change and the lingering effects of aviation-related water vapor emissions. The article also offers a thorough analysis of the costs, in monetary terms, of aviation pollution. It also examines opportunities for changes through teamwork, research, and updated technology; a part of this discussion is the reality of how changes and regulation impact the industry. Significantly, the article compares costs of change with the costs of long term environmental impacts. This comparison provides a rational basis for assessing the real value of change by taking “cost” out of its theoretical placement with regards to the environment. This article answers several parts of my research inquiry by addressing pollution, costs, growth, and sustainability. The article itself is detailed and well-written, with ample data to back up conclusions. The journal in which it is published is also a peer-reviewed source.

National Research Council, Committee on Aeronautics Research and Technology for

Environmental Compatibility. (2002). For Greener Skies: Reducing Environmental

Impacts of Aviation. Retrieved from <http://books.google.com/books?id=rmIZmcLs>

QUsC&pg=PA7&dq=aviation+and+environment&hl=en&ei=BjqGTcWLOom\_gQer94z

dCA&sa=X&oi=book\_result&ct=result&resnum=9&ved=0CFgQ6AEwCA#v=onepage

&q=aviation%20and%20environment&f=false

This report by the National Research Council provides an excellent overview of several major challenges for aviation to overcome with regards to environmental impacts. The authors carefully explain the issues—including air quality, emissions, climate change, noise pollution, and land use—and then relay both the environmental and economic costs. The issues are examined from a practical viewpoint that stresses responsible aviation practices. The material is neither overly eco-friendly at the expense of commerce and transportation needs nor unrealistic about the serious impacts the industry has on the environment. Instead, suggestions are made for implementing reasonable standards and oversight of environmental policies that use a teamwork approach. Vested parties including governmental departments and private corporations in the aerospace and consumer aviation sectors are called upon to collaborate on research and development initiatives; the government is called upon to increase oversight, support, and funding. At the end however, the authors firmly place responsibility on federal oversight organizations to mitigate the effects of aviation related pollution.

This report is useful for several reasons. First, the content fit perfectly within my research focus and provided background on major issues while focusing specifically on collaboration, oversight, and teamwork. It was authored by a major non-profit organization that provides many research reports to various branches of the federal government, so it is a credible source for information and recommendations. Additionally, each recommendation presented in the report was fully supported by a variety of current and relevant research sources.

Noppel, F. & Singh, R. (2008). Contrail avoidance in the aircraft design process. *The Aeronautical Journal*, 112(1138), 733-737.

This article presents research carried out by aviation engineers to create a standard for aircraft design that will pollute at lower levels than current aircraft. In particular, the article discusses how new designs can attempt to mitigate the effects of contrail production in the upper atmosphere by using certain criteria in forming the frame and cruising level specifications of aircraft. The authors identify the formation of contrails as among the worst environmental effects of the aviation industry. They go on to report testing the designs using NASA optimization specifications. This article is a high-quality text that explains an important area of technological research designed to mitigate aircraft pollution. Additionally, the journal in which this article appears is peer-reviewed, so it is likely to be a credible source of information on this topic. As for my own research needs, it fills an important piece of the research question by addressing how technology and research are helping to mitigate climate and other environmental effects.

Rachami, J., Zhou, L., and Bassarabi, R. (2009). *The Looming Challenges of Aviation Greenhouse Gas (GHG) Reduction* (Report No. AIAA 2009-7031). Retrieved from American Institute of Aeronautics and Astronautics database.

This is another article published by the American Institute of Aeronautics and Astronautics and provides excellent information on the huge challenges of controlling greenhouse gasses. It discusses the actual emission levels of aviation as a whole, which are less than other forms of transportation, but goes on to discuss the potential impacts. It is suggested that the emissions from jet fuel may actually be worse than from other forms of transportation because they occur so high up in the atmosphere. This compounded impact therefore may makes aviation a larger polluter than it would seem on the surface. The authors discuss current and proposed federal and state regulations for emissions, and

the potential impacts across the industry and to the environment that these may generate. The content of this article is extremely focused, making it an in-depth source for information about emissions and climate change. Unlike some other resources, it focuses squarely on this issue and examines how several types of regulation could function and the potential effects. The authors are scholars and engineers and are clearly knowledgeable about the topic. The information is detailed and high-quality, filling in a necessary piece of my research inquiry, related to climate change causes and regulatory actions.

Thompson, T. R., Graham, M. L., Augustine, S. J., DiFelici, J. D., Cointin, R. S., & Capozzi, B. J. (2006). *Estimating Potential Environmental Constraints on Aviation Growth* (Report No. AIAA 2006-7737). Retrieved from American Institute of Aeronautics and Astronautics database.

This article provides a description of a significant study of the current air traffic system and capacity for growth. It explores the measurable impacts that current commercial aviation has on the environment and suggests that mandates to reduce emissions and noise are out of alignment with current and projected levels of growth. It goes on to suggest changes that must occur in the private and governmental sectors in order to achieve a sustainable growth pattern. The findings suggest that behavior and attitude changes and enhanced regulations are both necessary to effect change.

Commercial carriers must work to conserve fuel while the FAA and air traffic systems need to become more efficient in quickly handling traffic to reduce idling, circling, awkward approaches, and taxiing times (all of which contribute to increased noise or emission levels). The article is well written and based on sound scientific research.

Through descriptions of methodology, charts, graphs, and discussions present a mountain

of data to support the assertions and recommendations of the authors. Additionally, it was compiled for the American Institute of Aeronautics and Astronautics and thus served as an information tool for other researchers in the aviation field. In addition to the credibility of the source, the material covers necessary projections about how policy and action on the national and local levels will impact the future sustainability of aviation—a core piece of my research question.

United States Government Accountability Office. (2000). *Aviation and the Environment: FAA's Role in Major Airport Noise Programs* (Report No. GAO/RCED-00-98). Retrieved from United States Government Accountability Office website:

[www.gao.gov/new.items/d08706t.pdf](http://www.gao.gov/new.items/d08706t.pdf)

This report was written to provide an overview of activities and subsequent recommendations to the Subcommittee on Aviation, House Committee on Transportation and Infrastructure. The report clearly details the role that the FAA has in regulating the activities of aviation. In this case, the report details the programs and regulations in place to control aircraft noise pollution levels. It also addresses future challenges in maintaining or reducing noise levels when aviation is expected to grow. The report itself is a government publication and provides details designed to aid congressional leaders in shaping policy and awarding funding. As such, the material is credible; the text also contains sufficient research to back up all discussion and conclusions.

#### **Annotated Bibliography of Less-Relevant and Non-Useful Sources**

Dillingham, G. L., & Martin, B. (2000). *Aviation and the Environment: Airport Operations and Future Growth Present Environmental Challenges* (Report No. GAO-RCED-00-153). Retrieved from <http://books.google.com/books?id=KOPeIqQSFSsC&printsec=>

frontcover&dq=aviation+and+environment&hl=en&ei=BjqGTcWLOom\_gQer94zdCA&sa=X&oi=book\_result&ct=result&resnum=2&ved=0CDIQ6AEwAQ#v=onepage&q&f=false

This report was compiled for congress by the United States Government Accountability Office and contains detailed information about the environmental effects of aviation through airport usage. The report deals with air pollution levels found around airport locations and the effects of noise and light pollution. It also addresses issues of land use and water pollution caused by the chemical runoff from deicing solutions. Wildlife issues are touched upon as well. Overall, this is a quality report and contains good information on the non-flight impacts of the field. Initially I had intended to include environmental effects of aviation as a whole field in my research paper; the effects of airports are, after all, a serious contributor to issues within the field. However, I began to narrow my focus as I conducted my research, focusing instead on the environmental effects of aircraft. To cover airports as well was simply too much. Therefore, while this is a quality article with many significant points and recommendations for policy, it is not useful for this paper.

Kenway, G. K., Henderson, R., Hicken, J. E., Kuntawala, N. B., Zingg, D. W. , Martins, J. R. McKeand, R. G. (2010). *Reducing Aviation's Environmental Impact Through Large Aircraft For Short Ranges* (Report No. AIAA 2010-1015). Retrieved from American Institute of Aeronautics and Astronautics database.

This report focused on the design of large aircraft for short duration flights as a means to reduce climate impacts. The information itself was innovative and was backed up by large quantities of data and calculations. It included an economic analysis that

suggested that such changes were both feasible and stainable over the long term. Initially I thought that this article was a good fit with the portion of my research that considered redesigned aircraft as a means to mitigate environmental impacts. In fact, I did find a number of sources that dealt with the redesign of aircraft using lighter materials for body construction and more aerodynamic frames, which I included in the sources for the paper. In the end, I felt that other sources I had located covered this technological change issue in sufficient depth; this article was simply extra. Additionally, I felt that for the purposes of a short research paper this article was a little too technical in nature. My ultimate goal was to introduce the concept of technological development as one of several factors contributing to collaboration designed to mitigate the effects of climate change. The specifics of how those designs might be implemented on an engineering level were out of the scope of this paper. Therefore, while interesting, this article was not useful.

Whitelegg, J. (2000). *Aviation: The social, economic and environmental impact of flying*.

Retrieved from University of York, Stockholm Environment Institute website:

[www.areco.org/air10.pdf](http://www.areco.org/air10.pdf)

This research report contains excellent discussions and overviews of the types of impacts that aviation has on the environment. It details pollution issues as well as the social and economic importance of air travel as a necessary means to move goods and people globally. It also examines the issues from local and global perspectives, noting the cumulative effects of pollution, the difficulty of implementing sustainable practices due to the high costs of changes in infrastructures, and the necessity of regulations and collaboration to bring about effective changes. Overall, this article contains some very useful content; however, the specific examples of local environmental impacts are all

drawn from the UK, which is where the author is based. While many of the issues facing aviation are necessarily global in nature, the particulars of this report fall outside the scope of my particular research, making this article useful only for background reading on broad climate change issues.

### **Research Journal**

#### **Session One: Development of a Research Question Using Concept Mapping**

Using the word *environmentalism* as a starting point, I used the concept mapping program XMind to create a mind map investigating concepts related to this broad topic. I began this free-thinking exercise by writing down all the major ideas that popped into my head about environmental concepts. This naturally led me to record environmental issues, which seem to be fresh in my mind in the wake of recent events. The Deep Horizon oil spill of the past summer, and subsequent PR campaign spurred by continuing TV commercials designed to paint BP as a caring and devoted company, has left environmental disasters as a lingering concern. Animal Planet's coverage of the ridiculous efforts of the crew chronicled in *Whale Wars* is another fairly constant reminder about environmental issues. I am also volunteering on a digital library project at Smathers Library concerning the draining and reclamation of the Everglades; reading through document after document about the political and economic interests of this endeavor has also fixed degradation acutely in my mind. Naturally these things led to an immediate outpouring of terms related to the concept of disaster on a massive scale—oil spills, pollution, climate change, destruction, inappropriate land use, and so forth.

Thinking further afield, I also began to arrive at less destructive ideas about environmentalism, including policies, sustainability, oversight, green energy, and conservation. These ideas led to subtopics that included the establishment of national and state parks, ideas

about mass transit, energy solutions (including current use of fossil fuels as well as alternative sources such as wind and solar). I also began to think about transportation, including the use of high-speed rails and airlines for transportation and shipping. This latter category proved intriguing since there are a number of related environmental issues. Upon further thought, aviation seemed to be an important concept with transportation and environmental concerns.

I jotted down potential subtopics, including the idea that it is a highly regulated field, has the potential to be either helped or hindered by environmental policy, and must be sustainable for airlines (which have fairly small profit margins). Energy use and pollution are obvious issues—for instance, with planes spewing jet fuel exhaust into the sky, are the effects worse than that of other transportation such as cars? Does the fact that multiple passengers are flying in one vehicle (and thus not driving separate cars) negate any effects on air quality? What about fuel alternatives? Who is spearheading research and how does it fit within government regulations and oversight? How about airport expansion, noise pollution, and wildlife? We have probably all heard about airplanes sucking flocks of birds through the jet engines, and the potential dangers to the plane and passengers—what about the wildlife? How can birds be redirected around airspace and what effect does that have on migrations, habitats, etc.? These are just some questions that crossed my mind and seemed to make aviation as related to the environment a rich topic for exploration. Plus, I like to fly and it seemed interesting to study what my passenger status might be contributing to from an environmental stance.

The mind map process is likely what led me to define aviation as an environmental topic. In noting ideas freely and without the constraints of a list, the terms fed into one another, generating rich connections between single topics, clusters of ideas, and entire categories. I emerged with a research idea that was more unique than simply looking at activism and more

directed than studying “energy use.” The topic is expansive and specific in scope simultaneously. The environmental impacts of aviation have a few main categories, and the associated attempts to regulate, research and mitigate impacts are closely related. Thus, the research question I formed from the concepts organized into the mind map is as follows:

- How can environmental effects from aviation be mitigated on local and national levels in ways that are both sustainable and cost-effective?

This research question is appropriate because it allows for the study of both governmental and private efforts to control pollution of all types (air, land, noise, etc.). It is also narrow enough to focus research efforts on few main components because it focuses on local and national effects, but does not attempt to cover international efforts or policy. The resulting research process and complete idea formation for a short paper will follow in subsequent entries.

### **Session Two: Web Search**

I began by using the search engine Bing and typing the terms *environment* AND *aviation* in order to identify broad sources. This returned a surprising number of relevant results within the first five listings, including a pdf document reporting to Congress on environmental regulatory issues from the Federal Aviation Administration (FAA), an overview page with vision statement from the International Air Transport Association (IATA), and similar pages from the National Business Aviation Association (NBAA), and Aerospace Industries Association (AIA). Further examination of these web pages revealed that each organization has a vested interest in supporting research to meet federal regulations and that each contained several research reports, vision statements, and other related documents.

I decided to narrow the search results by using the Bing advanced search feature, which really just offered the option to continue with Boolean search operators. I added the term *air* and results were returned for this search string, as well as the same using *environmental* in place of

*environment*. This yielded mostly links to European organizations, which for this research topic are largely out of scope. However, a link to a blog did provide the name of a 2010 report on air pollution and recommendations compiled by AIA. I was able to type the report name into Google and locate the pdf document online. I then tried searching by using a limiter to see if I could return documents focused on issues other air pollution by using NOT *air* in my search string. This had the effect of returning primarily links that related to non-environmental aviation concerns, such as safety and work environment. However, when I looked through several link pages I was able to locate a research circular from the independent governmental advisory committee Transportation Research Board (TRB) that contained reports on research findings from a large number of individuals and organizations doing research in the field related to noise abatement, water quality, alternative fuels, and so forth. I then decided to use Google to see if different sources would be returned. I began with the search phrase aviation environmental regulations, which returned a few presentations with overviews of International Civil Aviation Organization of the United Nations. I added ICAO to the search string, with the reasoning that even though I am interested in national and local issues this international board seems to be influencing the development of local and national environmental policy. This returned a detailed report on aviation and climate change, authored in 2010. I was also able to locate an article by the American Society of International Law explaining some legal issues surrounding environmental regulations. Googling aviation environmental regulations AND noise returned some additional documents, primarily from federal agencies and action groups. I continued conducting searches in similar fashion using variations on terms I identified as relating to environmental issues and regulations in aviation.

Having located a surprising number of government, academic, and institutional reports

through search engines, I decided to try identifying additional resources such as databases that might be useful in later search applications. I went to the Embry Riddle library webpage, assuming that this aviation university would have some useful directional links. From the page I located a list of suggested databases that might contain relevant articles, including the American Institute of Aeronautics and Astronautics Electronic Library and National Technical Reports Library. I also used the Google Books search option to limit my searches to related book materials. I located several useful full-text publications this way, as well as the titles of several books that I used in later library catalog searches. Overall, I found that simple and advanced web searching using two searching engines yielded much valuable information on this topic. Many reports were available right in the search results list while others were accessible from major web pages simply through performing site searches or browsing content lists. As a first step in the research process, the web proved extremely useful in identifying useful documents as well as pointers to additional resources. Next, I will be searching through the USF library databases to locate additional resources and perusing the catalog to search for titles identified through Google books, as well as other related resources.

### **Session Three: Database Search**

Having previously identified several databases related to the environmental aviation program through the Embry Riddle library guides, I decided to begin searching the USF databases by selecting specific titles. I browsed the alphabetical listing and located the AIAA Electronic Library, which provides access to 16 journals as well as books, meeting papers, and standards. Since much of the research in this field is fast-moving, papers and standards provide an important source of credible and timely information. The AIAA produces numerous research reports from scholars working with universities and private corporations. A search of the AIAA

database yielded many useful documents of this type. The search features, however, were somewhat limited offering only full-text searching or identification of specific journals, date. Ranges, authors, or document numbers. There was no way to search using subject headings. Even so, simply using full text searches of aviation and environmental impacts, aviation and wildlife, and so forth, returned many valid results. I limited the search range to 1990 – present. I found that using the term *aviation* was essential to get more relevant results and omit topics related to space weather and so forth.

I then decided to try a general database search to widen the results a little and see if I could locate some articles or reports from a wider base of sources. Beginning with the general resource set (searching Wilson, General One File, CQ Researcher, and Academic Search Premiere) I did a basic search using the keywords *aviation* AND *climate*. This returned some quality articles from a variety of different journals, but more importantly it allowed me to look at the subject headings under which different articles were classified (airplanes—environmental aspects, environmental impact analysis, airplanes—noise, etc.). This allowed me to incorporate controlled vocabulary into my next few searches in order to achieve narrower and more relevant results. Interestingly, however, this approach tended to weed out many of the government documents and reports that were available using a broader search strategy.

After locating many resources, I decided to try one more database search. Having already used a highly specific database and a generalized database search, I decided to try a subject area database resource. I chose the engineering resource, which searched databases related to applied science, and environmental, civic, and mechanical engineering. These seemed like appropriate topical sources for resources dealing with problems of engineering within aviation. A subject heading search of airplanes—environmental aspects yielded a number of

useful articles from sources such as the aeronautical journal; these sources dealt with climate issues from an engineering standpoint and provided a useful perspective on the issues. Several additional keyword and subject heading searches provided additional materials from this engineering perspective. Having located a number of diverse sources for articles and papers, I will next move on to exploring books.

#### **Session Four: Library Catalog Search**

I previously identified some books through a search of Google Books, several of which were available in full text. However, other books had only listings so I decided to begin a search of the USF library catalog by entering the titles of resources. In searching the first title, which was simple Aviation and the Environment, I was unable to locate the book with the first two search pages. However, the general nature of this title yielded multiple government documents from the U.S. Documents Collection in e-book and microfilm formats. I immediately discarded microfilm resources for two reasons, the first being convenience and the second being age. The microform resources were generally from 2000 or earlier, and since research has progressed and I am not covering the history of aviation environmental impacts these documents proved less useful. After pulling some of these documents, I clicked on the linked subject headings of several titles to reveal similarly cataloged items. This yielded several more books and reports on relevant topics. After following a number of subject categories, I decided to return to my original book search.

Since searching by title did not yield the correct book I decided to use the advanced search and add an author field entry. Unfortunately this yielded no results and upon searching just author name, I found two books, but they were titles related to law and security in aviation. I moved on to the next book title and located a copy in the circulating collection through

performing a title and author search. After moving through the six titles I had identified through a web search and finding them to have varying levels of relevancy, I performed a few more keyword searches and subsequently identified additional subject headings for searches.

### **Journal Summary**

Through the search strategies outlined above I located dozens of useful resources on the topic of aviation and the environment, specifically related to climate change, wildlife management, noise pollution, fuel use, and sustainability. These are all necessary subtopics within an examination of this field, and many of the reports backed up the findings of other reports, thus creating a web of credibility surrounding the topics. I acquired 30 of the resources I had located for the purposes of my in-depth research with the intention of further narrowing the field for my short paper. I am always in favor of reading more up front and weeding later instead of finding myself short on materials. During the course of my research I found broad sources that detailed all issues related to the environmental impacts and chose to further focus my areas of interest on a few issues that were the most directly related to economic and sustainability issues. These topics were, in the end, most closely aligned with my research question.

### **Research Summary and Reflections on Information Literacy**

The Association of College and Research Libraries maintains standards on information literacy that dictate that students should be able to locate, understand, synthesize, and utilize information. They are expected to pull information from various materials and to exercise search strategies that allow them to find broad and narrow sources that expand their understanding of a topic. The research conducted here, with appropriate record keeping activities, serves as an example of how an information literate individual approaches learning. In

fact, the research portion of this activity was the easiest to conduct. It was the brainstorming and narrowing of a topic that proved the most challenging aspect—a fact that is not lost on a great number of college students.

Through the course of my research I found it necessary to narrow the scope of my topic, while still seeking information that could fully address my research question. I had initially intended to cover both airplanes and ground environments in my examination of the field of aviation; I found, however, that a great number of resources address the issues of climate change and pollution as related to flight. Most of the focus within the field rests on setting standards for fuel usage and designing cost-effective solutions for creating quieter, lighter, and more efficient aircraft. This is a much richer area of inquiry than examining the effects of airports on area wildlife. I found that I could still answer the question of how environmental effects from aviation could be mitigated on local and national levels without actually having to address airport environments, and proceeded to make aircraft my main focus.

I found that in a field with highly practical implications the best sources of information were largely government documents and those issued by third parties in support of government oversight decisions and policy making. These sources were readily available through the Internet on government and non-profit web pages; they were also easy to locate in topical databases. This is not to say that searching was easy; it involved identifying sources cited and tracking down the original materials, which was time consuming. Tracking this process through journal entries proved quite enlightening as it provided in a window into my thoughts, and perhaps made me more conscious of trying specific techniques. For instance, I only sometimes use advanced features when doing preliminary web searches. Often I do a quick phrase search, take the information to get started, and move on to database resources. In this case, making a

concerted effort to use multiple web search strategies and search engines yielded documents that were quite useful. This was a good reminder that students are not the only ones that sometimes cut corners when it comes to developing search strategies.

I found this heightened awareness (almost fear of doing it “wrong” by missing a technique) to be a good thing. Because I was focused on covering all possible ways to approach a search I did a more thorough job, and I believe this to be the best part of the paper trail project. When I envision using this project as a teaching strategy I can see how beginning information literacy students would benefit from a heightened awareness of each step. Sometimes the process becomes muddled because there are no hard and fast rules to searching, only techniques and guidelines. This is both the fun and challenge of research and the part where laziness and frustration can be mistaken for an actual lack of available materials. For students, tracking the process helps to inspire reflection and leads to a more thorough understanding of how and what works.

In addition to providing an exceptional tool for reinforcing the research process, the paper trail project fulfills the need to provide differentiated instruction. In using this project in a classroom setting I would allow students to select any topic of interest. This way the student has a vested interest in the research. On one hand choosing from a topic list has the advantage of forcing students to brainstorm, likely without preconceived ideas; this brainstorming is essential for pushing ideas and building new connections. However, I feel that such an activity should be applied in situations where students would not ordinarily bother with the process because an idea is already “set” in their mind. To me this approximates an authentic experience they are likely to have in their own information pursuits, and provides practice in shaking up one’s expectations in order to generate richer topics and inquiry.

In addition to covering the search process and refining an idea into a manageable research question, I would cover synthesizing the information that is collected. Many students have difficulty in using a number of supporting resources that contain similar information, but this is how a body of research is built. In order to address the need to cite various authors making similar points as opposed to always choosing only one, I would include the requirement that they write one section of the paper they outline using two or three sources to underscore each point. This should provide practice in identifying and using multiple sources that work well to support a point.

In short, a paper trail project provides an excellent opportunity for students to practice, reflect, and showcase a variety of skills. It is an excellent primer on completing a thorough search process and can serve as a skill sharpener for information literate individuals that have allowed their abilities to get a bit soft.