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BAYLOR UNIVERSITY
DEPARTMENT OF AVIATION SCIENCES

FINAL REPORT FOR THE PROJECT TITLED:
DEMONSTRATION AND IMPLEMENTATION OF
ETHANOL AS AN AVIATION FUEL

PREPARED BY THE RENEWABLE AVIATION FUELS
DEVELOPMENT CENTER
(RAFDC)

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EXECUTIVE SUMMARY

The Renewable Aviation Fuels Development Center (RAFDC) has completed the "Demonstration and Implementation of Ethanol as an Aviation Fuel" project funded by the Western, Northwestern, and Great Lakes Regional Biomass Energy Programs.

A significant accomplishment of the program has been the number of additional demonstrations that were performed without additional funds from the sponsoring agencies. The original proposal called for seven demonstrations to be performed in the sponsoring biomass regions. RAFDC, by obtaining co-funding sponsorships from various local organizations in the areas involved, and by coordinating the travel schedule to maximize exposure, was able to obtain a no-cost extension of the program to the end of 1997, performing thirty-nine demonstrations.

Over the two and one-half years of the demonstration contract, under trying conditions for pilots, ground crews, drivers, exhibitors, volunteers, and aviation professionals (who responded warmly to challenges outside of their areas of normal responsibility), it became clear that there is a positive future for ethanol in aviation. Reasons for this include:

- There is growing public support for renewable ethanol as an aviation fuel and as a replacement for imported fossil-based fuels. The increasing levels of these imports represents a threat to the nation's national and energy security. Fossil fuels are heavily subsidized, their cost at the pump does not include extensive environmental health costs, military expenditures and commitments, as well as international policy encumbrances. The public seems to be increasingly aware of these issues. The response of the aviation community throughout the program was very encouraging: many pilots, some already familiar with the project, showed great interest in the program's progress and seemed anxious to be involved as soon as a supporting infrastructure is in place.
- There is a pending crisis in general aviation due to a mounting pressure to remove lead from aviation gasoline (Avgas). Avgas is the only gasoline in the US market still containing lead. The Environmental Protection Agency, which had temporarily exempted general aviation from the lead-free requirement, is now pressuring general aviation into finding an alternative.
- A petroleum-based, lead-free aviation gasoline is not a near-future alternative. The parties involved in the search for a petroleum-based alternative to Avgas, presented their latest

findings at the "Second International Conference on Alternative Aviation Fuels" hosted at Baylor University in November 1997. The new approach employed by the petroleum alternative proponents is a matrix of possible additives and components being analyzed in an organized fashion. This method will take at least a few more years to produce results. As expected, the petroleum industry is not in a hurry to find an alternative.

- Ethanol is a viable alternative now. The biofuel proponents, who presented their case at the "Second International Conference on Alternative Aviation Fuels", demonstrated by means of collected data, certification programs and personal experiences, that ethanol meets and exceeds all objective criteria for the next fuel for general aviation.
- There are commitments by the United States to reduce greenhouse gas emissions. According to the Argonne National Laboratory, each gallon of gasoline replaced by corn-based ethanol will cut CO₂ emissions by 35 to 46 percent. Those percentages will only improve, as cellulosic biomass joins feed grains as key feedstocks for the production of ethanol and other biofuels.
- Already available is FAA certification of two popular series of aircraft engines to operate on ethanol and a full certification on ethanol of a series of aircraft. This certification was a considerable achievement since it was the first to be granted by the Federal Aviation Administration to a non-petroleum fuel to be used in aircraft. With this foundation now in place and the extensive support infrastructure available to RAFDC, additional certifications will proceed much more rapidly.
- There is now recognition by the aviation industry for the need to proceed voluntarily and cooperatively in order to improve the overall environment in regions involved with airports and aircraft operations. RAFDC's initial work with the US Department of Energy (DOE) in promoting the Clean Airport Program verified this recognition. Five airports were designated as Clean Airports during the duration of the program and seven more aircraft were converted to use ethanol. Two more airports are ready to receive designation as Clean Airports. As a result of this experience, the withdrawal of DOE support for this program, and extensive interest by pioneers in international aviation, RAFDC is working internationally -- principally with the help of Canadian and European interests -- in advancing the International Clean Airports Program (ICAP).
- A flight school using ethanol in its training aircraft is being organized.

- A second full certification for a series of popular agricultural spray aircraft is expected to be granted in the next few months.

A synergistic effect created by the RAFDC's various activities in this field, greatly contributed to the success of the ongoing demonstration program.

There is a great opportunity right now for the use of biofuels in aviation which should not be missed! These opportunities are now becoming imperative by America's and the world's increasing dependence on oil-rich nations -- most of which are in the Middle East. Furthermore, aviation here at home and throughout the world, must do its share in stabilizing greenhouse gas emissions. The U.S. can and should provide leadership in both areas.

In terms of RAFDC's current and future activities:

- The RAFDC is in the process of developing a low-cost ethanol powered aircraft to perform air pollution monitoring. This aircraft will be aiding the RAFDC's already operating air pollution monitoring aircraft, a Beechcraft King Air, in its task to determine sources and transportation of air pollution in Texas. RAFDC's air pollution monitoring aircraft will help the Texas Natural Resources Conservation Commission (TNRCC) to develop a State Implementation Plan for the State of Texas. If successful, this low-cost air pollution ethanol powered aircraft could be replicated around the country to be used in similar air pollution investigations.
- The RAFDC test stand, finally completed with the emission testing equipment and electronic ignition system, is currently engaged in comparison testing of three fuels: ethanol, Ethyl Tertiary Butyl Ether (ETBE) and Avgas. Performance and emissions are being analyzed. Additional modifications are also going to be tested to further improve the efficiency of the engines on ethanol.
- RAFDC has recently expanded its scope of work to include research on bio-based alternative fuels for the turbine engine fleet. A mobile test stand for turbine engines is under construction complete with emission testing equipment. Compelling local and global environmental concerns are prompting this research. The United States market of turbine aircraft fuel is currently around 16.4 billion gallons/year. If only a small percentage (10 to

20%) could be replaced by a biofuel, considerable benefits would be realized by the biofuel industry, the domestic economy and the environment.

- The Clean Airports Program is currently being reorganized. As a result of the "Second International Conference on Alternative Aviation Fuels", held at Baylor University in November 1997, the Clean Airports Program is developing into the "International Clean Airports Program (ICAP)" involving international organizations and agencies. The potential for this program is tremendous, especially since there are growing environmental concerns involving aircraft and airport pollution, and the increasing environmental awareness symbolized by the Kyoto meeting and its aftermath.
- The academic program at Baylor University is also planning an expansion to include education in the subject of alternative fuel research, air pollution, Clean Airports management and designation, and other related topics.

Based on the additional experience gained as a result of this demonstration program and the factors outlined above, RAFDC seeks assistance in the following areas:

1. Gaining a much higher level of support from the ethanol industry, the farm community and others promoting the production and use of ethanol;
2. Developing a cooperative and focused program involving the U.S. DOE, the FAA and EPA to:
 - ◆ Come to closure on the issue of removing lead from aviation gasoline by using ethanol or ETBE as replacement fuels;
 - ◆ Support the concept of using a fleet of already FAA certified Cessna 152s flying on ethanol, and equipped with emissions monitoring technology, to determine air quality and movement patterns in the air sheds impacted by airport operations, and urban air quality in general. This will be an economical way of better understanding the source and the air quality impact of such emissions. It will also permit more cost-effective controls for inclusion in state air implementation plans;

- ◆ Provide support for the concept of the International Clean Airports Program by working cooperatively with the RAFDC and Canadian and European interests to establish a limited number of airports as pilot and demonstration sites. A starting point could be the Will Rogers International Airport in Oklahoma City;
 - ◆ Provide support to RAFDC in their efforts to determine the feasibility of using high-Btu content alternative fuels in aviation turbine engines. Those fuels could include: ETBE, biodiesel, natural gas refined into a liquid, P-Series fuels (ethanol, MTHF and natural gas liquids, etc.).
3. Expanding the well-established Aviation Science Program at Baylor University to produce graduate students with expertise in the above defined areas. Baylor University and RAFDC are also developing educational programs to support ICAP as well as distance learning programs covering all aspects of airport operations;
 4. Gaining the support of the Department of Agriculture in rapidly establishing fleets of crop-dusting aircraft running on locally produced, high-performance ethanol.

To put these findings and recommendations into perspective, it is suggested that this final report be reviewed with an emphasis on the following parts: "Review of Current and Future Activities" (pg.22) as well as "Critical Considerations Determining Future Successes"(pg. 28).

RAFDC recognizes the difficulties in commercializing ethanol as an aviation fuel, because of far more rigid safety controls, the conservatism of the aviation industry, and the need to certify all of the aircraft.

However, years of steady exposure to the aviation industry, the public and the government, has convinced the RAFDC that these challenges can be met and the goals achieved. The size of the aviation gasoline market (300 million gallons per year) can be easily handled by existing production of the ethanol industry, benefiting the agricultural economy, the nation's energy security, the balance of payments, the environment and, of course, general aviation.

One of the best indicators of the effectiveness of the demonstration program is the extensive media coverage received by the Baylor project. A sample of the printed media coverage is provided as part of the report, as well as a video featuring shows, television interviews and programs produced as a result of this project. The video includes a recently released program on renewable energy development in Texas narrated by Dan Rather of CBS News, featuring the RAFDC's Pitts Special flying on ethanol.

PROGRAM OBJECTIVES

The objectives of the program were to demonstrate the viability of ethanol as an aviation fuel at appropriate locations and audiences in the participating Biomass Energy Program Regions, and to promote implementation projects in the area. Seven demonstrations were to be performed during the Summer 1995 through December 1996 period.

To maximize the cost effectiveness of the program, additional corporate co-sponsorships were sought at each demonstration site and the travel schedule was arranged to take advantage of appropriate events taking place in the vicinity of the scheduled events or enroute. This way, the original funded amount was stretched to cover another year of activities increasing the number of demonstrations from seven to thirty-nine.

While the RAFDC contract focused on ethanol as an aviation fuel, RAFDC also promoted the broader use of ethanol as a transportation fuel.

DEMONSTRATIONS AND EDUCATION

The following are the locations where the exhibits/demonstrations/presentations were performed:

1995

Aberdeen, South Dakota; Hastings, Nebraska; Oshkosh, Wisconsin; Des Moines, Iowa; Portland, Oregon; Newark, Ohio; London, Ohio; Waco, Texas; El Paso, Texas.

1996

Mountain Home, Caldwell and Boise, Idaho; St. Louis, Missouri; Waco, Texas; Denver/Golden, Colorado; Sioux Falls, South Dakota; Edgar, Wisconsin; Oshkosh, Wisconsin; Redwood Falls, Minnesota; Beatrice, Nebraska; Grand Island, Nebraska; Harvard, Nebraska; Amana, Iowa; Lubbock, Texas; San Antonio, Texas; Austin, Texas.

1997

Mc Gregor, Texas; Oklahoma City, Oklahoma; Waco, Texas; Omaha, Nebraska; Hampton, Iowa; Oshkosh, Wisconsin; Mitchell, South Dakota; Harvard, Nebraska; London, Ohio; Bloomington, Illinois; Denver, Colorado; Sioux Falls, South Dakota; Waco, Texas; Dallas, Texas.

The demonstrations/exhibits/presentations were held at major airshows, farm shows, State Fairs and alternative energy related conferences.

At airshows around the country, the promotion of the fuel and the program was augmented and enhanced by the cooperation of various airshow announcers who had become very familiar with the program in the course of many years of demonstrations. During the performance of the ethanol powered aircraft, and periodically throughout the airshow, the announcers talked extensively about the technical characteristics of ethanol as an aviation fuel and as a transportation fuel in general. The announcers were also very well educated about the political, economical and social issues involved in the production and the use of ethanol.

Since the inception of the program, the Pitts Special, the aerobatic aircraft used in this program, had been entirely renovated with a new engine, a new set of wings and a new paint job with highly visible ethanol signage. A seed company sponsored the modification of the aircraft. An exhibit tent was acquired featuring the same colors of the aircraft (green and gold -- the colors of corn) with "ethanol performs" signs on all sides. A new display booth was also produced which has been updated with new pictures and new information. Printed information was also added as new materials became available.

The locations for the demonstrations were chosen by considering appropriate events at suitable geographical locations, possible media and public exposure, and potential impact on local aviation communities. The following are the locations, occasions, and brief description of each of the demonstrations/exhibits/presentations held during the term of the project.

Aberdeen, South Dakota, July 1995

This airshow was organized by the American Coalition for Ethanol and the South Dakota Corn Utilization Council which provided travel expenses for the aerobatic aircraft. The event was highly publicized around the state as an "All Ethanol Airshow". It was very well attended, it attracted people from all over the state and a fair amount of media attention. Max Shauck performed two demonstrations during the show and gave rides to the public.

Hastings, Nebraska, July 1995

The event in Hastings was completely centered around ethanol as an aviation fuel project. The Nebraska Ethanol Board helped to organized it and the local ethanol producers partially

sponsored the event. The morning was dedicated to an extensive seminar covering the technical and economical aspects of the use of ethanol in aircraft. The seminar was followed by a well attended airshow where the only acrobatic act consisted of the ethanol powered Pitts Special. The interest raised and the contacts made during this event were well worth the effort. Nebraska has probably the greatest potential to adopt this fuel in the near future, mainly because of the abundance of ethanol in the area, popular support for ethanol, and the political commitment to expand the industry.

Oshkosh, Wisconsin, July/August 1995

The largest airshow and aviation event in the United States is organized every year by the Experimental Aircraft Association (EAA) in Oshkosh, Wisconsin. RAFDC rented a 20'X10' commercial tent to house its display for this event. The Pitts Special was exhibited outside the tent together with four other ethanol powered aircraft. The Pitts Special was flown every day of the show (a week long event) during either the airshow or the showcase. Great exposure resulted from the announcers' narration's not only during the actual flying, but also throughout the show when Max Shauck was periodically invited on the podium for interviews broadcasted across the entire airfield.

A forum was presented by Max Shauck on this subject at the Oshkosh's well publicized forum tents. In order to give such presentations at Oshkosh, a formal written request has to be made months in advanced and the request has to be approved. Shauck invited Mr. Jimmy Tubbs, the Designated Engineering Representative (DER) for the FAA, in charge of the ethanol certification program, to give a presentation on this subject. The forum was very well attended with an outstanding question and answer session.

The Oshkosh show is, without any doubt, the one providing the most exposure for this project, not only to the aviation community, but to the general public as well.

Des Moines, Iowa, August 1995

The Pitts Special was transported by truck to the Des Moines State Fair grounds where it was exhibited with the display and all of the information material, together with other ethanol powered ground vehicles. Here, the target audience was not only the aviation community but also the general public (although pilots visiting the grounds flocked to the aircraft). The aircraft attracted much attention and interest from all age groups, from children gathering printed material for their research projects to adults involved in farming or just plain curious about the aircraft and its fuel.

Portland, Oregon, August 1995

The Portland demonstration was performed at the request of the organizers of the Bioenergy Conference held in Portland, Oregon, in August 1995. Representatives of the local airport, located just across the river from the convention's hotel, were very helpful in working with the Federal Aviation Administration to obtain permission for the demonstration flight. The flight demonstration during the outdoor luncheon was greeted with enthusiasm by the conference attendees.

As evidence of the demonstration's popularity, many of the conference's attendees took advantage of the organized shuttle bus to the airport where they were given a tour and rides in the aerobatic aircraft.

The effectiveness of this demonstration was not just limited to the conference audience. During the flight to Oregon, the Pitts Special had to land frequently to refuel (an aerobatic aircraft has very limited range). Being the first time that an ethanol powered aircraft was seen in this area, much interest was generated at each airport where the aircraft stopped along the route. Printed material, mainly pamphlets and articles describing the project and its objectives, were left at each Fixed Based Operation (FBO) interested in knowing more about the fuel.

Newark, Ohio, August 1995

The Pitts Special performed an airshow above the race track in Newark, Ohio at the opening of the races where an ethanol racing car was also performing. According to the comments and the enthusiasm of the public, the airshow was a welcome novelty for a race-track event. Moreover, it provided a great opportunity to expose a different type of audience to information about ethanol as a fuel and its benefits in general.

London, Ohio, September 1995

The aircraft and the display were taken to the Farm Science Review in London, Ohio. They were exhibited inside a tent together with an ethanol powered car and ethanol powered jet skis. This farm show is one of the most popular in the Midwest. Despite the persistent bad weather during the three day period, there was a continuous flow of people visiting the exhibit.

Waco, Texas, November 1995

An all ethanol airshow was performed during the "First International Conference on Alternative Aviation Fuels" held at Baylor University in Waco, Texas. Single aerobatics acts were performed by the Pitts Special and a RV3 from South Dakota. The Vanguard Squadron also exhibited a beautiful formation acrobatic act, and the airshow concluded with seven ethanol powered aircraft flying in formation: the first such flight in history. The Conference and the show received much media attention, nationally and internationally.

El Paso, Texas, December 1995

The ethanol powered Pitts Special was taken to El Paso, Texas to be exhibited at the Texas Renewables' 95 conference held in conjunction with the Texas-Mexico Border Energy Forum II. The display was exhibited inside the conference hall, while the Pitts Special was exhibited at the El Paso's Convention Center parking lot (taken there by ground transportation) where it was visited not only by the conference attendees, but also by the local general public.

Mountain Home, Caldwell and Boise, Idaho, May 1996

In May 1996, RAFDC received the first FAA certification for the use of ethanol in a series of aircraft engines. The most popular aircraft trainer in the world, the Cessna 152, became the first aircraft certified to be used in commercial operations powered by a non-petroleum fuel. The Cessna 152, used by RAFDC for the certification testing, was therefore taken in a cross-country tour to Idaho, to be exhibited at the Mountain Home Airshow and participate in other events in that state.

The trip, beside the promotion of the certification and the fuel along the way, also served as a data collection field trip in a variety of weather and altitude conditions. From Colorado to Wyoming, the Cessna 152 with two pilots on board, crossed a high mountain pass. At the airport in Laramie, Wyoming, where the aircraft then landed, the FBO personnel were very surprised that a Cessna 152 with two passengers aboard was able to cross the mountain pass. This type of aircraft, being under-powered for this type of high density altitude condition, is not frequently used in this part of the country. RAFDC's Cessna 152, by burning ethanol, produced around 20% more power allowing it to operate in these types of extreme environmental conditions.

Due to a weather system along the route, the Cessna 152 was only able to reach Mountain Home, Idaho, on the day of the airshow, and then, after the airport was closed for the airshow.

Consequently the Cessna had to land at a nearby airport where most of the people who flew to attend the show had also landed. However, the RAFDC display was set up at the airshow site together with the Idaho Natural Resources display on Biodiesel fuel.

Furthermore, Ethyl Tertiary Butyl Ether (ETBE) (carried along with the ethanol in the fuel trailer) was supplied to a local aerobatic pilot to be tested in his aerobatic aircraft. The pilot tested the fuel (100% ETBE) on the field, performed few aerobatic maneuvers, and felt confident enough to take his aircraft cross-country all the way to Boise. The aircraft performed well on its new fuel, except on its way back to Mountain Home, where just before landing, it experienced engine roughness. After a safe landing and upon inspection, the spark plugs were found to be wet with fuel. The pilot, due to his inexperience with the new fuel, had evidently used a mixture setting that was too rich for this fuel.

A seminar was presented at Caldwell airport on ethanol as an aviation fuel. The event, including a fly-in dinner, was well organized by a representative of the Idaho Natural Resources Department. The event was well attended by the local aviation community and representatives of the ethanol industry.

A press conference was also organized at the SIMPLOT hangar at Boise Airport. SIMPLOT is producing ethanol from potato wastes. Local papers, radio and television attended the event and interviewed the pilots. Ethanol was also provided by SIMPLOT for the trip back to Texas.

The data collected in the Cessna during the trip was very important. The cross-country flight represented a great chance to test the fuel consumption and the performance of the aircraft in a variety of environments. Furthermore, it also provided the opportunity to promote the fuel in all of the airports at which the aircraft stopped to refuel or to await better weather. Again, the overall value of ethanol in aircraft and in surface vehicles were equally highlighted.

St. Louis, Missouri, June 1996

RAFDC was invited by the National Renewable Energy Laboratory (NREL) to present a paper at the National Corn Growers Conference, in June 1996, in St. Louis, Missouri. Besides the presentation, an exhibit was set up together with various posters displaying the benefits of ethanol.

Waco, Texas, June 1996

The Texas State Technical College (TSTC) Airport was the first airport in the nation to be designated as a Clean Airport. The airport houses four ethanol powered aircraft and an ethanol refueling infrastructure. The designation ceremony was attended by state and federal government representatives, industry representatives, by the local academic and aviation communities and by representatives of the media. Following the official ceremony, an airshow on ethanol was performed by an entirely restored Pitts Special with a new, more powerful engine, new wings, a bright gold and green new paint job and very visible signs. The program also included a brain storming session on the future of the Clean Airports Program, followed by a luncheon at Baylor University.

Denver/Golden, Colorado, June 1996

The Pitts Special was flown to Denver and then taken via ground transportation to the National Renewable Energy Laboratories (NREL) headquarters in Golden, Colorado, where it was exhibited on the occasion of the World Renewable Energy Congress. Professors and personnel from the Colorado School of Mine, provided important help with all of the logistics in moving the aircraft at night on public roads. The RAFDC's display booth was also exhibited at the convention center in the exhibit hall for the duration of the conference.

Sioux Falls, South Dakota, July 1996

Another "All Ethanol Airshow" was organized by the South Dakota Corn Utilization Council. The airshow program included an "Ethanol as an Aviation Fuel" forum presented in the morning of the show by Max Shauck, at the South Dakota National Guard Headquarters. The ethanol powered Pitts Special, freshly restored, was featured with pyrotechnics on the wings to accentuate vertical maneuvers visibility. The Vanguard Squadron performed as well on ethanol both in formation flight and as single aerobatic acts. A new tent, of the same color of the aircraft was set up at the show site, and a new exhibit booth was also displayed.

The airshow announcer was by then a veteran of the subject and did a great job throughout the show. The whole day event was a very effective and successful showcase of the ethanol as an aviation fuel project.

Edgar, Wisconsin, July 1996

The Pitts Special together with the new exhibit booth was displayed at the Wisconsin Farm Progress Show. A seed company, Northrop King, which had sponsored the renovation of the

aircraft, hosted the aircraft and the display in its exhibit grounds. The farm show was very well attended and the public displayed a high level of interest in the aircraft and its fuel.

Springfield, Illinois, July 1996

The Pitts Special and the newly certified Cessna 152 were both taken to the "Springfield Rendezvous Airshow". The new exhibit tent was set up between the two aircraft with the display and the printed information. Large, highly visible signs were displayed on the tent and in front of the aircraft.

Oshkosh, Wisconsin, August 1996

The 1996 EAA Convention was again a great success. The Cessna 152 the center piece of the display area with all of the pertinent information on its certification. A big commercial tent was rented for the main exhibit, and the new "ethanol performs" tent was also set up to house the pilots bringing other ethanol powered aircraft and their information. There were eight ethanol powered aircraft exhibited, including a beautiful newly renovated Cessna 150 flown to Oshkosh from Canada. This project, sponsored by Environment Canada, had developed as a result of the "First International Conference on Alternative Aviation Fuels" held at Baylor University the previous November. The enthusiastic Canadian responsible for this project was also available to answer questions and talk to the people for the whole duration of the show, together with three other members of his project team.

The new Pitts Special again performed in the show and in the showcase, on either ethanol or ETBE, promoting both fuels as preferred alternatives to aviation gasoline. The coverage from the airshow announcers was even better than the previous year since the Cessna 152 certification on ethanol was important news, and also more announcers were becoming familiar with the program. The Vanguard Squadron also performed in the showcase, contributing to the extensive coverage of the program.

The forum/seminar this year was again presented by Max Shauck, who also involved in the presentation the Canadian team and members of the Vanguard Squadron. The forum raised excited discussions and comments, and so much interest that, at the end, the public had to be repeatedly invited out of the forum tent to allow the next presentation to proceed. The exhibit tents were also constantly visited by people, and printed material had to be restocked every day. Besides the usual RAFDC personnel, the Canadian team and the Vanguard pilots, two Baylor University Aviation Sciences students were employed full time during the convention to man the exhibit.

Since more ethanol was needed to refuel all of the aircraft, an enthusiastic Wisconsinian provided a couple of barrels of ethanol and, in addition, remained for the duration of the show to help man the booth.

During the convention, one of the most popular aviation magazines in the country, General Aviation News & Flyer, featured the news of the Cessna 152 ethanol certification on its cover page. All of these events contributed to a very successful and productive show.

Redwood Falls, Minnesota, August 1996

The Pitts Special was flown to Redwood Falls to be exhibited at the Farm Fest. The aircraft was again housed, together with the exhibit booth, at the Northrop King grounds. At this show, the aircraft was displayed alternatively in static display and flying exhibit. The local police and the show organizers provided great cooperation to allow Max Shauck to take off from a side road at the show site. The Vanguard Squadron flew from South Dakota to perform at the farm show as well, and the Pitts Special joined them for a great flight formation performance, which was announced from the show grounds by the executive director of the Minnesota Corn Growers.

Beatrice, Nebraska, September 1996

A forum was presented during the morning of this airshow in the main airshow hanger where the exhibit was also set up. The International Flying Farmers organization was present at the airshow and provided a very attentive audience at the seminar. Despite the fact that this was a small town airshow, it was well organized and very well attended.

Grand Island, Nebraska, September 1996

The aircraft was again taken by truck and trailer from the local airport to the "Husker Harvest Days" farm show grounds to be exhibited together with the booth for the duration of the farm show. This is the largest farm show in Nebraska and one of the largest in the Midwest. It was crowded the entire time and the project received a great deal of exposure.

Harvard, Nebraska, September 1996

This airshow, located in a small rural center in Nebraska, was amazingly well organized with as many aerobatics acts and static displays as found at some of the major shows in the country. A big hanger was available for exhibits and the whole-day event included a fly-in pancake breakfast, a fanfare show, a speech by Governor Nelson, and many other happenings besides the airshow itself. Governor Nelson visited the ethanol booth and talked about the RAFDC's

project during his speech and about the benefits of ethanol production to the economy and the environment. The Pitts Special airshow was extremely well received and Max Shauck had to promise the organizers to come back for the next year's show.

Amana, Iowa, September 1996

The Farm Progress Show is the largest farming event in the country. The Pitts Special was again taken by truck to the show grounds and exhibited close to the ethanol tent and its booth. Despite the bad and rainy weather, there were constant crowds at the show and the program received great attention not only from the public, but from national and local media.

Lubbock, Texas, October 1996

The Pitts Special and the display were taken to the Lubbock Farmer Stockman Show, mainly to attempt to interest the Texas farming community in ethanol production and usage. The aircraft flew only on the first day of the show since there were some logistical problems. The display was set up inside one of the main exhibit tents, hosted again by the Northrop King seed company. At this show there was interest in the program but not nearly as much as at the other farm shows. The farming community in Texas did not seem to be nearly as familiar with this fuel as farming communities of the Midwest. Much more education is needed in Texas on the subject of renewable fuels in general.

Austin, Texas, November 1996

The information booth was displayed at the Texas Renewable Energy Conference in Austin, Texas. Conference attendees visited the exhibits which were also open during the week-end to the general public and schools. Again, the Texas public needs to be educated about this subject, its social and economic implications, and the technical characteristics of the fuel. Unfortunately, with minimal interest in biomass fuels in the political environment in Texas, there are no incentives for the general public to be involved in this issue.

San Antonio, Texas, December 1996

RAFDC decided to participate at the Texas Farm Bureau Convention in San Antonio, Texas, in order to excite some interest for ethanol at a decision-making level of the Texas farming community, or, at least try to understand the reasons for the lack of involvement. Although there were some very interested people at the convention who took a copy of each piece of printed information, we again felt there was a general lack of information and interest. Even the president of the group, although very courteous and amicable, did not seem inclined to go into depth on the subject.

1997

Mc Gregor, Texas, April 1997

Mc Gregor in Texas was the first non-controlled airport to be designated as a Clean Airport. The designation ceremony was part of a whole day event which included FAA safety seminars, a barbecue luncheon for all of the attendees, an airshow and displays. The RAFDC tent was set up with an updated display and the RAFDC's aircraft. The seminars and the designation ceremony took place inside the main hangar. It was very well attended by the Mc Gregor city officials, FAA officials and the aviation community of the region. The ethanol powered aerobatic aircraft provided a spectacular airshow as the after-luncheon entertainment. McGregor Airport has a 1000 gallon in-ground ethanol tank, one aircraft converted to use ethanol, and ground and support equipment which also uses alternative fuels.

Oklahoma City, Oklahoma, June 1997

RAFDC was invited to display and perform at the "Airshow of the Americas", one of the major airshows in the Southern part of the US, in Oklahoma City, Oklahoma. RAFDC had been working with the Will Rogers International Airport officials since the previous year to designate their airport as a Clean Airport. In June the airport was ready for the designation. There had been some talk among the airport officials to designate it during the airshow, but they decided that the airshow would detract from the designation ceremony.

The tent, the exhibit and the aircraft were on display together with local alternative fuel vehicles in a good traffic location, close to the main airshow gate. RAFDC also displayed the air pollution monitoring aircraft together with the aerobatic aircraft. This generated additional curiosity about the display, and it provided an effective opportunity to convey further information to the public on both issues: fuel and air pollution, and their inter relationship.

The night show on ethanol on Friday had to be canceled by the organizers due to delays in the program and the lighting conditions. However, the airshows on ethanol were very well received on both days following.

Waco, Texas, June 1997

All of the RAFDC's aircraft were displayed at the 1997 Waco Airshow held at the TSTC airport. The exhibit was set up and the Pitts Special flew on both days of the airshow, despite the bad weather and thunderstorms of the second day.

Omaha, Nebraska, July 1997

A four hour presentation on the program was given at the International Flying Farmers Convention in Omaha, Nebraska. The presentation was attended by all of the conferees and interesting discussions were sparked. The Director of the Nebraska Energy Office, Robert Harris, spoke about the ethanol experience in Nebraska. The display was also well visited, and much of the available printed information distributed.

A shuttle from the hotel was made available to take the attendees to the airport to see the aircraft and to take rides. Due to extremely hot temperatures outside, that part of the event was canceled. Nevertheless, the presentation was very effective and resulted in a cover feature article in the International Flying Farmers magazine.

Hampton, Iowa, July 1997

The Hampton Airshow in Iowa is organized by a group of aviation enthusiasts who have asked RAFDC repetitively to have the ethanol aircraft perform at their show. Since the Hampton Airshow happens just a few days before the big Oshkosh convention, some of the vintage aircraft and aerobatic aircraft stop in Hampton on their way to Oshkosh. The Hampton airport is an attractive and clean airport cut right in the middle of the corn fields. A fly-in pancake breakfast was organized for the morning of the airshow. A big hanger was made available for the exhibit and to house the aircraft since bad weather was predicted. In fact, a thunderstorm arrived at the field just a few minutes before the airshow was scheduled to start. All the spectators were trapped in the hangars. Fortunately, the lightning and thunder stopped soon, but the rain did not. The ethanol Pitts pilot, not to disappoint the organizers and the spectators, flew a short show anyhow under light rain, to everybody's pleasure.

Oshkosh, Wisconsin, July/August 1997

This year's airshow was the best ever! The air pollution monitoring aircraft was also taken to the show to be exhibited together with the Pitts Special, the Canadian ethanol powered Cessna, and the South Dakota Vanguard Squadron's aircraft. Three students from the Aviation Sciences Department of Baylor University came along to man the booth and help set up of the exhibit.

This time a bigger (20'X20') commercial tent was rented for the exhibit and the other ethanol tent was also set up along side. Again, the same corner lot, one of the best spots of the show, was taken by the ethanol aircraft exhibit. The air pollution aircraft, a Beechcraft King Air,

attracted much attention and interest and gave the RAFDC team another opportunity to educate the public.

An internationally acclaimed airshow announcer, who had become extremely familiar with the project, the ethanol aircraft, and the pilot (Max), during the "Down Under Airshow" in Melbourne, Australia (during a week long show in February 1997) became the official announcer for the ethanol aircraft. He teamed up with the announcer from South Dakota who had been announcing the "All Ethanol Airshows" and the previous Oshkosh shows. Because of the interest of these two announcers who were constantly talking on the show podium, the project received an incredible amount of coverage. Interviews were scheduled with the pilot both on podium and at the exhibit site. The aircraft was also twice chosen to race the famous Shock Wave, the 370 mph "jet truck", on the busiest days of the show. The other days it flew every day in the showcase with outstanding commentary from the announcers who ended up co-announcing the performance of the ethanol Pitts. This brought great dividends since one of the announcers was more familiar with the technical issues, while the other was more familiar with the social, economic, and environmental issues.

The forum this year was scheduled for one of the busiest days of the show but, a little too early, 8 o'clock, for big crowds to show up. Considering the time, there was still a good attendance. Max Shauck gave the main presentation and then introduced a professor from the West Virginia University's Engineering Department, Chris Atkinson, who has considerable experience with ethanol powered engines. Both Max and Chris then answered the numerous questions from the audience. The discussions were so extensive they had to be continued at the exhibit site which was constantly filled with people interested in the program.

The Oshkosh show was a resounding success! (please see 1997 Oshkosh show support letter in Appendix A)

Mitchell, South Dakota, August 1997

Mitchell, South Dakota, was the site of the South Dakota's Farm Show. The Pitts Special was flown there and then taken to the site by ground transportation. The exhibit was housed under Novartis Seeds' tent and exhibit grounds. It was a well attended show. The Pitts Special was allowed to take off from a side road on the last day of the show, so that it could be seen flying over the show grounds.

Harvard, Nebraska, August 1997

The Husker Harvest Show in Harvard, Nebraska, was organized again this year, and requested the ethanol Pitts to perform. The Nebraska Ethanol Board helped to co-sponsor the event together with local ethanol producers. The show was even larger than the previous year and it had grown into a two day event. Again there were many other happenings in conjunction with the show. Nebraska's Governor, Ben Nelson, was there to greet the public and to promote ethanol. Ethanol was provided by the local producers. An exhibit was set up at the site.

London, Ohio, September 1997

London, Ohio, is the site of the Farm Science Review farm show. The aircraft was flown there and displayed with the ethanol tent and the exhibit. A steady flow of people kept the booth busy during the three days of the show. Many students from the schools of the Columbus area visited the show and collected huge amounts of printed information on ethanol for their research papers.

Bloomington, Illinois, September 1997

This year's Farm Progress Show, the largest farm show in the US, was held in Illinois. Again the Pitts Special was exhibited with the tent and the booth. There was a great amount of interest from the farmers, as it is always the case in the Midwest, and also from international guests -- tours were organized from many different countries to visit the show. Students flocked to the exhibit to gain information and material for their research on this subject. The Pitts was again allowed to take off from an adjacent road which added some excitement to the event.

Denver, Colorado, October 1997

RAFDC participated with its exhibit booth at the Clean Airport Summit in Denver Colorado. Additionally, the RAFDC's air pollution aircraft, an alternative-fuel turbine test-bed aircraft, was exhibited at the Denver International Airport at the reception site together with some alternative fueled ground vehicles.

Sioux Falls, South Dakota, October 1997

A Piper Pawnee, an agriculture spray aircraft which is the next aircraft to be certified by RAFDC on ethanol, was flown from Waco, Texas to Sioux Falls , South Dakota. There it was featured at the Tea Airport Clean Airport Designation ceremony. An ethanol refueling infrastructure has been in place at Tea for quite some time and the airport is the base for four ethanol powered aircraft -- plus two more being converted. State and City officials attended the

ceremony, which culminated in an airshow of ethanol powered aircraft and a low-pass flight formation of the South Dakota's National Guard team.

Waco, Texas, November 1997

The "Second International Conference on Alternative Aviation Fuels" was again held at Baylor University. This year, nine countries were represented. Due to the new air quality standards and the renewed environmental concerns regarding the impact of pollution from aircraft, the conference was very timely and particularly interesting. New concepts, ideas and future projects were sparked as a result of the exciting exchanges of information in the course of the two day event. The morning of the third day, RAFDC hosted an airshow at its facilities. There were ten ethanol powered aircraft on exhibit, and two more failed to arrive on time, being stuck by bad weather. There was an airshow and a luncheon at RAFDC's hangar. The conference and airshow were truly successful!

Dallas, Texas, November 1997

RAFDC's exhibit participated at the Texas Renewable Energy Industry Association's Conference this year in Dallas. Max Shauck gave a presentation on the "Renewable Fuels for Aviation" program during the plenary session. It was well received and inspired a lively discussion.

The RAFDC display booth was one of the most popular exhibits and was a focal point of attention for the conferees and students who were invited to the educational exhibit.

Part of the conference was a debate among high school students on environmental issues and in particular on the use of alternative fuels. The debate was very interesting and generated general public and media attention. The coach for the debates and some of the students visited the RAFDC's display and decided to include RAFDC's results on alternative aviation fuels in their future debates.

The high school debate coach just visited RAFDC to gather all of the available information on the project. Due to the high visibility of the lead issue in aviation fuel, he has decided to focus the efforts of his debate team on the benefits of renewable fuels in aviation. His team is going to be involved in numerous debates at prestigious universities around the country, including Harvard and Emory Universities.

IMPLEMENTATION

Five airports were designated as Clean Airports during the course of the program. Two more are ready to be designated. Seven more aircraft were converted to use ethanol.

The progress of the implementation phase of the program might seem modest if compared to the alternative fuels programs for ground vehicles and the rapid developments of the last few years in this area. On the other hand, to an aviation insider, it can seem like a gigantic step considering the conservatism of the aviation industry. Only when the technical and bureaucratic barriers in the aviation industry are taken into consideration can the achievements of the program be fully appreciated.

REVIEW OF CURRENT AND FUTURE ACTIVITIES

Certification

The Piper Pawnee, an agricultural spray aircraft, is currently being certified with the FAA on ethanol fuel. Its engine has already received FAA approval and the airframe is now undergoing certification. The certification program should be completed by Spring 1998.

This project has been one of RAFDC's nightmares. Not only was it initially underfunded, but the particular aircraft chosen to be taken through certification turned out to have structural damage (impossible to detect during a normal purchasing inspection) and had to be practically rebuilt causing great financial difficulties in carrying out the project.

However, the aircraft has been flying on ethanol for a few years now and performing flawlessly. It was presented during January 1998 at the Texas Agricultural Applicators Convention in Galveston, Texas, during a seminar organized by the Texas Renewable Industries Association and sponsored by the Regional Biomass Energy Programs. The seminar was intended to spark pilot projects in Texas involving the aviation-agricultural community. This project sparked the interest of a group of pilots operating a fleet of agriculture spray aircraft. They are now exploring the possibilities of converting the entire fleet to ethanol.

The whole series of this type of aircraft will be approved for ethanol use once the required modifications are implemented.

As RAFDC's experience in the certification process continues to grow, it becomes easier to proceed in dealing with its organizational structure. The Federal Aviation Administration representatives in charge of the ethanol certifications are themselves becoming increasingly familiar with the fuel and its characteristics and are somewhat more comfortable now with the ethanol concept.

As more engines and airframes are being certified, less testing will be required of each engine or airframe, since only the differences between the new systems and those already certified would require testing. A previous program of mass aircraft certification, carried out by the EAA and a private company for autogas certifications, has proven the concept of mass certification by taking approximately ten years to certify all of the eligible aircraft in the US fleet. With adequate resources and proper technical personnel, an ethanol fuel mass certification might take even less time to be completed.

A certification of an aviation engine on ETBE is under consideration. ETBE has been used in RAFDC aircraft since 1995 with outstanding results. Max Shauck flew the Pitts Special on pure ETBE at the Paris Airshow in 1995. Since then he has been using this fuel alternately with ethanol.

Funding for an ETBE certification program is currently being sought with the help of the American Corn Growers Association.

Emission testing

The RAFDC test stand is finally entirely functional. This project was also a financial strain on RAFDC since the very expensive test stand and emission testing equipment had to be purchased with piecemeal funding from various organizations. However, it is now fully operational, and data is being collected on performance and emissions of three different fuels: Avgas, ethanol and ETBE. Data will be validated, reduced and summarized during the next several months and then made available to the public.

Due to the current situation regarding aviation gasoline and the phase-out of lead, emissions testing of the alternate candidate fuels are critical. Both ethanol and ETBE have great potential and are demonstrating superior performance, reliability and economy in comparison to aviation gasoline.

International Clean Airports Program

The Clean Airports Program, not supported any longer by the US DOE, will continue under a different organizational structure. The reasons given to RAFDC personnel for the withdrawal of support were that DOE does not have jurisdiction over aircraft, ships or trains and it lacks resources to oversee it.

There is currently a great deal of controversy concerning the pollution caused by large commercial airports, particularly those in the non-attainment areas. Recent studies have reported that the pollution from the aircraft engines is having a greater effect on pollution levels that had been previously thought. The primary reason is the unprecedented growth of airline traffic. Although aircraft engine manufacturers have made great strides in cleaning up emissions from the large turbine engines, this has not been sufficient to prevent significant increases in pollution caused by commercial airliners in extremely sensitive urban areas. Combine this with the fact that aircraft emissions are not currently regulated beyond mandatory standards, and it becomes clear that this is not only an important issue but one that is politically sensitive.

Furthermore, there is mounting concern that U.S. dependence on imported oil to meet aviation needs, with even greater dependence of other democratic nations, is becoming a mounting threat to national security. There is also recognition that one of the world's most advanced industries, the aviation industry, must provide leadership in stabilizing greenhouse gas emissions.

With these backdrops:

- Termination of DOE's support for the Clean Airport Program;
- Increasing recognition of the aviation industry's contribution to air pollution;
- Requirements for the aircraft industry to become less dependent of fossil fuels imports; and
- The need for the aircraft industry to demonstrate leadership in stabilizing greenhouse gas emissions,

The Second International Conference on Alternative Aviation Fuels, held at Baylor University in November 1997, developed innovative concepts, original ideas and international support to launch the International Clean Airports Program (ICAP).

RAFDC feels very confident that it will be able to structure a dynamic and effective program together with the national and international organizations and agencies interested in initiating the new program. RAFDC's background is unique in the areas of aviation, education, clean alternative aircraft fuels and air pollution research. This combination of talents does not exist elsewhere. RAFDC by providing its experience in these issues will be able to make a significant contribution to the problems facing the aviation industry and highly polluted urban areas. This program will also offer a great opportunity to effect implementation of renewable fuels in aviation.

Air pollution monitoring with instrumented aircraft powered by renewable fuels

RAFDC has been involved for quite some time in air pollution investigations involving instrumented aircraft. Extensive experience in this field includes very large and important studies conducted in North, Central and South America.

RAFDC's Beechcraft King Air has been used since 1996 to collect air pollution data in the state of Texas. During the summer of 1997 alone, the aircraft flew in excess of 200 hours during air pollution missions. Very interesting and extremely useful information is being produced from the summer research. RAFDC's work is helping the Texas Natural Resources Conservation Commission (TNRCC) develop a State Implementation Plan for the state of Texas. According to a TNRCC chairman's comments "the Baylor aircraft has allowed TNRCC to better characterize air quality in our state in a manner never before possible in the 25-year history of the state's air quality monitoring program". One engine of this aircraft will soon be flying on a renewable fuel blend.

Because of the increased need for these type of air pollution investigations and the great opportunity to power these aircraft by renewable fuels, RAFDC is developing a low-cost air pollution instrumented aircraft powered by ethanol. Baylor University has purchased from the state of Texas, the first aircraft fully certified on ethanol. This aircraft will be instrumented during Winter and Spring of 1998 with miniaturized air pollution equipment and it will be tested during the summer in Texas. If successful, it will be widely duplicated, probably worldwide, and it will support the scope of the Clean Airports Program.

Training operation and pilot project on ethanol

A sizable pilot training operation on ethanol is being considered that will serve as a test project and a showcase for ethanol as an aviation fuel. Students at Baylor University and

RAFDC's personnel have been flying the certified ethanol powered Cessna 152 for a year now. There are no technical or logistical problems in implementing the program, whose purpose will be to prove the technical and economical advantages of using ethanol in a commercial operation.

Turbine fuel research

RAFDC is building a mobile turbine test stand equipped with emission testing equipment. This research is prompted by environmental concerns over the emissions of commercial aircraft.

RAFDC's initial testing will focus on blends of biodiesel and Jet A-1 fuel. Previous studies have shown that a 20% blend of biodiesel in jet fuel might decrease particulate emissions by 80%.

Educational programs

The summer of 1997 demonstration/education programs have been the most productive ever for the RAFDC project. The interest and attention attained by the program along the years has been increasingly gaining momentum. This is probably the result of a combination of three factors:

1. An increased public environmental awareness;
2. The impending aviation gasoline crisis (the lead issue);
3. RAFDC's growing experience in developing and organizing these demonstration/educational events. This year the presence of the RAFDC's King Air aircraft at selected shows has greatly increased the interest in the display.

RAFDC, building on the knowledge gained through the extensive experience of these past years, is planning to propose series of demonstration/educational programs which will comprise multi-aircraft displays with the opportunity to link the subjects of alternative fuels and air pollution. Appropriate information would be produced to be distributed at these events and computers would be made available to "see" the air pollution data collected in the area and to learn how alternative fuels can help clean up the air.

RAFDC's personnel will be available to discuss details with anyone interested in this type of effective educational activity.

Baylor University Academic Programs Development

In the organizational structure of Baylor University, RAFDC is a research center based at the Aviation Sciences Department. The chairman of this academic program is Dr. Max Shauck. The primary focus of this program, until recently, has been to provide a strong undergraduate education coupled with a professional pilot program, including all the necessary pilot ratings. This program places heavy emphasis on the sciences, mathematics and computer science as well as the humanities and professional aviation courses. The strong interdisciplinary content of the program has enabled many of the undergraduates to work in fuel research programs and air pollution investigations conducted by RAFDC. Consequently, RAFDC has employed a number of its own graduates full time, and they have been the most enthusiastic and productive members of the research team.

The development of a graduate program in the areas of alternative aviation fuel research and air pollution using instrumented aircraft is now under consideration. In addition, because of the overwhelming interest shown at the recent conference by attendees from various countries, a series of short courses will be developed to train and certify at least one representative from each of the airports involved in the International Clean Airport Program.

These courses will be developed using the skills of the RAFDC team members coupled with internationally recognized experts in this area. RAFDC has developed an extensive network of international associates who will be the nucleus of ICAP. Necessary courses will be taught via internet or via an appropriate distance-learning medium with annual workshops on site either at Baylor or at other participating institutions. Baylor is also collaborating with a retired senior executive of a major international airline to develop a program taught via distance learning. This program will lead to a graduate degree intended to prepare middle management personnel for senior management positions in the airline industry. Baylor will develop modules concerning the environmental impact associated with the airline industry and possible solutions to this problem.

CRITICAL CONSIDERATIONS IN DETERMINING FUTURE SUCCESSES

Much progress and development has occurred since the inception of this demonstration/education/implementation project. However, at RAFDC we are still striving to find the right formula to spark the interest necessary for a mass conversion of piston engine aircraft to alternative fuels. There are two indisputable factors:

1. There are no insurmountable technical obstacles to prevent this from happening and;
2. General aviation is in urgent need of a clean alternative fuel.

The question then becomes: What is preventing this from happening?

1. Limited amount of resources available.

In order to implement effective programs sufficient resources are critical. RAFDC has always stretched its resources, especially human power, to their limits in order to maximize the value, impact, and the cost effectiveness of the programs. The success of RAFDC's programs is the result of immense amount of time and physical effort employed in organizing and carry out these activities. This amount of effort can only be the result of the unlimited enthusiasm and dedication to the project of the people involved. In the case of the educational programs, two people are mainly responsible for their organization and implementation with periodic help from other RAFDC personnel or students. These projects are carried out while managing a number of other related research and certification projects and air pollution investigations.

At the current level of program development, more people and more funds are needed to deploy an organized plan toward the goal of the implementation of ethanol as an aviation fuel on a significant scale. Resources are needed to:

- a. Continue educational programs.** It is evident from "field" experiences that there is a lack of understanding on this subject among the general public. Lack of education is still the major obstacle. The misinformation about ethanol, devised by those committed to keeping this country captive to fossil fuels is preventing the general public from learning truthful and basic information about this fuel, such as the economical and environmental benefits derived from its use. The basic facts, if known, would bring about a major change in the attitude of the American consumers.

b. Proceed with certification programs. This activity can be carried forward on a continuing basis while implementation and pilot projects are spreading.

c. Further research into improving the efficiency of ethanol engines. This research can also be pursued in parallel to the educational and certification activities. Emission testing of aviation engines is a research area that is just emerging. The new fuel will have to be a clean fuel, renewable, and domestically produced aviation fuel.

2. Lack of a concerted effort .

Over time, RAFDC has received important but sporadic help from several federal and state agencies, agricultural organizations and some private individuals and industries.

Considerable efforts are always underway to insure continuous commitments and support from these groups. It seems as if the objectives of these organizations vary with the changing of their executive directors and administrators. The lack of steady commitments from the supporting organizations has been frustrating especially considering the continuous loss of critical time spent in pursuing needed resources. A concerted effort would considerably promote and expedite the implementation phase. Commitment is critical from:

a. National and state agricultural organizations. The National Corn Growers Association, for example, has been ambivalent about their support of this program. The executives of this organization have frequently complimented the RAFDC activities over the years, but their support has never materialized. Conversely, some of the Corn Growers state organizations have been supporting the program, but, that support is always at the mercy of the current administrator. Lack of top level support is in conflict with the manifest interest and enthusiasm of the farmers for this project. Especially in the corn belt, where RAFDC has been exhibiting at the largest farm shows, farmers have repetitively made the most encouraging remarks about the project. They always assume that RAFDC's presence at the shows is supported by the national organizations to which they entrust their check-off money, and they are always very surprised to hear that, indeed, this is not the case.

It is easy to see the benefits that would accrue to the farming community if biofuels were to be widely adopted. Coordination among the national and state agricultural

organizations and RAFDC's activities would be highly advantageous for the creation of a refueling infrastructure and a distribution system for biofuels at and near airports.

b. Federal and state agencies. The US Department of Energy (US DOE), for example, should have a more active role in the implementation of biofuels. The Clean Airports Program which started as a US DOE initiative, under RAFDC's coordination was achieving major results. This is especially true considering the very limited amount of resources available to the program. It provided a great opportunity to establish a distribution system of biofuels at airports. Five airports were designated as Clean Airports in 18 months of operation and two more airports are ready , and will be designated. Nonetheless, the DOE has chosen to cut formal support previously granted, therefore inflicting a major setback to the numerous ongoing working relationships with potential Clean Airports around the country.

The program was working well and gaining momentum, even without federal funds. Again, discontinuity in the objectives of the agency caused by changing priorities is very damaging to worthy projects. Once a program is established and demonstrated its merits with little federal assistance, it should be supported and not terminated.

RAFDC is also receiving considerable support from the Federal Aviation Administration (FAA) for research and development of biofuel powered engines and emissions comparisons. However, the FAA's policies do not allow its funds to be used for engine certification or promotional activities.

The Environmental Protection Agency (EPA) is also interested in many of the activities undertaken by RAFDC, especially the air pollution monitoring and air pollution research.

Solid commitments from these agencies, brought together in a coordinated manner to implement a very effective program of biofuels promotion, would guarantee and expedite adoption of biofuels in aviation to the benefit of the nation, its economy, environment, and its leadership position in the world.

c. Biofuel producers, distributors and related industries. The ethanol industry, still emerging, and dependent on political decisions for its future, has been mostly concerned with its own survival, and is at best inconsistent in its commercialization strategies and plans for the future. The main objective of these industries is the promotion of an ethanol blend for the automobile market, and some might perceive ethanol aviation fuel as an exotic idea. Some industries have contributed limited support along the years, and some do keep a vigilant eye on the progress of the program. However, consistent support, commitment and trust from the industry is critical to move the program forward. Logistical problems can be easily solved with the support of the existing industry, especially with greater fuel availability around the country.

3. Aviation industry conservatism and power of the petroleum industry.

Inherent in the nature of aviation is the need for an unusually high degree of safety awareness. This need causes many representatives of the commercial aviation industry to be extremely conservative, particularly when it comes to adopting new technology. RAFDC has always operated with safety as the number one priority in all of its operations. However, an element of risk is always introduced in the testing phase of a new technology in aviation, particularly a new fuel. The risk phase of ethanol and ETBE development has long since been concluded. Ethanol has been subjected to a far more extensive testing process than aviation gasoline was required to undergo, mainly because it is a new fuel competing with a well established one. The testing of ethanol as an aviation fuel has been in progress for 17 years, and has been subjected to intense scrutiny by the FAA, aviation industry, and, in particular, the petroleum industry.

A de facto alliance between many members of the aviation industry, federal agencies, politicians and the petroleum industry has grown up over time. While this is to be expected, given the requirements of close cooperation between these groups, it has led, in a natural manner, to a situation which tends to perpetuate the use of technologies which could not prevail in the current circumstances in the absence of the power structure built around them over time. More specifically, if aviation gasoline and ethanol were both new fuels, given no preference on either side because of power alliances, political contributions and the myriad of other entanglements, both political and commercial, there would be no contest between the two fuels. Ethanol would easily prevail. Ethanol outperforms aviation gasoline, is more economical, far better environmentally, and is renewable and domestically produced. The refusal of some key people to acknowledge the

documented facts and their implications is a disservice to not only the aviation community but the nation.

One of the very difficult obstacles to overcome is the strong influence the petroleum industry wields on the media. Again, this influence can be understood as almost natural given the large revenues various media receive from advertising fees from the petroleum industry. It is only mentioned in this context in order to help develop an understanding of the difficulties of implementing ethanol, or for that matter, any non-petroleum fuel, as a commercial aviation fuel.

CONCLUSION

RAFDC is appreciative of the opportunity provided by the Regional Biomass Programs in allowing the continuation of the educational and implementation phase of its program. A combination of extensive experience, circumstances, hard work and careful planning enabled this team to complete over five times more events than proposed with the same funding originally requested. The cost effectiveness of this project and its impact on the target audience are results in which RAFDC takes great pride.

RAFDC is equally confident that the implementation portion of the program more than fulfilled the stated goals. The Clean Airports Program was a key part of the implementation program, and requests for involvement from major airports around the US had been received. While the DOE withdrawal from this program has created some problems, RAFDC is proceeding with an expanded version of the original Clean Airports Program, the ICAP. This expansion was a result of enthusiastic support from the attendees at the Second International Conference on Alternative Aviation Fuels.

The combination of all programs outlined in the body of this report has great potential to benefit not only the US, but will also provide benefits on an international scale. Overall, the relationship between RAFDC and the US DOE has been productive and has provided cost effective benefits.

The threat to the environment, as a result of the use of fossil fuels, coupled with the threat to the national security as a result of the nation's increasing energy dependence, can no longer be ignored. The potential of RAFDC's programs to benefit the nation's energy

security, to improve the quality of the environment, and to provide quality public education on these issues is tremendous.

We have only begun to realize the possibilities and the benefits that could accrue from the development and utilization of renewable, clean-burning, domestically produced aviation fuels. RAFDC has proved that it has the capability to develop reliable, high-performance, clean burning, renewable fuels for aircraft engines, and to carry out an effective educational program in a highly cost effective manner. An expansion of the current level of support from the various sectors, federal and state agencies, agricultural organizations and the biofuel industry for the RAFDC's program would be a productive investment in the future of our country.