An Analysis of Alternative Jet Fuel (AJF) Supply for Manassas Airport

Project Proposal

Samira Monshi

Seungwon Noh

Wilfredo Rodezno

Brian Skelly

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Course Professor: Dr. Andrew Leorch

Project Sponsor: Dr. Lance Sherry

1. BACKGROUND AND PROBLEM

Jet fuel is a common type of aviation fuel used to power gas turbines. There are many variations of jet fuel, but in the civilian aviation industry, three variations are used: Jet A, Jet A-1, and Jet B. While each of these three jet fuels is slightly different, they are similar in that all are derived from kerosene. Kerosene is a fuel oil that is made by distilling petroleum. And because petroleum is a non-renewable energy source for which there is a limited supply on Earth, there is a lot of interest in creating synthetic kerosene from non-petroleum sources. A jet fuel creating from synthetic kerosene would be classified as an "alternative" jet fuel.

Unlike other modes of transportation, the aviation industry is limited in the sources of power from which it can choose. To date, batteries big enough to power a commercial airplane are too heavy. Nuclear powered aircraft present unacceptable risk to the flying public. And solar power has not proven to be feasible for commercial operation. Because of these limitations, and the limited supply of petroleum on Earth, it is in the interest of the aviation industry to find alternative jet fuels.

1.1. Financial Considerations

Biofuel offers the aviation industry the ability to diversity their fuel supply. As mentioned earlier jet fuel in use today is derived almost entirely from petroleum. Unfortunately, its supply is diminishing and its rising prices are highly volatile. In 2013 airline jet fuel costs are predicted to be over 12 billion dollars[1], this does not including costs due to carbon taxes. This poses a concern for airlines since jet fuel prices have a severe impact on their overall performance and has been the major cause in the upward trend in airfares. In fact, airlines are increasing their efforts in finding ways to mitigate jet fuel costs.

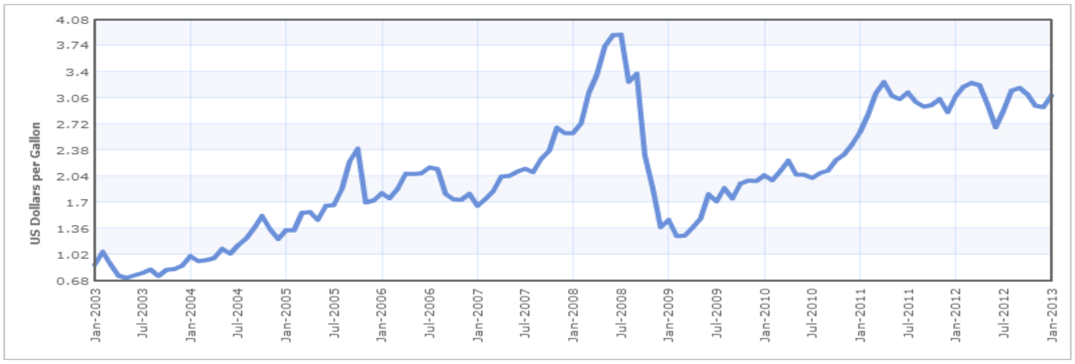

Figure 1. Jet fuel monthly prices for the past ten years.

Biofuels provide airlines with the opportunity to potentially reduce jet fuel prices along with their volatility by diversifying its supply and reducing the impact of carbon taxes. With biofuels airlines may also have the ability to enter into long-term supply contracts with potential producers to further decrease fuel price volatility.

Nevertheless, while biofuels have the potential to reduce airline costs by diversifying the market, they have a high startup cost. Supply of feedstock is currently limited due to limited demand and the technologies needed to store, transport, and turn feedstock into fuel is cost intensive. It is expected that if biofuels where to become an alternative jet fuel then as time progresses feedstock supply and technology would improve to reduce costs.

1.2. Environmental Considerations

The aviation industry can potentially reduce its environmental footprint by using alternative jet fuel. While the hope is that bio-based alternative jet fuel will reduce greenhouse-gas (GHG) emissions, it's possible these emissions may increase when accounting for emissions during the entire lifecycle of alternative jet fuel, including production, distribution and combustion of the fuel. Analyzing emissions through the entire supply chain is known as life-cycle analysis, and is important to obtain an accurate estimation of the environmental impacts of an alternative jet fuel project.

A reduction in greenhouse gas emissions has an immediately favorable impact on an airport's operations. Airports must comply with National Ambient Air Quality Standards (NAAQS), which are Environmental Protection Agency (EPA) standards for air throughout the United States. Airport operations planning, including air traffic patterns, ground operations, and airport capacity, are all affected by NAAQS. A reduction in greenhouse gas emissions means an increase in flexibility of airport operations.[2]

1.3. Drop-in Alternative Jet Fuels

Alternative jet fuels are fuels derived from an energy source, or “feedstock,” other than petroleum. These alternative sources can be non-petroleum fossil fuel feedstocks, such as coal or natural gas, and bio-based renewable feedstocks, such as plant or animal oils, crop residue and woody biomass. To create alternative jet fuel, synthetic kerosene would have to be created from these alternative feedstocks.

The biggest technical challenges in creating jet fuel from alternative feedstocks, is the alternative must be capable of replacing regular jet fuel without requiring new infrastructure. Infrastructure for aviation fuel includes everything from storage tanks and pipelines in the fuel supply chain to the fuel system that powers the engines on an aircraft. Requiring changes to existing aircraft fleets or fuel distribution networks would make alternative jet fuel practically infeasible. An alternative jet fuel capable of achieving this type of interoperability is known as a “drop-in” fuel.[3]

Drop-in alternative jet fuel must meet the same chemical specifications as conventional jet fuel. In the United States, the American Society for Testing and Materials (ATSM) has established these specifications for Jet A, which are described in ATSM Specification D1655.[4] Currently, there are two accepted methods that have been developed for creating the synthetic kerosene, which precipitates the creation of alternative jet fuel.

Fischer-Tropsch (FT) – A chemical process used to convert natural gas, coal, and biomass into liquid fuel. When applied for aviation purposes, it can be used to create Fischer-Tropsch Synthetic Paraffinic Kerosene (FT-SPK), an alternative jet fuel that can be blended with conventional jet fuel to meet ATSM Specification D1655, the U.S. standard for commercial jet fuel.[5]

Hydroprocessing – A process of refining plant oils and animal fats into liquid fuels. When applied for aviation purposes, it can be used to create Hydroprocessed Esters and Fatty Acids (HEFA), also referred to as Hydroprocessed Renewable Jet (HRJ), an alternative jet fuel that can be blended with conventional jet fuel to meet ATSM Specification D1655, the U.S. standard for commercial jet fuel.[6]

1.4. Jet Fuel Supply Chain

While these methods can create fuel very close to reaching ATSM Specification D1655, neither method has been able to achieve the entire specification on its own. Instead, conventional jet fuel must be mixed with the alternative jet fue to create a blended fuel that satisfies all requirements in ATSM Specification D1655. The fact that a stand-alone drop-in alternative jet fuel has yet to be invented is a key inhibitor to integrating alternative jet fuel into an airport's fuel supply chain. To date, the highest percentage of alternative jet fuel that has been approved in a blended fuel is 50%.[7]

Figure 1 below shows a conventional jet fuel supply chain. The fuel is made with petroleum-based kerosene at some offsite facility and transported to the airport fuel farm where it can be store nearly indefinitely.

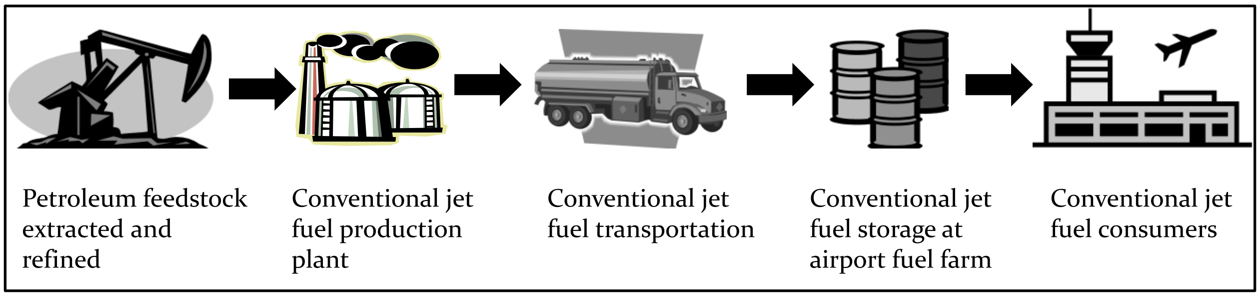

Figure 2. Conventional jet fuel supply chain from petroleum extraction to end user consumption.

Figure 2 shows how alternative jet fuel would be incorporated into the supply chain. Like jet fuel, the alternative fuel would be created at an offsite facility. But because it is not yet drop-in grade jet fuel, it must be transported using different infrastructure so as to not contaminate the conventional jet fuel. A blending facility must then be constructed near the airport fuel farm so the alternative and conventional fuels may be blended (While the blending does not have to occur at the airport fuel farm, it is a desirable location because it does not significantly disrupt the already existing conventional jet fuel supply chain and an airport is likely to already own the land where a blending facility would be built. Both of these aspects present significant cost savings.[8])

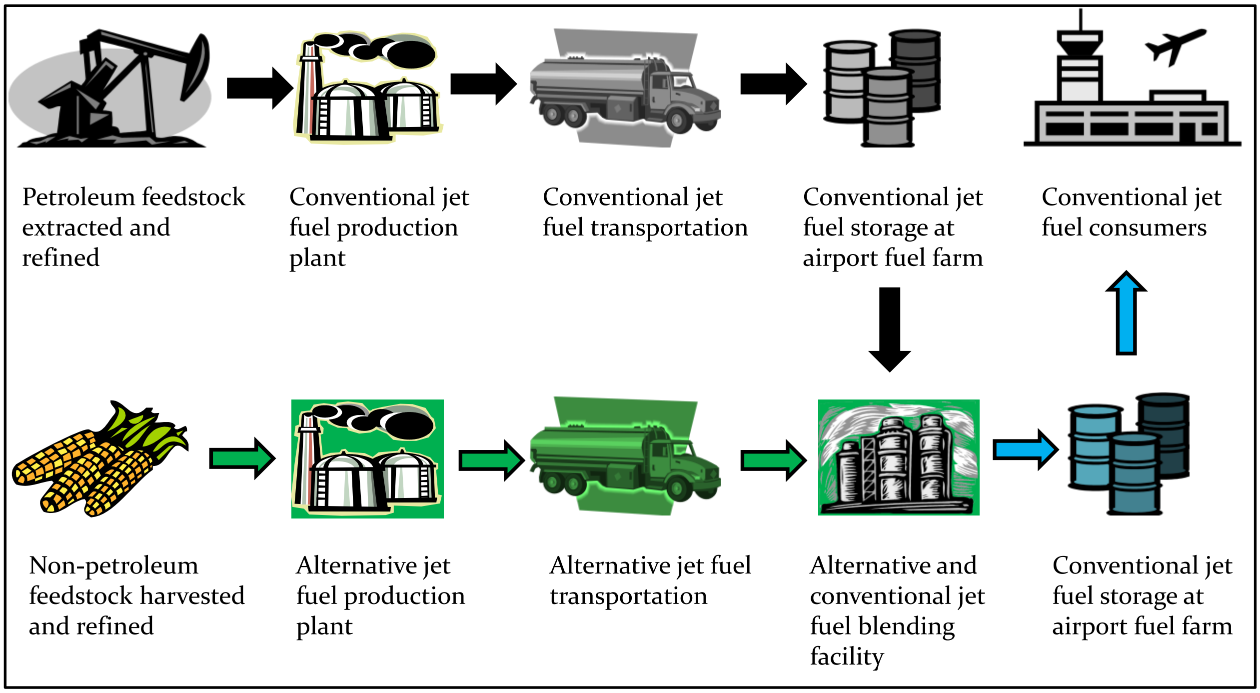

Figure 3. Bio-based alternative jet fuel supply chain from biomass harvestation to end user consumption.

1.5. Project Description

In 2012, the Airport Cooperative Research Program (ACRP), a collaborative aviation research initiative focused on improving airport competitiveness with innovative solutions, published a report titled, *ACRP 60: Guidelines for Integrating Alternative Jet Fuel into the Airport Setting*. This report outlines a framework for evaluating the feasibility of introducing alternative jet fuels into an airport's jet fuel supply chain. Considerations that are part of the framework include

- **Regulatory –** Alternative jet fuel projects should consider regulations in the following three categories:
    - FAA policies and regulations
    - Environmental reviews and permitting
    - Energy Policy
- **Environmental –** There are two potential environmental benefits that can be achieved from using alternative jet fuels, which can assist in selecting which feedstock and alternative jet fuel type should be used:
    - Reduced life-cycle GHG emissions (e.g., CO_2)
    - Reduced particulate emissions (e.g., $PM_{2.5}$)

- **Logisitical –** There are two primary logistical considerations when evaluating alternative jet fuel projects
    - Transportation and storage of feedstocks
    - Transportation and storage of the alternative jet fuel
- **Financial –** Financial considerations for an alternative jet fuel project include:
    - Price of conventional jet fuel
    - Project cost and profitability
    - Project financing

Metron Aviation, who co-authored *ACRP 60*, is interested in validating the report's evaluation framework. Manassas Municipal Airport (KHEF), a regional airport in Northern Virginia, is interested in learning about the logistical and economic implications with integrating alternative jet fuel into its fuel supply chain. These two entities are both important stakeholders for this project. Under the guidance of George Mason University's (GMU) Center for Air Transportation Systems Research (CATSR), the project sponsor and primary stakeholder, the research project team will use the *ACRP 60* method to assess alternative jet fuel integration at KHEF.

Using the information collected from stakeholders, the project will proceed by conducting a thorough analysis on the logistics of supplying biofuel. Included in the analysis will be supply chain costs, type and volume of biomass availability, and alternative pathways. Environmental impacts, stakeholder costs, benefits and opportunities engendered by supply chains will be measured using analytical models to determine the feasibility of substituting biofuels for jet fuel.

2. LITERATURE SEARCH

The team's literature review for this project include:

- Airport Cooperative Research Program (ACRP, http://www.trb.org/ACRP/ACRP.aspx), which developed the approach for evaluating alternative jet fuel projects.
- The Commercial Aviation Alternative Fuels Initiative (CAAFI, www.caafi.org), a coalition of U.S. government agencies, manufacturers, airlines, and airport organizations that promote alternative fuels.
- The Sustainable Aviation Fuel Users Group (SAFUG, www.safug.org), a coalition of airlines, manufacturers, and other organizations that promote alternative jet fuel.

- Federal Aviation Administration (FAA, www.faa.gov), aviation oversight authority in the United States

3. TECHNICAL APPROACH:

This project will follow the same framework defined in ACRP 60. A summary of the process is illustrated in Figure 4.

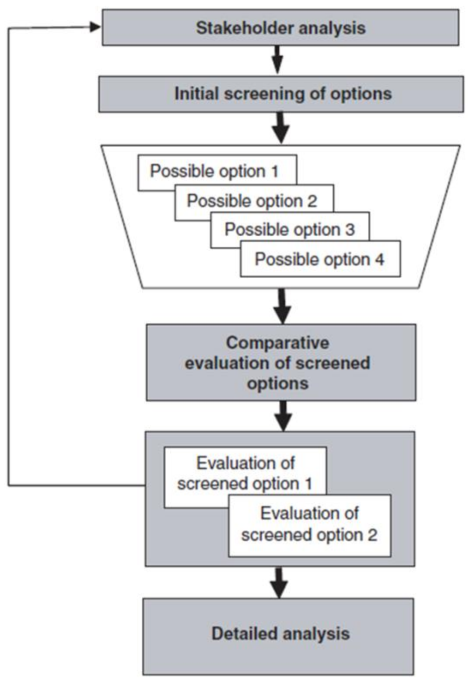

Figure 4. Framework for integrating alternative fuel[9]

3.1. Stakeholder Analysis

During this phase the report will evaluate:

- What stakeholders need to participate in the alternative jet fuel project?
- How the interests of stakeholders can be identified?

A survey will be conducted using a questionnaire that addresses potential requirements of each stakeholder in this project and determine whether or not the project meets those needs.

3.2. Formulating the options and performing an initial screening

Given the large number of possible feedstock and technology combinations, the report will focus on determining a reasonable number of options for this study. The location of the processing facility and investment time horizon will provide the initial screening.

The initial screening of possible biofuel suppliers will continue by assessing supplier feedstock and technology, as shown in Figure 5. This includes the availability of feedstock, airport proximity to feedstock, availability of technology, and compatibility of technology with feedstock.

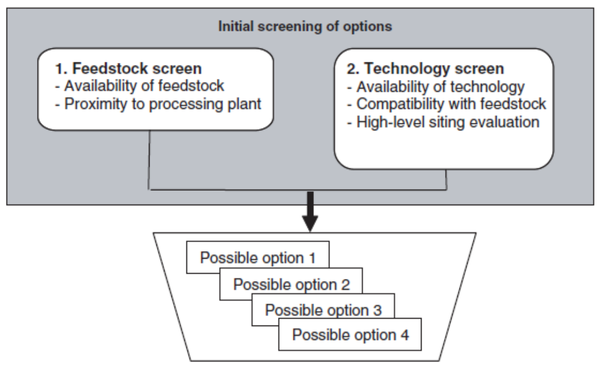

Figure 5. Initial screening of options[10]

3.3. Conducting a comparative evaluation

The study will evaluate the options identified in initial screening based on four categories including regulatory, environmental, logistical, and financial (the last two categories are the focus of this project). The project will closely follow worksheets provided by the ACRP 60 report to provide guidance regarding how well each alternative fuel option meets the requirements of a specific category.

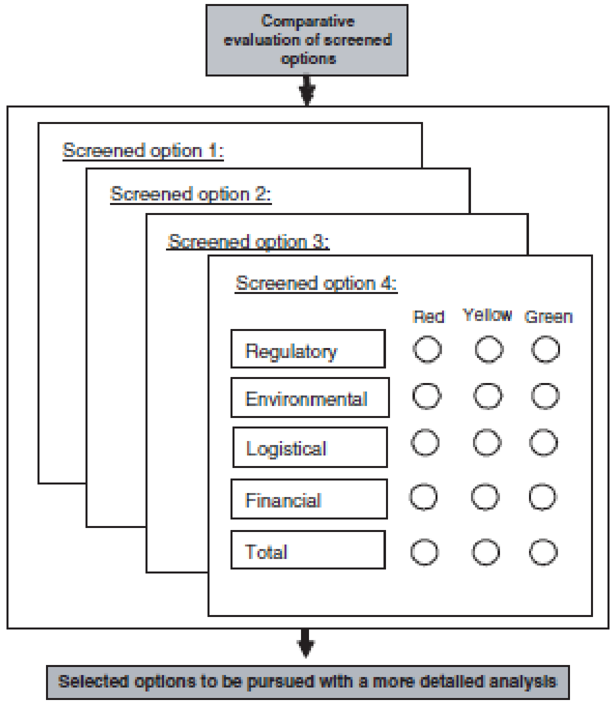

Figure 6. Comparative evaluation of different options[11]

3.4. Detailed Analysis

Jet fuel is supplied to Manassas's airport via trucks coming once or twice a week to the fuel farm that consists of nine storage tanks. For every tank at most eighty percent of the tank's storage capacity can be used to store fuel because of safety regulations. Fuel is purchased and sold to airplane owners through Manassas's Fixed Based Operator (FBO). Airplane owner's fuel charges are based on the costs incurred by the FBO in supplying the fuel. Manassas itself does not incur jet fuel costs. Furthermore, meetings with Manassas airport have indicated that they are not interested in growing biofuel feedstock. Nevertheless, the airport may be interested in building a blending facility to blend biofuel and jet A to create drop-in biofuel if the facility could be funded by the federal government. Thus, it must be the case that any biofuel at Manassas airport would be supplied through trucks and stored among the 9 storage tanks in the fuel farm. The question of interest here is whether the FBO should purchase drop-in blended biofuel from a supplier or should the airport build a blending facility and have the FBO purchase biofuel that will be blended at the airport. The goal is to not to entirely replace conventional jet fuel with biofuel but to determine how much of the existing fuel supply can be replaced with biofuel and estimate the costs resulting from such an action.

For each supplier that can provide drop-in ready biofuel and makes it through the initial screening process mentioned in sections 3.2 and 3.3, an inventory model will be formulated to determine an ordering policy for that supplier. This policy will determine the costs the FBO would undertake if they were to obtain drop-in biofuels. The assumption will be made that the fuel costs of an airplane owner will be about one percent higher per gallon than the costs the FBO receives from supplying a gallon of jet fuel.

The inventory model will resemble an Economic Order-Quantity (EOQ) model. However, demand and fuel costs will be stochastic. As such, a simulation model will be used to estimate an ordering policy. Demand and costs will be determined using an autoregressive moving average model based on monthly fuel flowage data provided by the Manassas airport and national reports on jet fuel prices per gallon.

The models built for suppliers that can provide drop-in ready biofuel will be compared against a similar inventory models that assumes the airport has a built blending facility. Biofuel suppliers will no longer be the ones that can provide blended drop-in biofuel but will be suppliers that can provide biofuel that can be blended at the airport. The model will assume that most of the blending facility's construction costs will be funded by the federal government. How much of the costs will be funded by the government will be revealed in the initial screening process of the report. The models will be compared on how well the FBO's costs are mitigated in each supply chain.

Finally using the models built for the supply chains and using historical jet fuel pricing trends the project will determine the cost of drop-in biofuel for airplane owners, the FBO's cost of supplying biofuel, and when the biofuel becomes cost feasible for the FBO and the airplane owners.

4. PROJECT MANAGEMENT

4.1. Work Breakdown Structure

Figure 7 below illustrates the Work Breakdown Structure that will be used manage project tasks.

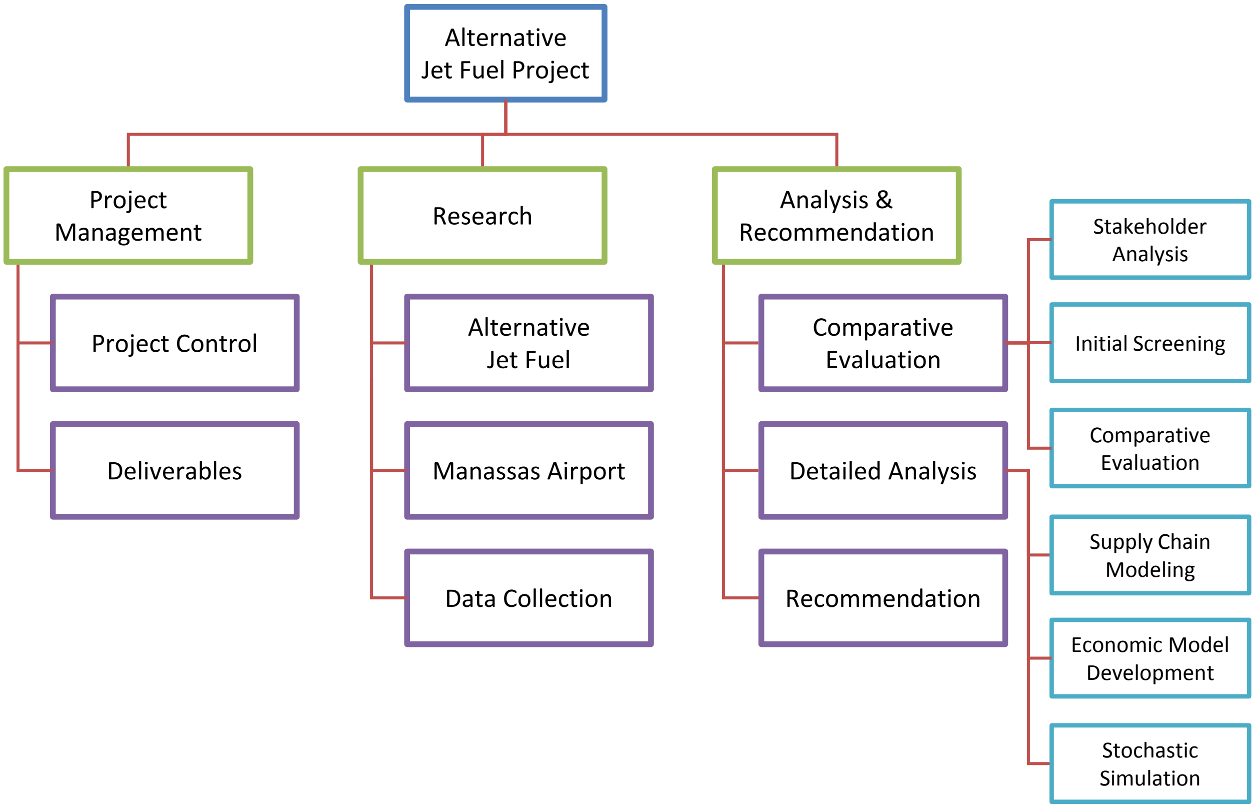

Figure 7. Work Breakdown Structure for the Alternative Jet Fuel Team.

4.2. Schedule

Table 1. Master Schedule for the Alternative Jet Fuel Project

	Week1	Week2	Week3	Week4	Week5	Week6	Week7	Week8	Week9	Week10	Week11	Week12	Week13	Week14	Week15
Alternative Jet Fuel Project	Feb.3	Feb.10	Feb.17	Feb.24	Mar.3	Mar.10	Mar.17	Mar.24	Mar.31	Apr.7	Apr.14	Apr.21	Apr.28	May.5	May.10
1. Project Management															
1.1 Project Control															
1.1.1 Meetings (Team, Sponsors & Stakeholders)	√	√ / √	√ / √	√	√ / √	√	√ / √	√	√	√	√ / √	√	√	√ / √	√
1.1.2 Allocate Tasks	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
1.2 Deliverables															
1.2.1 Proposal															
1.2.2 Status Report															
1.2.3 In Progress Review Presentation/Website															
1.2.4 Final Report															
1.2.5 Final Presentation															
2. Research															
2.1 Alternative Jet Fuel															
2.1.1 Background															
2.1.2 Possible Alternative Jet Fuel & Technology															
2.1.3 Alternative Jet Fuel Suppliers															
2.2 Manassas Airport															
2.2.1 Background															
2.2.2 Jet Fuel Supply Chain															
2.2.3 Traffic & Fuel Consumption															
2.3 Data Collection															
3. Analysis & Recommendation															
3.1 Comparative Evaluation															
3.1.1 Stakeholder Analysis															
3.1.2 Initial Screening															
3.1.3 Comparative Evaluation															
3.2 Detailed Analysis															
3.2.1 Supply Chain Modeling															
3.2.2 Economic Model Development															
3.2.3 Stochastic Simulation															
3.3 Recommendation															

4.3. Project Risk

Schedule creep and scope creep present the highest risk to the successful completion of this project. With multiple stakeholders to manage, the team will need to proactively avoid broadening the scope on stakeholder requests, or delaying project milestones while waiting for stakeholder review. To mitigate these concerns, the team will focus on meeting the needs of our primary stakeholder, GMU's Center for Air Transportation Systems Research (CASTR), while meeting the needs of our secondary stakeholders, Metron Aviation and Manassas Municipal Airport, only as they align with that of primary stakeholder.

4.4. Summary

The problem we're trying to solve with this project is how to integrate biofuel into the existing jet fuel supply chain at Manassas Municipal Airport in Manassas, VA. The primary feature that must be achieved with biofuel is that it be drop-in ready. While technology exists for creating drop-in biofuel, out contribution will be studying the technology and recommending the best method for Manassas Municipal Airport. We will research feasible options for attaining the biofuel, and then study the impacts of achieving drop-in grade jet fuel by blending the biofuel on the airport property or blending at an offsite location.

The project will be complete when the final report is delivered, including the following information:

- Complete assessment of alternative jet fuel options for KHEF using the ACRP 60 method
    - Will include recommendations and lessons learned using the ACRP 60 approach
- Model of logistics and technical feasibility of drop-in bio jet fuels at KHEF (how would it work, what new infrastructure/procedure is required).
- Model of economic feasibility. Will include:
    - Model of demand/supply will be developed and used to determine feasibility in presence of increasing fossil fuel prices
    - Breakeven for infrastructure costs.

We will seek concurrence on these deliverables from appropriate stakeholders two weeks before delivery of the final report. This will allow one week for stakeholder review and one week for incorporation of stakeholder comments.

[1] http://www.iata.org/publications/economics/fuel-monitor/Pages/price-analysis.aspx
[2] http://www.faa.gov/airports/environmental/environmental_desk_ref/media/desk_ref_chap1.pdf
[3] http://www.faa.gov/airports/environmental/environmental_desk_ref/media/desk_ref_chap1.pdf
[4] http://www.caafi.org/resources/glossary.html
[5] http://www.eaa.org/autofuel/jetfuel/d1655_specs.asp
[6] http://renewablejetfuels.org/what-we-do/the-basics#terminology
[7] http://renewablejetfuels.org/what-we-do/the-basics#terminology
[8] ACRP Report 60: *Guidelines for Integrating Alternative Jet Fuel into the Airport Setting*, Section 2.1
[9] ACRP Report 60: *Guidelines for Integrating Alternative Jet Fuel into the Airport Setting*, Section 5.2.2
[10] ACRP Report 60: *Guidelines for Integrating Alternative Jet Fuel into the Airport Setting*, Figure 3
[11] ACRP Report 60: *Guidelines for Integrating Alternative Jet Fuel into the Airport Setting*, Figure 4
[12] ACRP Report 60: *Guidelines for Integrating Alternative Jet Fuel into the Airport Setting*, Figure 5