Environment and Natural Resources Trust Fund
2020 Request for Proposals (RFP)

Project Title: **ENRTF ID: 202-EH**

Modelling PAH Emissions from Aircraft Surrounding MSP Neighborhoods

Category: H. Proposals seeking $200,000 or less in funding

Sub-Category: E. Air Quality, Climate Change, and Renewable Energy

Total Project Budget: $ 96,400

Proposed Project Time Period for the Funding Requested: June 30, 2022 (2 yrs)

Summary:

Use commercially available software (AEDT) to model emissions of polycyclic aromatic hydrocarbons and other air toxic gases from aircraft in areas surrounding MSP. Disseminate to public. Put results into context.

Name: Jacob Swanson

Sponsoring Organization: Minnesota State University Mankato

Job Title: Professor

Department: College of Science Engineering and Technology

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Bloomington MN 55431

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Location:

Region: Metro

County Name: Carver, Dakota, Hennepin, Ramsey, Scott

City / Township: Bloomington

Alternate Text for Visual:

Maps showing aircraft traffic data, different emissions, tool used to model emissions (AEDT), and end result - map of emissions near MSP

_____ Funding Priorities	_____ Multiple Benefits	_____ Outcomes	_____ Knowledge Base
_____ Extent of Impact	_____ Innovation	_____ Scientific/Tech Basis	_____ Urgency
_____ Capacity Readiness	_____ Leverage	_____ TOTAL	_____%

PROJECT TITLE: Modelling polycyclic aromatic hydrocarbon (PAH) emissions from aircraft surrounding MSP

I. PROJECT STATEMENT

Pollution from aircraft adversely effects human health by increasing mortality rates, exacerbating respiratory problems for at risk populations such as the young and elderly, and possibly accelerating degenerative diseases like Alzheimer's and Parkinson's. Minnesota generally has good air quality but there is no "zero threshold" for health effects; for example, adverse health effects from carbon monoxide (CO) exposure occur at levels far below the existing EPA mandates. Of particular importance is polycyclic aromatic hydrocarbons or PAHs. Human exposure to PAHs is linked with cancer, cardiovascular disease, and poor fetal development. The MSP airport operates thousands of commercial aircraft flights daily, with typical take-off flight paths cutting through South Minneapolis, Edina, and Richfield neighborhoods, resulting in increased levels of noise and exhaust pollution for residents. While noise pollution mitigation techniques have been enacted in these neighborhoods, air pollution is more difficult to address. The Minnesota Pollution Control Agency (MPCA) currently operates 26 air quality monitoring sites in the metropolitan area but there is *only one within approximately 10 miles of the MSP airport.* Determining spatially and temporally resolved air quality is difficult due to the relatively high cost of a single instrument that can accurately measure these pollutants so that measuring the effects of aircraft traffic on local air quality is not possible with current tools. The best solution for moving forward in understanding the magnitude of the problem is to model the emissions with software.

We seek to use commercially available software to model emissions of polycyclic aromatic hydrocarbons (PAH) and other air toxic gases from aircraft in areas surrounding MSP. This work will leverage government (FAA) developed, commercially available software called *Aviation Environmental Design Tool (AEDT)*. In brief, "AEDT is a software system that dynamically models aircraft performance in space and time to produce fuel burn, emissions and noise. Full flight gate-to-gate analyses are possible for study sizes ranging from a single flight at an airport to scenarios at the regional, national, and global levels. AEDT is currently used by the U.S. government to consider the interdependencies between aircraft-related fuel burn, noise and emissions".[1] Specifically we will focus on the following compounds that consist of PAHs and other important air toxics or hazardous air pollutants (HAPs): 1,2,3; 1,2,4; 1,3,5-trimethylbenzene,1,3-butadiene, 1-methyl naphthalene, 2-methyl-naphthalene, acetaldehyde, benzaldehyde, benzene, dimethylnapthalenes, ethylbenzene, formaldehyde, isopropylbenzene, naphthalene. These represent some of the most hazardous gas phase emissions from aircraft and approximately 22% of their total volatile organic carbon (VOC) gas phase emissions. The primary outcome of this work is accurate, temporally and spatially resolved, air quality model results that will allow stakeholders to make informed decisions about aircraft flight patterns and housing choices that preserve, protect, and improve local air quality and/or reduce PAH exposure. Results would also provide guidance on the advantages and consequences of the densification of aircraft take-off and landing routes. Analyses will provide insight into what changes should be implemented, if any, to preserve, protect, and improve local air quality.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1 Title: Model development
Description: *Preparation, procure all software and hardware required, training, determine and finalize emissions factors to convert VOCs into speciated organic gases*

ENRTF BUDGET: $10,000

Outcome	Completion Date
1. All hardware and software for modeling activity 2 is procured	*Sept, 2020*

[1]https://www.faa.gov/about/office_org/headquarters_offices/apl/research/models/aedt/

1. All information needed to run accurate models	*Dec, 2020*

Activity 2 Title: Modeling
Description: *Use AEDT software to model emissions of PAHs and air toxics as a function of weather, season, location, air patterns (dispersion of plume), etc*

ENRTF BUDGET: $56,400

Outcome	Completion Date
1. Maps showing modeled concentrations of PAHs and air toxics as a function of weather, season, location, air patterns (dispersion of plume), etc. We expect about 50 cases to be evaluated and presented	*Dec, 2021*

Activity 3 Title: Context and dissemination
Description: Review literature and analysis to put emissions levels in context with 1) concentrations that are health-relevant, 2) emissions due to other sources (vehicle traffic). Emissions maps (activity 3) will be shared with stakeholders in the following ways 1) submitted to http://mspfairskies.com/ for posting online, 2) published in peer-reviewed literature, 3) presented to residents in a public forum tbd.

ENRTF BUDGET: $20,000

Outcome	Completion Date
1. Literature that put emissions levels in context	*Sept, 2021*
2. Peer-reviewed paper, knowledgeable stakeholders	*Sept, 2021*
3. Knowledge of what appropriate actions, if any, are required to reduce the impact of air pollution on residents in neighborhoods surrounding MSP to acceptable levels	*Sept, 2021*

III. PROJECT PARTNERS AND COLLABORATORS:
The project will be led by Prof. Jacob Swanson of Minnesota State University, Mankato and a small team of undergraduate engineering students. Prof. Swanson is internationally recognized for his work on emissions from engine combustion engines, including those from gas turbines. Activity 3 dissemination activities will be assisted by the City of Minneapolis' air quality analysts.

IV. LONG-TERM IMPLEMENTATION AND FUNDING:
We will seek continuation funding so that model results can be expanded to other pollutants of interest (e.g. NO, NO2, PM, etc). In parallel with this work, a proposal will be submitted to a FAA grant proposal under FAA-12-01 – Chapter I. FAA Research Grants Program, Technical Areas of Research #7. The proposal will support extension of our work. Additional funding will allow for some model validation with the two nearest air quality modeling stations and perhaps with historical results since flight paths are archived. Ultimately, this software is also capable of noise modeling which could possible support concerns about the existing noise thresholds used, the metrics reported, and the independency of the results. Data, models, and lessons learned will increase opportunities for successfully procuring this additional funding.

This project will take two years to complete We are planning for six months of set-up and purchasing, one year of gathering data, and six months to compile data and disseminate data.

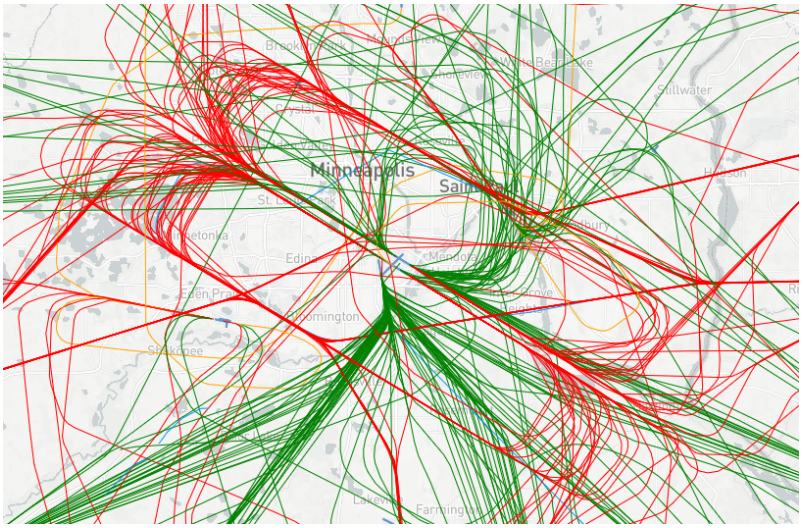
Attachment A: Project Budget Spreadsheet
Environment and Natural Resources Trust Fund
M.L. 2020 Budget Spreadsheet
Legal Citation:
Project Manager: Prof. Jacob Swanson
Project Title: Modelling polycyclic aromatic hydrocarbon (PAH) emissions from aircraft surrounding MSP
Organization: Minnesota State University Mankato
Project Budget: $96,400
Project Length and Completion Date: Sept, 2021
Today's Date: 4/13/2019

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Budget	Amount Spent	Balance
BUDGET ITEM			
Personnel (Wages and Benefits)	$ -	$ -	$ -
Prof. Jacob Swanson, Project Manager, (82% salary, 18% benefits); 21% FTE for 1.5 years	$ 46,400		
3 Undergraduate Research Assistants (92% salary, 8% benefits, $13/hr); 100% FTE for 1.5 years	$ 40,000		
Professional/Technical/Service Contracts			
	$ -	$ -	$ -
Equipment/Tools/Supplies			
AEDT modeling software and special computers to run models, hard drive for storage	$ 10,000	$ -	$ 10,000
Capital Expenditures Over $5,000			
None of line 20 individually is >$5k.	$ -	$ -	$ -
Fee Title Acquisition			
	$ -	$ -	$ -
Easement Acquisition			
	$ -	$ -	$ -
Professional Services for Acquisition			
	$ -	$ -	$ -
Printing			
	$ -	$ -	$ -
Travel expenses in Minnesota			
	$ -	$ -	$ -
Other			
	$ -	$ -	$ -
COLUMN TOTAL	$ 96,400	$ -	$ 10,000

SOURCE AND USE OF OTHER FUNDS CONTRIBUTED TO THE PROJECT	Status (secured or pending)	Budget	Spent	Balance
Non-State: Expect to submit FAA grant proposal under FAA-12-01 – Chapter I. FAA Research Grants Program, Technical Areas of Research #7	Pending	$ -	$ -	$ -
State: Minnesota State University Mankato overhead waiver	Secured	$ -	$ -	$ -
In kind: Assistance from City of Minneapolis with information dissemination	Secured	$ -	$ -	$ -

Other ENRTF APPROPRIATIONS AWARDED IN THE LAST SIX YEARS	Amount legally obligated but not yet spent	Budget	Spent	Balance
		$ -	$ -	$ -

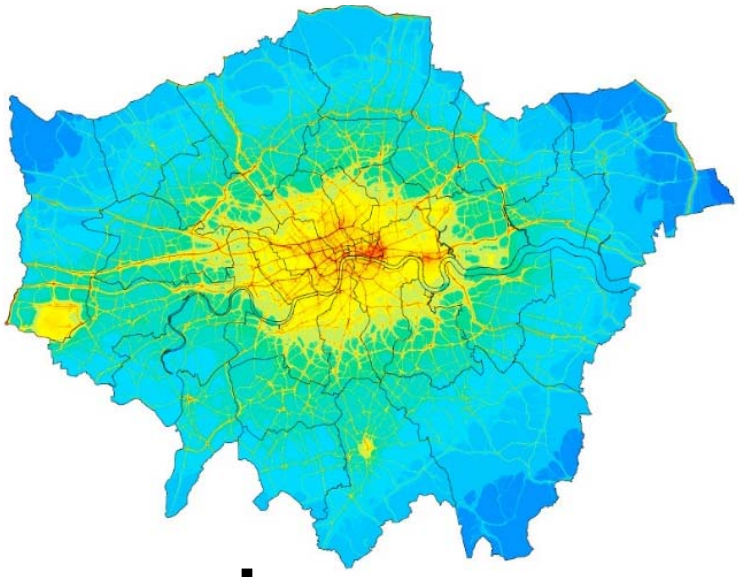
MSP aircraft traffic data



PAH and toxic air emissions considered

Formaldehyde
Acetaldehyde
Benzenes
1,3-butadiene
Naphthalenes

Map of modeled air toxic concentrations



Aviation Environmental Design Tool (AEDT) modeling software

Analysis

Data to make informed decisions about aircraft flight patterns and housing choices that preserve, protect, and improve local air quality and/or reduce PAH exposure

I. PROJECT MANAGER QUALIFICATIONS

Dr. Jacob Swanson is an Associate Professor of Engineering in the **Twin Cities Engineering Program** in the Department of Integrated Engineering at Minnesota State University Mankato. He is also an Adjunct Associate Professor in the Department of Mechanical Engineering (ME) at the University of Minnesota. He was previously a Research Associate in the Department of Engineering at the University of Cambridge, UK and before that, a graduate of UMN's Mechanical Engineering Department. Prof. Swanson is internationally recognized for his work on emissions from engine combustion engines, including those from gas turbines. He has published 39 papers and given more than 80 conference presentations on these topics. He is currently advising about 25 students as part of his ENGR Design course. He has 3-4 other external projects supporting about eight undergraduate students. He annually supports, by co-advising, on average 1-2 graduate students in the Particle Technology Laboratory and Engine Research Labs at the University of Minnesota. **He is a recognized expert in the fields of air quality and aircraft emissions.** His specific experience, as related to aircraft, includes a significant amount of real world, field experience measuring aircraft emissions all over the world:

- Participated in previous LCCMR-funded air quality monitoring project
- Participated in UK "SAMPLE" campaigns in the United Kingdom (UK) and Switzerland aimed at determining a methodology for measuring aircraft gas turbine particulate matter
- Operation of the Cambridge Intermediate Pressure Gas Turbine Combustion (CIPCF) facility (supported by Rolls Royce) at the University of Cambridge
- Participation in US EPA "VARIAnTII" "VARIAnTIV" sample campaigns in Tennessee and Minnesota that were also aimed at determining a methodology for measured aircraft gas turbine particulate matter.

II. ORGANIZATIONAL DESCRIPTION

Twin Cities Engineering (TCE) is a program of the Department of Integrated Engineering of Minnesota State University, Mankato. TCE has the purpose of expanding the pool of qualified engineers in the Twin Cities Metro area by establishing an affordable, accessible, and unique option for the region's engineering students. TCE offers an inclusive and innovative learning experience that has attracted non-traditional students and veterans at a higher rate than traditional students. The BSE degree program includes several features that differentiates it from traditional engineering degree programs. TCE addresses the entire learning experience and not simply one component of the curriculum. Five features, designed to produce desired attributes in BSE graduates, are as follows.

- Trans-disciplinary thinking
- Industry-sponsored, project-based-learning
- Experiential learning in context
- Competency-based assessments
- Significant exposure to professionalism, design, creativity, and innovation