U.S. Department of Transportation
Federal Aviation Administration

FINAL PROJECT REPORT

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PART I - PROJECT IDENTIFICATION INFORMATION

1. Institution and Address	2. FAA Program	3. FAA Award Number
University of Illinois at Urbana-Champaign	Air Transportation COE, AJFE	13-C-AJFE-UI-006
1901 S. First Street, Suite A Champaign, IL 61820-7406	4. Award Period From 12/16/14 To 11/30/15	5. Cumulative Award Amount $15,000

6. Project Title

Overall Program Integration and Analysis, Area #7

PART II - SUMMARY OF COMPLETED PROJECT (For Public Use)

The focus of this work is to integrate the efforts of the six areas in the ASCENT COE National Jet Fuel Combustion Program (NJFCP), ensuring that the goals outlined in its agenda are achieved through synergistic and interactive collaboration between the groups. The Area #7 team, with the guidance of the NJFCP Steering Committee, integrated the research efforts of the individual teams, incorporated and disseminated feedback from industrial and governmental partners, and provided critical data analysis and recommendations. The activities of Area #7 encompassed (1) integration of team efforts in the NJFCP, (2) dissemination of information, (3) analysis of data and computational results, (4) communication between teams, (5) coordination and reporting, (6) overview of publications, and (4) providing recommendation for future research directions. This award (University of Illinois) particularly focused on the following three tasks in this effort.

- Integration and dissemination of NJFCP test data through an alternative fuels database
- Analyze experimental data in NJFCP. Dr. Lee will focus on laser and optical diagnostics efforts
- Coordination of laser diagnostics effort for both Areas #3 and #6 in the combustion program

PART III - TECHNICAL INFORMATION (For Program Management Uses)

1. **ITEM** (Check appropriate blocks)	NONE	ATTACHED	PREVIOUSLY FURNISHED	TO BE FURNISHED SEPARATELY TO PROGRAM	
				Check (X)	Approx. Date
a. Abstracts of Theses	✘				
b. Publication Citations	✘				
c. Data on Scientific Collaborators	✘				
d. Information on Inventions	✘				
e. Technical Description of Project and Results					
f. Other (specify)					

2. Principal Investigator/Project Director Name (Typed)	3. Principal Investigator / Project Director Signature	4. Date
		2/1/2016

FAA Form 9550-5 (03-03) Supersedes Previous Edition

Project 034
National Jet Fuels Combustion Program – Overall Program Integration and Analysis, Area #7

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*this report covers portion of University of Illinois

Project Lead Investigator

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University Participants

University of Illinois at Urbana-Champaign

- P.I.(s): Tonghun Lee, Associate Professor
- FAA Award Number: 13-C-AJFE-UI-006
- Period of Performance: 12/16/2014 to 11/30/2015
- Task(s):
    1. Compilation of test data and review of laser diagnostics plan.

Project Funding Level

Funding Level: $15K
Cost Share: In-kind academic time of the PI, Partial support for student Research Assistantship

Investigation Team

- Kyungwook Min (Graduate Student, University of Illinois at Urbana-Champaign): Compilation of fuel test data.
- Anna Oldani (Graduate Student, University of Illinois at Urbana-Champaign): Compilation of fuel test data and analysis of laser diagnostics.

Project Overview

The scope of work in this proposal is collaborate with UDRI, AFRL, FAA, and the National Jet Fuel Combustion Program (NJFCP) steering committee in the program to ensure that close integration is carried out in the NJFCP program. This will involve working closely with the university research teams, engine manufacturers, federal government researchers, and NRC Canada to perform detailed comparative analyses of modeled and measured data. In particular, University of Illinois will focus its effort on integration of overall test data in the NJFCP and to ensure that laser and optical measurements in the NJFCP program are carefully monitored and guided by a mutual committee.

Task 1 – Compilation of Test Data and Review of Laser Diagnostics Plan

University of Illinois at Urbana-Champaign

Objective(s)

The focus of the proposed study is to integrate the efforts of the six areas in the ASCENT COE National Jet Fuel Combustion Program (NJFCP), ensuring that the goals outlined in its agenda are achieved through synergistic and interactive collaboration between the groups. The Area #7 team, with the guidance of the NJFCP Steering Committee, will not only integrate the research efforts of the individual teams, but also incorporate and disseminate feedback from industrial and governmental partners, and provide critical data analysis and recommendations. The activities of Area #7 encompass (1) integration of team efforts in the NJFCP, (2) dissemination of information, (3) analysis of data and computational results, (4) communication between teams, (5) coordination and reporting, (6) overview of publications, and (4) providing recommendation for future research directions. Dr. Tonghun Lee at the University of Illinois which will be focused on the following three activities:

- Integration and dissemination of NJFCP test data through an alternative fuels database
- Analyze experimental data in NJFCP. Dr. Lee will focus on laser and optical diagnostics efforts
- Coordination of laser diagnostics effort for both Areas #3 and #6 in the combustion program

Research Approach

Integration and Dissemination of NJFCP Data through Database

The PI will ensure that the data generated through the NJFCP program is integrated with proper reporting format (guidance from NIST) and disseminated efficiently through a shared archive and ultimately distributed to the wider academic community as well as industry through a standardized database. There is an effort in the FAA COE for development of a standard database (Project 33, led by Dr. Tonghun Lee) in collaboration with NIST and AFRL. We will ensure that data can be compiled, standardized, and disseminated within a cyber-based infrastructure through this project. For the first year of the project, we will work to figure out the initial type of data that will be generated by the teams and prioritize them according to the critical requirements of the NJFCP. We will work closely with Dr. Tim Edwards (AFRL), Dr. Pam Chu (NIST), and Dr. Mike Kweon (ARL) in this effort.

Analysis of Experimental Data and Coordination of Diagnostics Effort

As part of Area #7, Dr. Lee will assume a leadership role in analysis of experimental data with a focus in standardizing diagnostics data that are (1) of high fidelity, and (2) relevant to the numerical simulation tasks outline in other areas of the NJCFP. Central to the diagnostics efforts is the referee combustor tests that will be carried out by UDRI and Dr. Lee at Wright Patterson Air Force Base and the advanced combustor tests (Area #3) to be carried out at GATech. Most importantly, Dr. Lee will be responsible for coordinating a committee to ensure that diagnostics direction and data mining are mutually agreed upon by both modeling and experimental PIs in the program. The committee will convene monthly to make sure that things stay on track

Milestone(s)

Milestones from Each Period

Proposed (3 Month): At the 3 month mark, we will outline a roadmap that shows a solid integration of the teams and set forth a template of deliverables from each team. Preliminary integration of the efforts with the FAA database will also take place during this time.
Achieved: Set up a subcommittee for laser and optical diagnostics with participation from modeling and experimental PIs in the program. Set up a data collection protocol for the NJFCP PIs

Proposed (6 Month): At the 6 month mark, a standard for integration of the data should be in place for the NJCFP and an initial review of the experimental setup for each Area will take place. The focus of the experimental setup will be to ensure that all teams are focused on experimental conditions and diagnostics that can be synergistically integrated down the road. Any problems will be identified and corrected at this phase.
Achieved: A careful review of the experimental efforts were made for both Areas #3 and #6. Visit were made to both GATech and AFRL to prioritize the diagnostics plan and experimental techniques. A concept of the fuels test database was established to integrate data from the NJFCP.

Proposed (9 Month): At the 9 month mark, the analysis of the experimental efforts should be completed and the focus will

shift towards experimental data generation. The PI will analyze efforts by individual teams to provide data with a focus on laser and optical measurements being deployed in each setup. We will also work closely with the numerical simulation and modeling teams to ensure that the data being generated can be fully coupled and utilized for development of a comprehensive combustion model.

Achieved: At this point, the subcommittee on diagnostics has prioritized efforts and preliminary measurements have been made. Shakedown measurements have yielded data which have been carefully scrutinized by both the experimental PIs and modeling PIs to ensure agreement. The construction of the test database has commenced where the NJFCP data will have its own space. The PIs have also submitted their first round of data from the NJFCP program.

Proposed (12 Month): At the 12 month mark, a solid integration plan should be in place with specific details on the integration efforts and a clear understanding of each Area's roles in the overall efforts. A set of deliverables will be sent to each individual Area and an evaluation matrix should be implemented. Near the end of year one, we will provide a report outlining these issues, as well as plans for reporting and dissemination of data and recommendations for future years in the NJCFP program.

Achieved: The PIs in the NJFCP program have submitted their second round of data and we have established that data should be collected every quarter (initially through KSN but through the actual database in the future). The subcommittee on laser diagnostics has also yielded fruitful changes in the NJFCP program resulting in more optimized directions in the program. In particular, we have adjusted diagnostics plans in Area #6 of the program to ensure that more time is allocated to fuel screening in the referee combustor.

Major Accomplishments

The first task that was accomplished was that we have started to gather, archive, and analyze data that is being generated by the NJFCP. Near the second half of year I, the PIs were asked to submit data that is generated from the NJFCP to the KSN website every quarter. The data will be organized and archived on a web portal that is being created as part of Project 33 (Alternative Jet Fuels Test Database) of ASCENT. The data will be displayed separately as NJFCP data under its own heading along with other relevant information specific to the fuels and test being executed in the NJFCP (fuel specs, etc.). The data in itself will of course benefit the NJFCP efforts but we believe that we will also contribute to establishing a foundational database that can be referenced for similar efforts in the future. A screenshot of the NJFCP part of the test database is shown in Figure 1.

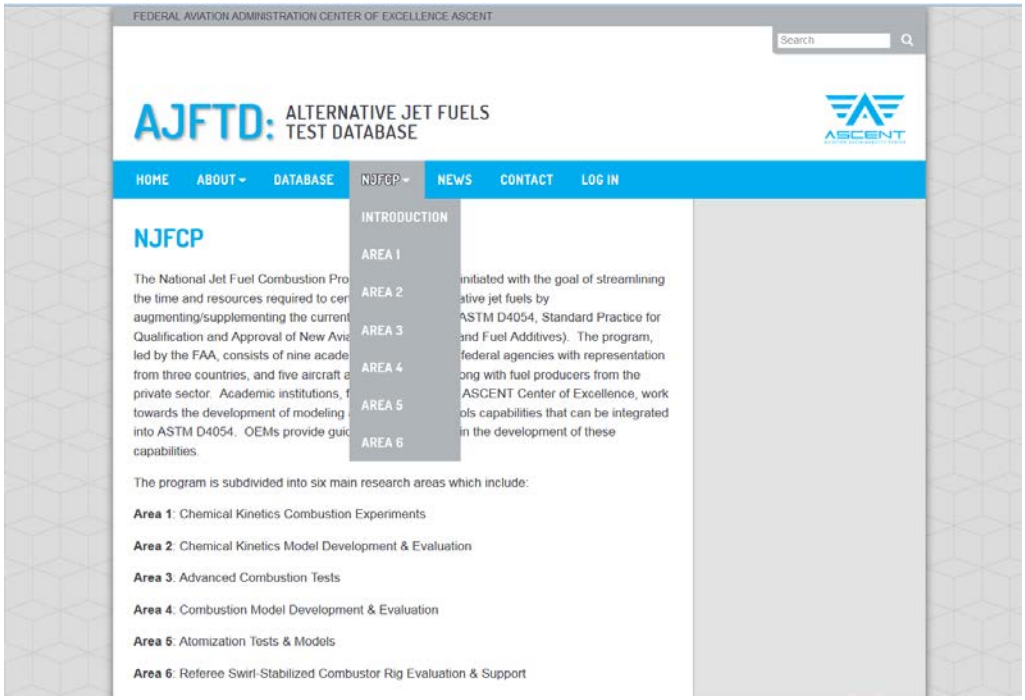

Figure 1 NJFCP section in the ASCENT fuels test database

The second task that was accomplished was the establishment of the diagnostics subcommittee to ensure that the detailed diagnostics efforts in the NJFCP are carefully coordinated between the different areas. The subcommittee has been (1) making sure that the data collected is carefully scrutinized and the best possible quantification is carried out, and (2) continually adjusting and prioritizing the diagnostics effort through discussion. In year I, the diagnostics subcommittee (led by Tonghun Lee) convened every month to ensure that the diagnostics methods being carried out were in line with the requirements of the modeling needs and that the limited resources were bring used in the best possible way. This effort will continue in Year II for both Areas 3 and 6. We have also established a standard data collection protocol which are listed below.

Data Collection Protocol

The goals of the proposed data protocol are to:

- ensure data can be shared among project members without confusion,
- limit the need for clarification communications,
- allow data and metadata to be accessible by scripts,
- and keep the effort required to share data to a minimum.

DATA PACKAGE

A data package is a zipped folder (Area X.zip) containing a data set which may include:

- matrices;
- images;
- scripts, macros, and executables;
- txt file that contains description of data and other useful notes

A data package must have a corresponding text (.txt) file with the file name matching the data folder name. This file contains a brief set of metadata. It should be outside of the data folder so it can be easily viewed. It contains the following, with each item on a new line:

package name: This should be human readable and match the data package folder name exactly.
date created: Use YYYY_MM_DD format.
last modified: Date of last modification to data package.
created by:
modified by:
matrix: y or n (as in, does the package contain matrix data? yes or no)
image: y or n
code: y or n
other: y or n (if yes, note what it is on the comment line)
readme: y or n
comment: Optional message that should be kept to a minimum and contain no line breaks. Detailed information should go in a readme file located within the data package. Avoid special characters as a general rule.

FORMATS:

matrix

Save matrix style or tabular data as a Comma-Separated Values file (csv) whenever possible. If the file contains fields that are calculations, such as cells containing formulas, consider including the native file as well.

Image

The preferred format for image data is the uncompressed Tagged Image File Format (tiff or tif). Image sequences can be stored as a multipage tiff file. Avoid downsampling the bit depth, especially if the image data is quantitative (many scientific cameras are 12-bit and should be saved as 16-bit if needed, but not 8-bit). If an image set is reduced (in bit depth, resolution, number of frames) or processed (background subtraction, filtered, etc.), make a note of this in a readme file. Some acquisition software outputs a metadata file with the image set, which may be helpful if included (for example, .cih files from Photron's PFV software).

Code

If sharing source code, use comments. Include information on the nature of the code, compilation platform etc. Macros/scripts should be text files.

Publications
None

Outreach Efforts
None

Awards
None

Student Involvement
Two graduate students (listed above) have participated in this project on a rotational basis to address various aspects of the project. They have mainly contributed in establishment of the ASCENT test database and analysis of the data for integration into this database. The students did not play a role in the formation and operation of the diagnostics subcommittee, which was mainly carried out by Dr. Lee.

Plans for Next Period
In year II of the NJFCP, we will continue our efforts in both the data archiving and subcommittee for prioritization of the laser and optical diagnostics. As the test database gets fully underway through project 33 in the ASCENT program, we will need to develop an optimized metafile that will need to operate with the NJFCP data. The issue is expected to have complexity in the fact that NJFCP data is varied in terms of both format and scope. The subcommittee on diagnostics is expected to make more contributions as we evaluate data and ascertain feedback from the modeling groups on how to steer the next round of measurements.