Program Progress Performance Report for University Transportation Centers
Marine Engine Testing and Emissions Laboratory (METEL)
Led by Maine Maritime Academy

Federal Agency and Organization Element to Which Report is Submitted:
U.S. Department of Transportation Research and Innovative Technology Administration

Federal Grant or Other Identifying Number Assigned by Agency: DTRT13-G-UTC43

Project Title: Tier 1 Marine Engine Testing and Emissions Laboratory

Program Director: Dr. Richard Kimball, richard.kimball@mma.edu, 207-326-2375

Submission Date: October 31, 2018

DUNS and EIN Numbers: 071746630 and 01-60000724

Recipient Organization: Maine Maritime Academy, Pleasant Street, Castine Maine 04420

Recipient Identifying Number or Account Number: Not Applicable

Project/Grant Period: October 1, 2013 – September 30, 2018

Reporting Period End Date: September 30, 2018

Report Term or Frequency: This report covers the period from April 1, 2017 to September 30, 2018, per the Grant Deliverables and Requirements for UTCs instructions

Signature of Submitting Official:

1. ACCOMPLISHMENTS

What are the major goals of the program?
The Marine Engine Testing and Emissions Laboratory (METEL) focuses on research and development of practical and commercializable emissions reductions technologies and engine efficiency enhancement technologies for marine and related power plants (US DOT strategic goal focus area of environmental sustainability).

METEL also provides maritime transportation workforce development and educational opportunities for undergraduates, graduate student as well as middle and high school students (Through its STEM activities).

METEL has nine projects as the focus of the UTC funded activities which are:

Project 1: Field Testing of Diesel/Glycerin Emulsion fuels as a low cost, low emissions, drop-in fuel for marine diesels. Project closed June 30 2018, final report issued.

Project 2: At Sea testing of a hydrogen injection system on MMA Work Vessel for emissions reduction. Project closed July 2018 final report issued.

Project 3: Development and engine testing of Forest Biomass fuel derivatives being developed at UMaine's Chemical Engineering Department and Forest Bioproducts Research Institute.

Project 4: Development and testing of an exhaust heat recovery thermoelectric generator (TEG) for marine engine efficiency improvement using current advances in thermoelectric materials.

Project 5: Development of a Marine Engine Continuous Emissions Monitoring System which operates on actual at-sea vessels as well as in the lab.

Project 6: Studies the capability of particular Algae strains to produce Glycerin fuel for use as a low cost low emissions transportation fuel.

Project 7: Development of Medium Speed Engine Testing Laboratories for Efficiency Improvement and Emissions Reduction Technology Evaluation.

Project 8: Sustainability Education and Laboratory Training for Workforce Enhancement

Project 9: Efficiency Improvement of Workboats through Hull Form Optimization Develop a high efficiency, advanced hull form for application to the coastal fishing fleet.

All of the projects work with commercial partners and have the potential to be practical solutions which can be implemented into the maritime industry in a timely, cost effective manner. Testing at METEL is a vital step toward proving out these technologies for practical use in the real working environment for which they would be subjected.

What was accomplished under these goals?
Major Activities and Specific Objectives

General METEL accomplishments:

- Completed final report for Glycerin/Diesel Emulsion fuel project July 2018
- Completed final report for Hydrogen fuel project July 2018
- Delivery of thermal deoxygenation oils for upgrading blending research for testing in METEL diesel engine.
- Contact resistance issues on TEG identified, solutions being investigated
- Studies on salinity shocking to induce algae to excrete glycerin show positive results in increasing algae glycerin output to about 20mg/ml of media(~2% by mass)
- Completion of design and validation of a continuous cylinder pressure measurement system using an in-house developed air cooling system installed in medium speed diesel engine lab.
- Completion of a major test contract for a large oil company using the newly developed medium speed diesel lab. Results for client very positive w/ more test contracts coming.
- Workforce Development: Incorporation of the medium speed diesel lab in the maintenance course and diesel course in the MMA engineering curriculum.
- Completion of experimental Work Boat hull at The Landing School in Arundel, Maine (topside remaining).

Refinement of the test infrastructure to support the various research projects is ongoing.

The following summarizes the tasks for each project which were accomplished over the reporting period:

Project 1: Diesel Glycerin Emulsion Fuel Project

The summarized accomplishments for the reporting period are:

- Project closed and final report issued July 2018

Project 2: Hydrogen Injection Fuel Project

The summarized accomplishments for the reporting period are:

- Project closed and final report issued July 2018

Project 3: Forest Biomass Diesel fuel project

The summarized accomplishments for the reporting period are:

- Completed thermal deoxygenation of a mixture of calcium levulinate and calcium formate salts to produce 18 L of thermal deoxygenation oil for upgrading, fractionation, and blending research.
- Completed hydrotreatment of thermal deoxygenation oil using Ni on Si-Al catalyst in a continuous flow tubular reactor for fractionation and combustion performance research at the Maine Maritime Academy.
- Completed fractional distillation of 12 L of thermal deoxygenation oil and 9 L of hydrotreated thermal deoxygenation oil.
- Blended distilled fractions to produce 3.8 L of 200℃ - 325℃ distillate from each type of oil and delivered the oil blends to the Maine Maritime Academy.

All the research activities were conducted at the University of Maine's Technology Research Center. Thermal deoxygenation oil was produced using a 50 L stirred semi-batch reactor in August 2018. Each reaction consumed 20 kg of a mixture of calcium levulinate and calcium formate salts and produced approximately 3.6 L of crude thermal deoxygenation oil. A total of 5 reactions were completed yielding

18 L of crude oil. Suspended solids in the crude oil was removed by filtering the oil to 25 microns. Water in the crude oil was removed in liquid form by gravity separation and in the form of ice by cooling the filtered oil to 0 °C.

Hydrotreatment of the crude oil was completed using Ni on Si-Al (65 wt% Ni) in a bench scale continuous flow tubular reactor (Parr, Model 5402) over a period of 262 hours. The hydrogenation reaction was carried out at 300 °C and 750 psig of hydrogen with a weight hourly velocity of 0.3 hr^{-1}. The catalytic hydrogenation increased the hydrogen content of thermal deoxygenation oil from 9.7 % to 12.6 % and decreased the specific gravity from 0.99 kg/dm^3 to 0.88 kg/dm^3.

Distillations were performed on a BR instrument 9400 fractional distillation apparatus that meets ASTM D2892 specifications. The distillations of crude and hydrotreated thermal deoxygenation oils were performed over the atmospheric equivalent temperature range of 40-350 °C in four different increments, consecutively 135 °C, 25 °C, 125 °C, and 25 °C. All the distillations were performed under vacuum (50 mmHg pressure) and the maximum flask (pot) temperature was limited to 290 °C to prevent thermal cracking of hydrocarbons in the oil. During each run 2 L distillation flask was loaded with 1.5 L of crude or hydrotreated oil. Distillate fractions collected from 200°C to 325°C were blended to produce 3.8 L of oil for combustion performance research at Maine Maritime Academy.

Project 4: Thermoelectric Exhaust heat recovery generator (TEG) project
Summarized accomplishments:

- Seebeck performance testing underway
- Variable resistor added to load bank circuit to determine more appropriate resistor range

Description of accomplishments:

The Seebeck performance evaluation of the thermoelectric materials developed at LASST is underway. The Seebeck load bank circuit has been used to provide a load on a number of different combinations of thermoelectric couples, including couples consisting of P and N type materials from the commercial couple from the manufacturer, the bulk materials pressed in the lab, and the nanostructured materials pressed in the lab. It was observed from the data that the original resistor valve range used in the load bank (0.1mΩ to 30mΩ) was too narrow of a range. The range was determined using the manufacturer specifications for the commercially available module, but did not account for the increase in couple resistance caused by contact resistances. The commercial couple was split and the individual P and N type materials were used in the same fashion as the laboratory developed materials to confirm that the resistance range was too small. A potentiometer was installed with a range from 0Ω to 5Ω and was used to measure a load sweep of the thermoelectric couples. Figure 1, left, shows the results of such a load sweep conducted on a commercial material couple, a bulk material couple, and a nanostructure material couple conducted at a 150°C temperature difference. The trendline does show a parabolic shape to the couple power outputs when plotted against current output, which is consistent with literature. It can be seen in this figure that the commercial material did have a higher peak performance when compared to the bulk and nano material. The bulk material did, however, have a more consistent power output over the load sweep, comparatively. Figure 1, right, shows the results of a load sweep test on the nano material at differing temperature differences. Also consistent with literature, the power output does increase with an increasing temperature difference in this temperature range. In both graphs, however, there are still gaps in the data to produce a smoother and more consistent curve. The potentiometer aided in determining a more appropriate resistor value range. New resistors have been put on order to be installed on the load bank to produce more repeatable and consistent results with fewer gaps on the trendline curves.

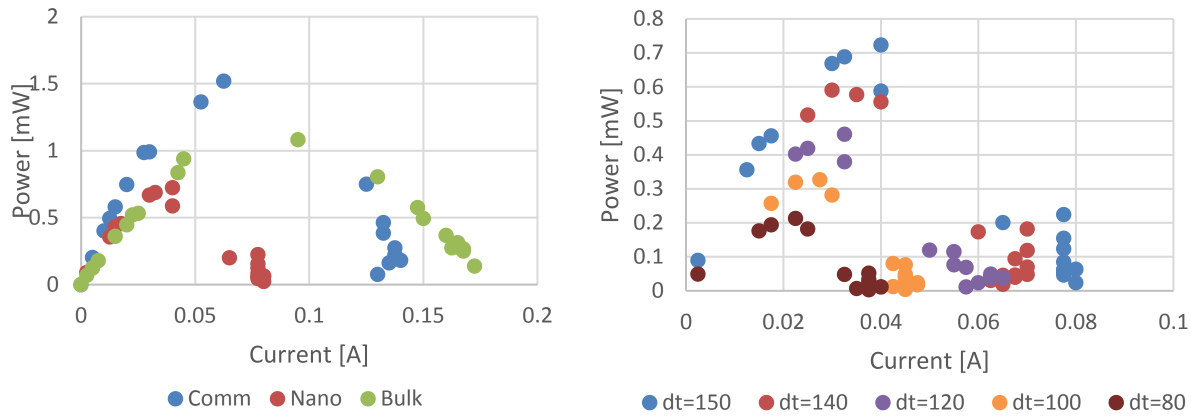

Figure 1: Seebeck testing results from testing: (left) comparative test of commercial couple, a nano structured couple and bulk material couple; (right) effect of temperature difference on nanostructured couple

Future goals;

- Install the new resistor load range
- Complete the test protocol for the Seebeck testing and have material characterized at independent laboratory
- Complete and publish PhD dissertation work

Project 5: Marine Engine Continuous Emissions Monitoring System

Summarized accomplishments:

- Designed and implemented Air cooled continuous monitored in cylinder pressure system
- Ran in cylinder pressure system successfully for client tests.

Description of accomplishments

We implemented the use of Optrand in cylinder pressure sensors into our continuous monitoring data system but had serious problems with sensors failing due to cylinder temperature exposure when run continuously. The signal from the sensors, which were rated for operating temperatures above the exhaust temperatures of the engine, where degrading after time both during the testing day and between each day. After discussing the issue with the sensor's manufacturer, it was determined that the failure was due to thermal shock and stress of the pressure sensor's diaphragm. To alleviate this issue an air cooling system was installed using a constant speed air compressor to blow air over the surface of the sensor that is in contact with the engine cylinder indicator valve. The system was tested using a simulated sensor that had a thermocouple mounted in place of the pressure sensor to track the temperature drop. Figure 2 shows the air cooling system installed on the engine used to cool the pressure probes. The cooling system successfully dropped the temperature experienced by the sensor by 50°C to 150°C dependent on the load on the engine, keeping the sensors under 200°C for all engine load conditions. Figure 3 shows the drop in temperature experienced by the sensor when the air cooling system is turned on. As is seen in the figure, when the air cooling system was activated, while the engine was at idle, the sensor experienced an approximate 125°C temperature drop.

Figure 2: In-cylinder pressure sensor cooling system

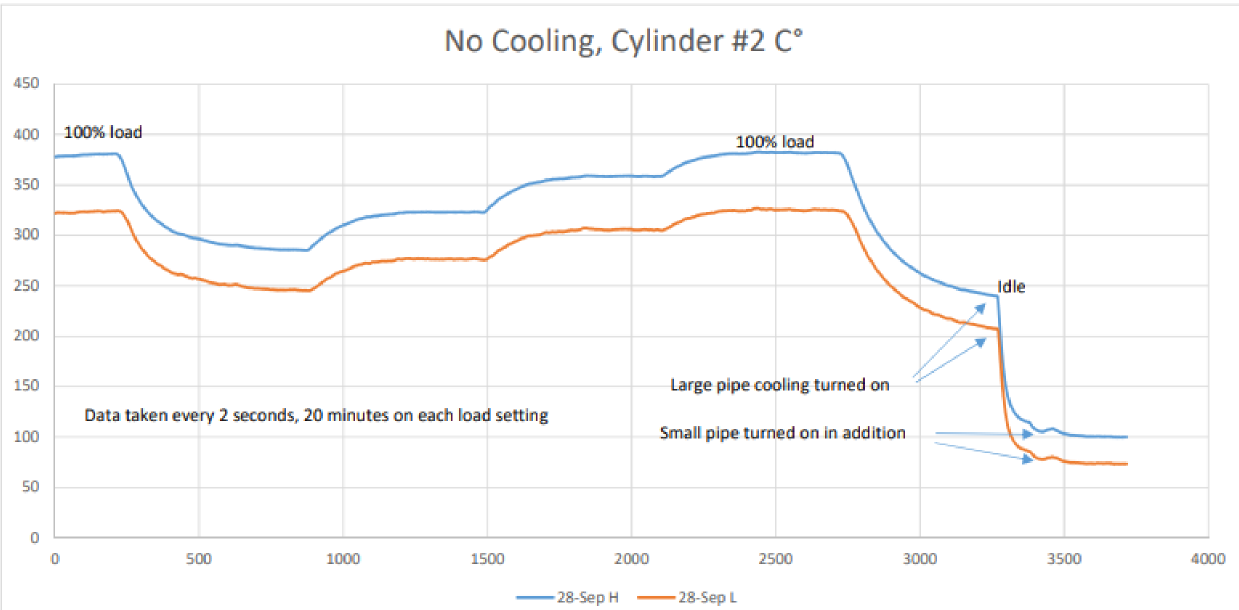

Figure 3: The effect of the air cooling system on the pressure sensor while the engine was at idle

The final design of this new air cooled system was run for several test days for a client test and performed well with no continued failure of probes or significant degradation of performance measured.

The previously reported emissions monitoring system was used for about 200 hours of client testing and performed well. However the consumption of liquid nitrogen in the FTIR system would not be acceptable on a long term shipboard monitoring system and the use of a thermoelectrically cooled FTIR is recommended for that application.

Project 6: Algae based glycerin fuel project
Summarized accomplishments:

- Results from osmotic shocking experiments show significant extracellular glycerin production of about 20mg/ml in the algae growth media over as little as 2 hours.

Description of accomplishments for the Algae Glycerin Fuel project:
The microalga *Dunaliella tertiolecta* produces glycerol as a byproduct. This study has been attempting to utilize the glycerol to produce glycerol using hyperosmotic shocking. Figure 4 shows the culture setup for the experiment. The microalga was shocked for a period of 4 hours, and samples were collected at the initial shock, 20, 40, 60, 120, and 240 minutes. The method used to measure glycerol was a chemical method, which utilizes the oxidation of glycerol, production of diacytldihydrolutidine (DDL). DDL produces a yellow color, and is then measured using a spectrophotometer. As standard curve of known glycerol concentrations was made in order to estimate the amount of glycerol produced by *D. tertiolecta* during hyperosmotic shocking. The microalga successfully produced glycerol over the time period of shocking. The shocking solutions had 1 M, 3 M, and 5 M NaCl, as well as another set with 1, 3, and 5 M NaCl as well as additional $NaHCO_3^-$ for additional carbon availability for the microalga to utilize for glycerol production. The cultures with no additional $NaHCO_3^-$ produced the greatest amount of glycerol between 2 and 4 hours (Figure 5). The shocking treatments with the additional $NaHCO_3^-$ produced the greatest amount of glycerol at the initial time. The *D. tertiolecta* cells reuptake glycerol, and it appears the microalga excreted glycerol, and then uptook it after the initial shock when in the shocking solutions with additional $NaHCO_3^-$ (Figure 6).

Figure 4: Algae Osmotic shocking experiment: Culture setup

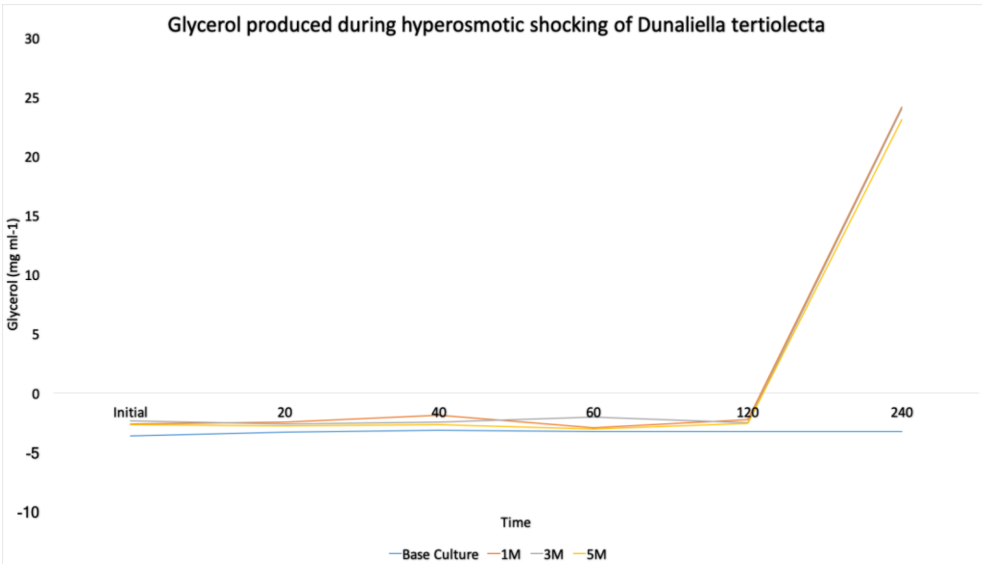

Figure 5. The microalga *D, tertiolecta* samples were collected, and the glycerol from the shocking treatments (1, 3, and 5 M) was measured using a spectrophotometer.

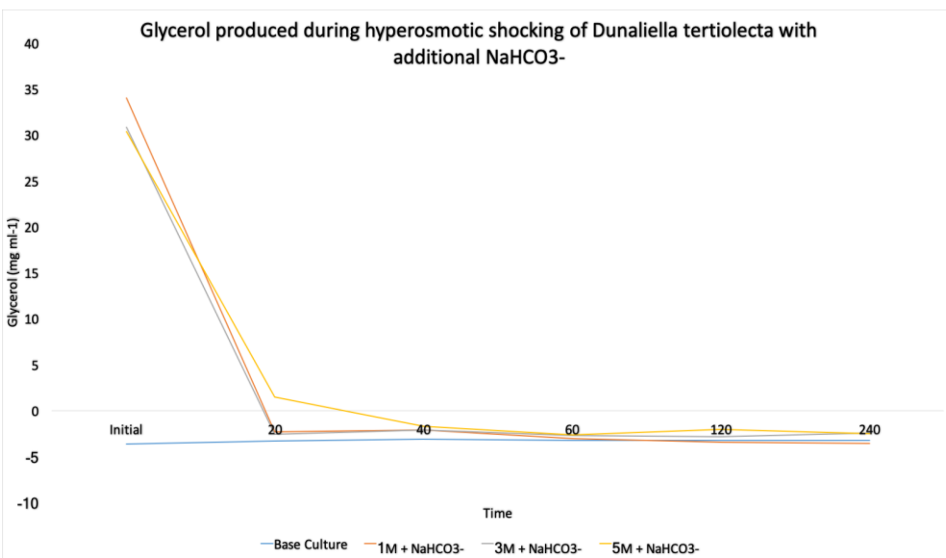

Figure 6. The microalga *D, tertiolecta* samples were collected, and the glycerol from the shocking treatments (1, 3, and 5 M with additional $NaHCO_3^-$) was measured using a spectrophotometer.

Project 7: Development of Medium Speed Engine Testing
Summarized accomplishments:

- Second client test contract near completion
- Engine running condition improvements complete

Description of accomplishments:
The stable control of a number of operating conditions of the engine were needed to the completion of the second client test. Upon review of the operating data with the client, it was observed that a number of temperatures, including intake air temperature and fuel inlet temperature were outside of the +/- 1^{o}C tolerance set forth in the test plan. METEL implemented a new design of the air intake conditioning system and fuel cooler control system which has been installed and has been proven to maintain the 1^{o}Celsius control of intake air and fuel temperature in a consistent manner to meet demanding customer test specifications. Figure 7 shows pictures of examples of the controllers installed to meet these requirements. The picture on the left shows the air plenum that was designed and installed to provide temperature control of the intake air to the engine. The plenum first heats the air to a temperature set point, then cools the air to the desired testing parameter. This control is achieved by the use of centrifugal pumps and PID controllers, shown in the center picture of Figure 7. The heating is achieved by circulating a freshwater closed loop system that has a constant temperature maintained by a resistive heater, controlled by a PID and PWM tandem controller. The cooling is achieved by modulating the flow rate of an open loop freshwater flow tapped off of the low temperature freshwater inlet to the engine. The flowrate is modulated by a manual bypass valve and fine-tuned by controlling the rotational speed of a centrifugal pump with a PID controller and VFD. The last picture in Figure 7 on the right is the fuel cooler. The control of the fuel cooler cooling medium is the same as the intake air cooling circuit.

Figure 7: The intake air plenum (left), the heating and cooling fluid controllers and pumps (center), and the fuel cooler with controller and pump (right)

One remaining control system issue was in controlling the cooling water inlet temperatures for the low temperature and high temperature cooling circuits to the engine. The issue is that the seawater side of the cooling changes performance significantly due to the height of the tide required to be overcome by the seawater cooling pumps. The change in seawater flow to the seawater heat exchangers causes changes to the repeatability of the inlet cooling water and charge air temperature to about 1.5 to 2^{o}C over the test cycles which is out of specification with the customer specification of 1^{o}C control of these temperatures over the duration of the tests. We have completed a preliminary design of a seawater bypass control loop to better control these inlet water temperatures and expect to implement this design over the next few months.

Future goals:

- Install seawater flowrate control system
- Complete second testing contract
- Begin planning for the next contract

Project 8: Sustainability Education and Laboratory Training for Workforce Enhancement

METEL has been getting increasingly involved in the curriculum at MMA. The lab is becoming the showcase training facility for the students. The lab has been involved in developing and improving material and labs in a number of courses, brought students into the operations and maintenance of the engine and supporting systems, and has been used as an example for student tours for a number of classes. Examples of coursework and materials that have been improved or developed follow:

- EN401 Air Pollution & Emissions Testing and Control is being offered this semester by Prof. Brendyn Sarnacki, who is using data gathered by the continuous emissions monitoring system in METEL to develop numerous new labs and course material to instruct and expose the students to the importance of air pollution and techniques used to measure pollution levels.
- From an observation made during testing, a case study was developed on the effect of hunting of the intake air cooling pump on the intake air temperature and cylinder temperatures. Graphical representations of the effect was distributed to professors to be used as part of course material in Diesel Power, Thermodynamics, and Automation and Control.
- METEL lab personnel has been involved in the Maintenance training program. Historically, the maintenance program has been held onboard the TS *State of Maine*, MMA's training ship, but this semester a two groups of students per week have been assigned to the METEL engine lab to perform routine and improvement maintenance procedures on the lab equipment and engine under the supervision of METEL personnel. Figure 8 shows examples of the students working in the lab on maintenance projects, the left picture depicting students working on the fuel system and the right picture showing students working on the charge air cooler.

Figure 8: Students participating in maintenance in the engine lab

In addition MMA continues to implement the Environmental minor with the offering of courses with a new course *EN402 Biofuels; Production and use* offered this spring. This course will be offered in the spring 2019 semester and will feature fuel testing using the DOT UTC METEL Medium Speed Diesel lab as a laboratory for the course, using the labs fuel chemistry equipment.

The Medium speed diesel lab also continues to be a resource for students in several marine training courses including: EG101 Fundamental of Engineering Operations, EG234 Power Equipment Lab EG 292 and EG392 Diesels I & II and ET 431 Thermal Fluids Laboratory. Students utilize the lab for various labs in the courses including system tracing and identification, Diesel equipment operations, Diesel maintenance and thermal systems labs involving engine performance.

Project 9: Efficiency Improvement of Workboats through Hull Form Optimization

The summarized accomplishments for the reporting period are:

- Completion and joining of upper and lower hull sections.
- Installation of 37.5 hp 4-cylinder diesel engine, shafting, fuel system, electrical system, raw water cooling, wet exhaust, steering, throttle, and helm station.
- Application of coatings: epoxy sealer, epoxy primer, topcoat, bottom paint.
- First start of diesel engine October 29, 2018.
- Partial completion of sidehulls.

Description of Accomplishments:

Maine Maritime Academy has developed a high efficiency, advanced hull form for application to coastal fishing and transportation. The design has undergone extensive model testing and exhibits improved performance in the typical cruising speed range of these vessels. Reductions in fuel consumption and emissions are in the range of 15% to 25% depending on loading condition and sea state. The design achieves these reductions through the use of an optimized trimaran hull, allowing for the large required deck space without the large waterline beam and power requirements of current boats.

The prototype vessel is in the final stages of construction at The Landing School in Arundel, Maine. The boat is estimated to be 98% complete. The project is currently on budget, with a total grant value of $97,257. Launch has likely been delayed to spring 2019, with sea trials taking place spring and summer 2019.

The state of the vessel as of September 2018 is shown in Figure 9. All painting, including the cabin trunk, is now complete. Note the missing bow section. The boat will be able to bolt on different bow shapes to test the effect on resistance, powering, maneuverability, and seakeeping. The sidehulls are also not attached in the photo and will be similarly bolted on to test different geometry and the impact upon the static and dynamic stability. The engine and working deck are shown in Figure 10. Not the helm, throttle, and instrument panel, as well as the traditional deck. From this vantage point there is no indication that the vessel is a multi-hull. Figure 11 shows the propeller installation and shafting arrangement.

A short list of things remains to be done:

- Finish and bolt-on sidehulls
- Machine and bolt-on bow section
- Fabricate rudder and skeg
- Fabricate and install companionway door
- Order and install deck fittings and rub rail
- Transport and/or acquire appropriate boat trailer

Now that the engine has started, the vessel will be moved from Arundel to Castine. The fall schedule and cooling weather may require that the launch take place in spring 2019.

Figure 9: Nearly complete vessel at The Landing School

Figure 10: First diesel engine start October 29, 2018

Figure 11: Propeller installation

Education, Workforce development and STEM accomplishments

Activities for this area are described in Project 8.

Significant Results:
Project 1: Diesel/Glycerin Emulsion fuel project
- Project Completed

Project 2: Hydrogen Injection Fuel Project
- Project completed

Project 3: Forest Biomass Diesel fuel project
- Blended distilled fractions to produce 3.8 L of 200℃ - 325℃ distillate from each type of oil were delivered the oil blends to the Maine Maritime Academy for engine testing.

Project 5: Marine Engine Continuous Emissions Monitoring System

- Air cooled continuously monitored in cylinder pressure system implemented and utilized in client testing

Project 7: Development of Medium Speed Engine Testing

- A large testing program completed for major industrial client; more contracts pending

Key Outcomes:

How have the results been disseminated?

Project 1: Diesel/Glycerin Emulsion fuel project

- TRIB final report

Project 2: Hydrogen Injection Fuel Project

- TRIB Final report

Project 3: Forest Biomass Diesel fuel project

- Nothing to report
- Approximately 12 L of TDO were hydrotreated which will be used to prepare fuel blends for engine tests at MMA

Project 4: Thermoelectric Exhaust heat recovery generator project

- Material performance testing underway(Seebeck measurements)

Project 5: Continuous Emissions Monitoring System

- Completion of air cooled continuously monitored in cylinder pressure measurement system designed and implemented.
- Performance and emissions data of lube oil were collected in the medium speed engine lab as part of client testing.

Project 6: Algae Based Glycerin fuel project

- Nothing to Report

Project 7: Development of Medium Speed Engine Testing

- Automation and data acquisition improvements and upgrades completed
- Second client test contract underway
- Engine running condition improvements underway

Project 8: Sustainability Education and Laboratory Training for Workforce Enhancement

- EN420 offered this semester to MMA Students

Project 9: Efficiency Improvement of Workboats through Hull Form Optimization

- Significant progress on construction at The Landing School in Arundel, Maine

What do you plan to do during the next reporting period to accomplish the goals?

Over the next reporting period we plan the following goals and accomplishments for the projects:

Project 1: Diesel/Glycerin Emulsion fuel project: Already completed

Project 2: Hydrogen Injection Fuel Project: Already completed

Project 3: Forest Biomass Diesel fuel project

- Testing of blended fuels in diesel engine at METEL

Project 4: Thermoelectric Exhaust heat recovery generator project

- Publish paper pending acquisition of data
- Complete project, graduate PHD student (final defense)

Project 5: Continuous Emissions Monitoring System

- Closeout the project and complete final report.

Project 6: Algae Based Glycerin fuel project

- Close out the project and complete final report.

Project 7: Development of Medium Speed Engine Testing

- Continue testing for industry
- Implement Seawater temperature control loop
- Closeout the project and complete final report.

Project 8: Sustainability Education and Laboratory Training for Workforce Enhancement

- Develop Standard operating procedure for engine startup for us in training
- Offer EN402 next semester
- Closeout the project and complete final report.

Project 9: Efficiency Improvement of Workboats through Hull Form Optimization

- Complete construction of work boat.

Education, Workforce development and STEM:

- See project 8 above

2. PRODUCTS: What has the program produced?

Publications, conference papers, and presentations

Journal publications:

Project 1: Diesel/Glycerin Emulsion fuel project

- Final report issued and uploaded to TRIB database
- *Combustion and emissions of a glycerol-biodiesel emulsion fuel in a medium-speed engine* Scott J. Eaton, Travis T. Wallace, Brendyn G. Sarnacki, Thomas Lokocz Adams, Richard W. Kimball, Joshua A. Henry & George N. Harakas
- Journal of Marine Engineering & Technology (Online) 20 Aug 2018

Project 2: Hydrogen Injection Fuel Project

- Final report issued and uploaded to TRIB database

Project 3: Forest Biomass Diesel fuel project

- Nothing to report

Project 4: Thermoelectric Exhaust heat recovery generator project

- Nothing to report

Project 5: Continuous Emissions Monitoring System

- Nothing to report

Project 6: Algae Based Glycerin fuel project

- Nothing to report

Project 7: Development of Medium Speed Engine Testing

- Nothing to report

Project 8: Sustainability Education and Laboratory Training for Workforce Enhancement

- Nothing to report

Project 9: Efficiency Improvement of Workboats through Hull Form Optimization

- Nothing to report

Books or other non-periodical, one-time publications:

None to report

Other publications, conference papers and presentations:

Oral Presentations:

- None to report

Website(s) or other Internet site(s)
The METEL website can be found at: www.mainemaritime/metel
This is the main website for the DOT UTC Center, describing the center's mission as well as the projects, key personnel and serves as a repository for the research reports generated by the project.

Technologies or techniques Development of an air cooled continuous in cylinder pressure measurement system.
Inventions, patent applications, and/or licenses Nothing to Report
Other products Nothing to Report

3. PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS: Who has been involved?

What individuals have worked on the program?
The tables below summarize the information for the individuals who have worked on the program:

Name	Dr. Richard Kimball
Program/Project Role	P.I. /Technical Director
Work Effort during reporting period	2 months
Contribution to Program/Project	METEL Technical Director
Funding support	DOT UTC
Collaborated with individual in foreign country	No
Country of Foreign Collaborator	NA
Travelled to Foreign Country	No
If travelled to foreign country(ies) duration of stay	NA

Name	Thomas Lokocz
Program/Project Role	Research Engineer
# Hours worked during reporting period	1000 hrs
Contribution to Program/Project	METEL Research Engineer (full time) for all projects
Funding support	DOT UTC
Collaborated with individual in foreign country	No
Country of Foreign Collaborator	N/A
Travelled to Foreign Country	No
If travelled to foreign country(ies) duration of stay	N/A

Name	Brendyn Sarnacki
Program/Project Role	Research Engineer (half time)
# Hours worked during reporting period	600 hours

Contribution to Program/Project	METEL Research Engineer for all projects
Funding support	DOT UTC
Collaborated with individual in foreign country	No
Country of Foreign Collaborator	N/A
Travelled to Foreign Country	No
If travelled to foreign country(ies) duration of stay	N/A

Name	Travis Wallace
Program/Project Role	Research Engineer (half time)
# Hours worked during reporting period	600 hours
Contribution to Program/Project	METEL Research Engineer for all projects
Funding support	DOT UTC
Collaborated with individual in foreign country	No
Country of Foreign Collaborator	N/A
Travelled to Foreign Country	No
If travelled to foreign country(ies) duration of stay	N/A

Name	Clayton Wheeler
Program/Project Role	UMaine Co-P.I.
# Hours worked during reporting period	55.47
Contribution to Program/Project	Lead P.I. for UMaine effort; Leading the TDO/FAsP project at UMaine
Funding support	0 month (DOT)
Collaborated with individual in foreign country	No
Country of Foreign Collaborator	N/A
Travelled to Foreign Country	No
If travelled to foreign country(ies) duration of stay	N/A
Name	Dr. William DeSisto
Program/Project Role	UMaine Senior Personnel
# Hours worked during reporting period	0
Contribution to Program/Project	Co- P.I. for UMaine effort; Co-supervising graduate student research.
Funding support	0 month (DOT)
Collaborated with individual in foreign country	No

Name	Sampath Karunarathne
Program/Project Role	UMaine Postodoctoral Researcher
# Hours worked during reporting period	160
Contribution to Program/Project	Production of TDO Blendstocks
Funding support	0.842 month (DOT) 0 month (UMaine)
Collaborated with individual in foreign country	No

Name	Clayton Wheeler
Program/Project Role	UMaine Co-P.I.
# Hours worked during reporting period	55.47
Contribution to Program/Project	Lead P.I. for UMaine effort; Leading the TDO/FAsP project at UMaine
Funding support	0 month (DOT)
Collaborated with individual in foreign country	No
Country of Foreign Collaborator	N/A
Travelled to Foreign Country	No
If travelled to foreign country(ies) duration of stay	N/A

Name	Dr. William DeSisto
Program/Project Role	UMaine Senior Personnel
# Hours worked during reporting period	0
Contribution to Program/Project	Co- P.I. for UMaine effort; Co-supervising graduate student research.
Funding support	0 month (DOT)
Collaborated with individual in foreign country	No

Name	Sampath Karunarathne
Program/Project Role	UMaine Postodoctoral Researcher
# Hours worked during reporting period	160
Contribution to Program/Project	Production of TDO Blendstocks
Funding support	0.842 month (DOT) 0 month (UMaine)
Collaborated with individual in foreign country	No

Name	Elisha Cram
Program/Project Role	UMaine Research Engineer
# Hours worked during reporting period	160
Contribution to Program/Project	Production of TDO Blendstocks

Funding support	0.842 month (DOT) 0 months (UMaine)
Collaborated with individual in foreign country	No

Name	Nathan Hill
Program/Project Role	UMaine Research Technician
# Hours worked during reporting period	168
Contribution to Program/Project	Production of TDO Blendstocks
Funding support	0.884 month (DOT) 0 month (UMaine)
Collaborated with individual in foreign country	No

Name	Scott Eaton
Program/Project Role	UMaine Asst. Research Professor
# Hours worked during reporting period	480
Contribution to Program/Project	Production of TDO Blendstocks
Funding support	2.53 month (DOT) 0 month (UMaine)
Collaborated with individual in foreign country	No

Name	Matthew Kline
Program/Project Role	UMaine Graduate Student
# Hours worked during reporting period	80
Contribution to Program/Project	Hydrotreating of TDO Oil
Funding support	1 month (DOT) 0 month (UMaine)
Collaborated with individual in foreign country	No

What other organizations have been involved as partners?
None for this reporting period. Note: Test contract clients have requested anonymity due to the propriety nature of their products.

What other collaborators or contacts been involved?
Nothing to Report

4. IMPACT:

What is the impact on the development of the principal discipline(s) of the program?
The completion of the medium speed diesel lab, as a unique, world class test facility have only just begun to have impact on the R&D of fuels, lube oils and emissions reduction strategies. This lab is engaged in several major test contracts with key companies in the marine industry, providing direct technology transfer to our industries. In addition, the lab has proven a major asset for the training of our marine engineering students and exposes them to state of the art research relevant to their future.

What is the impact on other disciplines?

Nothing to Report

What is the impact on the development of transportation workforce development?

The medium speed diesel lab is being used in key courses in the marine engineering program to improve the training of marine engineering students by direct, hands-on work on the medium speed diesel systems including maintenance and operation of the engine. Marien engineering students are licensed USCG officers upon graduation and enter the transportation workforce.

What is the impact on physical, institutional, and information resources at the university or other partner institutions? The METEL lab infrastructure has provided new training facilities and opportunities (described previously) as well as outreach to our industry through R&D test contracts.

Physical resources such as facilities, laboratories, or instruments;

What is the impact on technology transfer? The continued use of the medium speed diesel lab to support industry testing in new fuels, lube oils and emissions devices is having direct impact on the R&D efforts of our client companies. We have completed two major industrial test contracts to date with two more in the works for next year.

What is the impact on society beyond science and technology? The work being done for industrial clients is in the development of new fuels and lube oils to reduce emissions and improve engine efficiency, addressing directly issues of pollution, climate change (reduction of NOx and Sox and particulates) as well as economic productivity of the marine transportation industry.

5.CHANGES/PROBLEMS

Nothing to report

6. SPECIAL REPORTING REQUIREMENTS

Nothing to report