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

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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 – March 31, 2018

Reporting Period End Date: March 31, 2017

Report Term or Frequency: This report covers the period from October 1, 2016 to March 31, 2017 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. This fuel is being developed and commercialized by the startup SeaChange Group LLC

Project 2: At Sea testing of a hydrogen injection system on MMA Work Vessel for emissions reduction. This system is being developed by Global Marine Consulting

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 for the performance period:

- Completed installation and break-in of a 1,020 kW medium-speed Wartsila 6L20 diesel engine for alternative fuel performance and emissions testing. First commercial product testing service currently underway for clients.
- Competed curriculum review and internal approvals for the implementation of a Sustainability Minor at Maine Maritime Academy.
- Awarded a Maine Technology Institute grant for work boat efficiency improvement project ($97,257).
- Detailed gas and particulate emissions analyzed for biodiesel-based glycerol emulsion fuel – Results currently being written for publication.
- Hydroprocessing experiments were conducted on two different FASP oils to determine optimum process conditions for a nickel-based catalyst
- 23.25 L of TDO Oil/Diesel blends (5%, 10%, 15%, 20% by volume) were prepared and delivered to MMA for engine testing.
- Published research progress for biomass to biofuels project in the ACS Journal Sustainable Chemistry and Engineering.
- Awarded Maine technology Institute grant for enzymatic biodiesel project ($18,000) to improve pilot plant design to enhance glycerol/diesel emulsion project.
- Graduated 8 marine systems engineering students after successful completion of METEL supported capstone projects.
- Developed procedure for consistent production of Bismuth Telluride particles with diameters <50 nm from bulk material.
- Algae project: Glycerin to media calibration performed for conductivity and refractive index.

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:

- Detailed gas and particulate emissions analyzed for biodiesel-based glycerol emulsion fuel – Results currently being written for publication.
- Awarded Maine technology Institute grant for enzymatic biodiesel project ($18,000) to improve pilot plant design to enhance glycerol/diesel emulsion project.

Laboratory Testing Results for Particulates Collected on Glycerol/Diesel Emulsion Fuels

An experimental emulsion fuel blend of 8-22 wt% glycerol, 2-8 wt% water, 70-90 wt% B50 biodiesel (50% biodiesel, 50% diesel) was tested on the CAT C2.2 laboratory test cell to generate particulate matter for gravimetric and imagining analysis. Combustion of alternative fuels has the potential to significantly alter the chemistry and morphology of particulate matter. This test was conducted to determine the impacts of glycerol/diesel fuel emulsions on engine performance and particulate matter emissions. Samples were collected at various engine loads from idle to 100% power rating. Analysis of the engine exhaust shows that the number of particulates emitted per unit power from the engine remains constant, but the compositional analysis of the soot changes with increasing glycerol content. Figure 1 is a plot comparing the volatility of particulate matter as a function of temperature using a thermogravimetric analyzer at a ramp rate of 10°C in nitrogen. The graph shows that particulate matter contains significantly

more volatile matter within the 100-200°C temperature regime which is consistent with increased condensed hydrocarbon vapor.

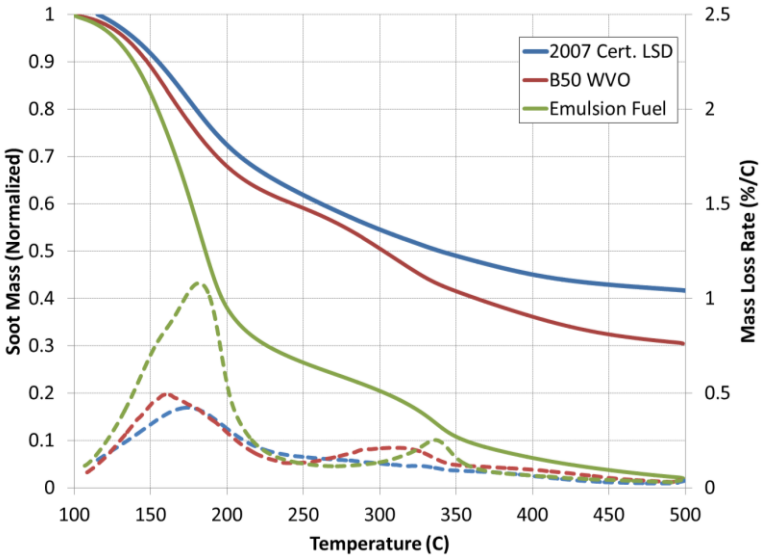

Figure 1: Thermogravimetric comparison of soot volatility for low sulfur diesel fuel, B50 biodiesel/low-sulfur diesel and a glycerol/biodiesel/diesel emulsion fuel.

Thermogravimetric analysis results are consistent with transmission electron microscopy (TEM) images which exhibit increased condensed –phase material when glycerol content of the fuel is increased.

Project 2: Hydrogen Injection Fuel Project

The summarized accomplishments for the reporting period are:

- No work performed during this reporting period
- Focus on the medium speed engine lab has temporarily taken time away from this project. We plan on returning to it over the next several months.

Description of accomplishments for the Hydrogen Injection Fuel Project:

We anticipate finishing research and closing the project out during next period activities.

Project 3: Forest Biomass Diesel fuel project

Lead by UMaine – this project is exploring multiple forest biomass processing routes for the commercial production of liquid transportation fuels. These materials are projected to displace fossil fuel consumption and reduce greenhouse gas emissions within the transportation industries. Two candidate processing routes explored through this center project are formate assisted pyrolysis (FAsP) and thermal deoxygenation (TDO). A summary of accomplishments for each processing route is provided below.

The summarized accomplishments for the reporting period are:

- 23.25 L of TDO Oil/Diesel blends (5%, 10%, 15%, 20% by volume) were prepared and delivered to MMA for engine testing.
- Hydroprocessing experiments were conducted on two different FASP oils to determine optimum process conditions for a nickel-based catalyst

Results:

- A two-stage thermal deoxygenation process was demonstrated to improve TDO yields at liter-per-day scales
- Economics were calculated for pyrolysis of forest residues using an ASPEN model

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

Summarized accomplishments:

- Developed procedure for consistent production of Bismuth Telluride particles with diameters <50 nm from bulk material.
- Produced macroscopic thermoelectric materials with consistent electrical conductivities from nanomaterials
- Developed furnace for annealing thermoelectric materials with in-situ four point probe conductivity measurement capabilities

Description of accomplishments for the thermoelectrics:

METEL and UMaine researchers were awarded $98,776 from the universities' Research Reinvestment Program to support a grant entitled "Layer-by-layer Fabrication of Thermoelectric Films Using Polymerized Bismuth-Telluride Nanoparticles to Yield High-Efficiency Thermoelectric Generators for Marine Applications." The first objective of the project is to develop a methodology for inexpensively producing nanoscale thermoelectric materials.

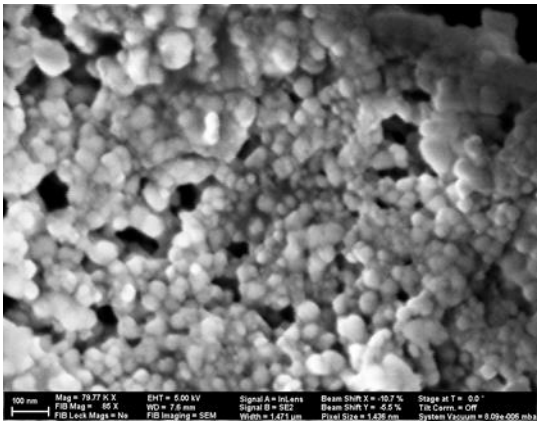

Figure 2. Scanning electron microscope image of nanoparticle bismuth telluride powder.

To that end bulk p-type, bismuth antimony telluride from Sigma Aldrich (99.99% trace metal basis) was combined with 40% by mass Polyallylmethylammonium chloride (PADAMAc) and ball milled with 0.1 mm zirconium oxide shot for 30 minutes. The PADAMAc is necessary to modify the surface properties of the newly generated particles and keep them from

agglomerating. Average particle diameter is measured using X-ray diffraction, dynamic light scattering and scanning electron microscopy (Figure 2). The powder is then poured into a 13mm diameter pellet press and compressed at 24,000 psi for 3 minutes.

The electrical conductivity of the resulting pellets is low ostensibly because of the presence of the polymer, which is nonconducting. Thermogravimetric studies under flowing nitrogen gas show that the polymer desorbs from the sample at temperature between 200-300˚C. In keeping with this observation Figure 3 shows that the conductivity of macroscopic pellets increases significantly over this temperature range and that those increases are permanent.

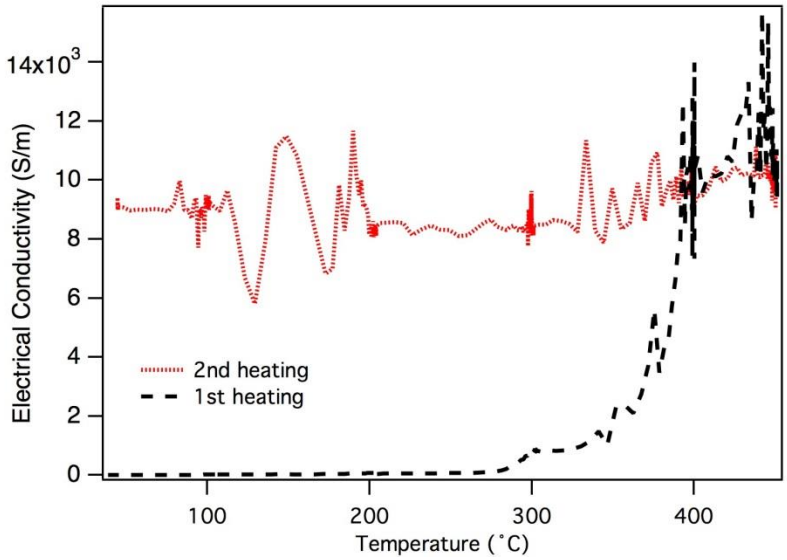

Figure 3. Graph of in-situ electrical conductivity of pellet of nanomaterial, p-type bismuth telluride versus annealing temperature

Project 5: Marine Engine Continuous Emissions Monitoring System

The summarized accomplishments for the reporting period are:

- Installation of continuous emissions monitoring system on the Medium speed diesel lab.
- Focus on continuous monitoring emissions systems development is currently focused on installing these systems on our medium speed engine and is described in more detail in that project section.

Description of accomplishments for the Marine continuous emissions monitoring system Project:

Figure 4 shows the installation of the Fourier Transfer Infrared Spectrometer and Scanning mobility spectrometer with condensate particulate counters systems on the medium speed diesel engine. The engine was run on USLD Diesel to and demonstrate the operation of the continuous emissions monitoring system and Figure 5 shows some basic emissions outputs for these measurements.

Figure 4: Continuous Emissions Monitoring systeme installed on Medium Speed Diesel

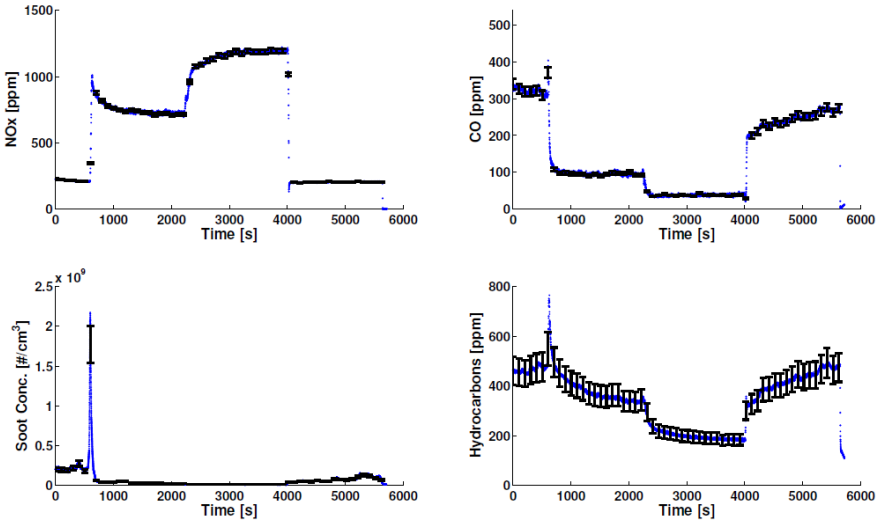

Figure 5: Emissions Measurements on Medium Speed Diesel engine

Project 6: Algae based Glycerin Fuel Project

Summarized accomplishments:

- Developed calibrations for Glycerin in media as a function of refractive index, conductivity and pH for use as a continuous monitoring system indicator for algae farm glycerin production.
- Conducted initial growth experiments with carbonate doping to study the effects of carbon content on algae growth
- Initiated study for salinity shocking to induce algae to excrete glycerin to be collected from the media as fuel

Description of accomplishments for the Algae Glycerin Fuel project:

Figure 6 shows the calibrations for refractive index and conductivity for the concentration of glycerin in the algae growth media. This data is used to calibrate instruments in the algae farm

system for continuous monitoring of glycerin production in the media in real time.

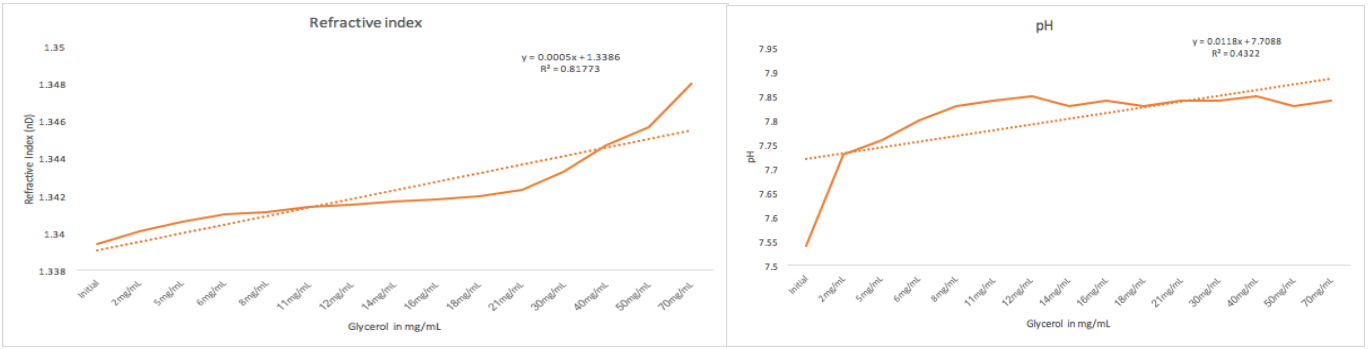

Figure 6. Measurements of refractive index & Ph to media samples with the addition of pure

Project 7: Development of Medium Speed Engine Testing

Summarized accomplishments:

- Laboratory renovations complete
- Complete engine rebuild complete
- Full support systems functionality
- Maine Department of Environmental Protection gaseous and particulate emissions permitting complete
- First client sponsored project is underway
- Second client project is currently being negotiated

We are proud to announce that the Marine Engine Testing and Emission Laboratory has completed commissioning of the new medium-speed diesel engine laboratory. At the heart of the laboratory is a Wärtsilä 6L20 engine capable of 1,020 kW at 900 RPM as seen in Figure 7. The engine is heavy-fuel capable and is the only known engine of its kind dedicated to research and develop projects in a University setting. The engine underwent a complete top-end rebuild and required the installation of multiple support systems including exhaust stack, sea water cooling, heavy-fuel oil processing skid, fuel purification skid, lube oil purification skid, start air compressor, load bank controls, and full instrumentation.

6 new or rebuilt cylinder heads	6 new cylinder liners	All new piston rings
All new piston crowns	All new crankshaft bearings	All new connecting rod bearings
All new piston wrist pins	All new camshaft bearings	Cleaned Charge Air Cooler
All new fuel pumps	New intake and exhaust valves	Cleaned oil pump and passages

Figure 7: Photograph of installed medium-speed engine and ancillary equipment

Completed Systems

The Salt Water (SW) system pulls cooling water from Penobscot Bay at Maine Maritime Academy's waterfront facility and circulates the seawater through two heat exchangers providing low-temperature and high-temperature cooling for the medium-speed engine. The salt water system has been tested and is fully functional and in good working order. The salt water cooling system can be seen in Figure 8. Also seen is the engine start air compressor and receiver. These have also been plumbed to the engine, and are in good working order.

Figure 8: The salt water cooling system

The fuel skid is an important component of the medium-speed engine testing lab. This important piece of equipment allows the operator to switch between fuels and measure the fuel consumption very accurately with the mass flow sensors donated by our industrial partner, Emerson Electric Company. The system is comprised of three (330 gallon) day tanks with independent selection values. The skid uses three Coriolis meters to monitor fuel density, mass flow rate continuously during testing. An inline viscometer monitors fuel viscosity during testing to validate fuel switch operations and ensure proper fuel heating. The logic systems have been tested for functionality and work properly. Figure 9 shows the completed fuel skid. The fuel skid also features a 15 kW electric heater that will be the main heat source to bring the heavy fuels (350 to 700 cSt) up to temperature to reduce its viscosity to the allowable range of the engine and its injection system.

Figure 9: Photograph of fuel handling skid equipped with heat tracing, mass flow controller and viscosity monitors.

The fuel tank gallery has been completed and installed on the day tank mezzanine. There are three tanks (330 gallons each) installed on this mezzanine, one each for a dedicated fuel service of ultra-low sulfur diesel, the desired test fuel, and a heavy fuel tank. The heavy fuel tank is equipped with an electric heater to maintain the temperature of the heavy fuel to a viscosity that allows the fuel to be pumped into the fuel skid. These three tanks are piped into a common manifold into the fuel skid. The fuel tank gallery, along with the fuel skid, is seen in Figure 10.

Figure 10: Fuel tankage mezzanine with fuel handling skid in the foreground

The emissions equipment, including an MKS FTIR and Bechtel CPC/SEMS equipment is installed to monitor gas-phase and soot emissions during testing. The data acquisition utilizes a custom National Instruments interface and programmed using LabVIEW.

Project 8: Sustainability Education and Laboratory Training for Workforce Enhancement
Summarized accomplishments:

- New Environmental Sustainability Minor successfully adopted and approved at Maine Maritime Academy. Two of the classes required for this minor were successfully offered in Fall semester 2016: "Intro to Environmental Sustainability" and "Renewable Energy"

MMA's Engineering Department also recently developed an Environmental Science Minor comprised of six new courses. This minor combines thermodynamics and other key STEM classes that utilize the new labs as key training tools for workforce development in mitigating and remediating transportation related environmental concerns.

Project 9: Efficiency Improvement of Workboats through Hull Form Optimization
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 summarized accomplishments for the reporting period are:

- Successful grant for the construction of a half-scale technology demonstrator at The Landing School in Arundel, Maine. Grant includes funds for engineering, workforce development, and construction cost for 22 ft. prototype.

- Completion of detailed structural calculations for the 38 ft. fishing boat.
- Redesign of sidehull geometry to meet CFR 46 stability criteria.
- New concept design applying the technology to coastal ferries.

Description of Results for Workboat Hull Form Optimization:

To further reduce risk on a radical new hull design, MMA will construct a half-scale prototype at The Landing School, to be launched in May 2018. The collaboration has led to the investigation of not only the lifetime emission reduction of the vessel, but to reducing the carbon footprint of the hull itself. The Landing School recently built three 19 foot vessels with near-zero carbon footprint for hull construction. In addition, this opportunity provides significant opportunity for workforce development, as the hull will require new construction techniques and structural arrangements. The total value of the grant is $97,257.

Several technical investigations continue for the project. Engineering calculations for refinement in the areas of stability, maneuvering, seakeeping, and propeller design took place during the performance period. The results will contribute directly to the half-scale prototype.

Notable milestones include completion of the structural calculations for the 38 ft. fishing vessel, redesign of the sidehull geometry to meet relevant stability criteria, and concept design of a coastal ferry based on the trimaran hull form. The stability improvement for the new sidehull geometry are shown in Figure 11. The righting arm curve for the original sidehull geometry exhibited significant drop-off in righting energy at low angles of heel, resulting in unusual roll motions. The new geometry increases cumulative righting energy by up to 55% at small angles, allowing the vessel to meet the stability criteria for CFR 46 170.173, the weather criteria for vessels of unusual form.

Sketches of the technology demonstrator are shown in Figures 12 and 13. Figure 12 shows the prototype at scale with the original fishing vessel. Figure 13 shows the construction sub-assemblies that will be built at The Landing School, demonstrating the critical horizontal hull panel joining the upper and lower hull components.

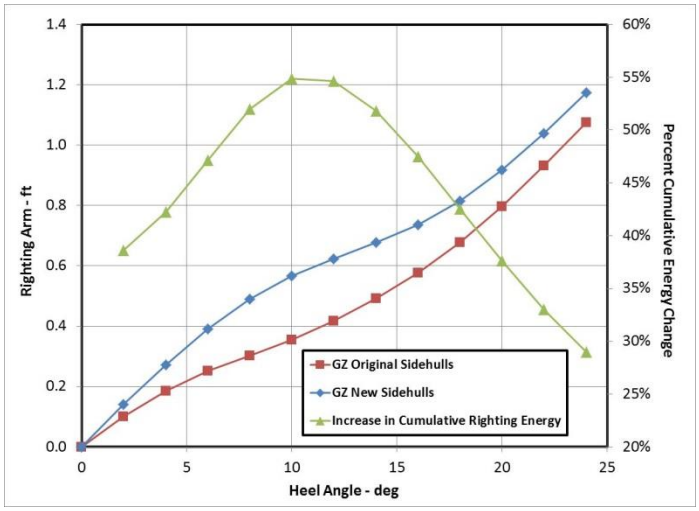

Figure 11: Improvement in righting energy due to new sidehull geometry, allowing vessel to meet CFR 46 170.173 weather stability criteria for vessels of unusual form.

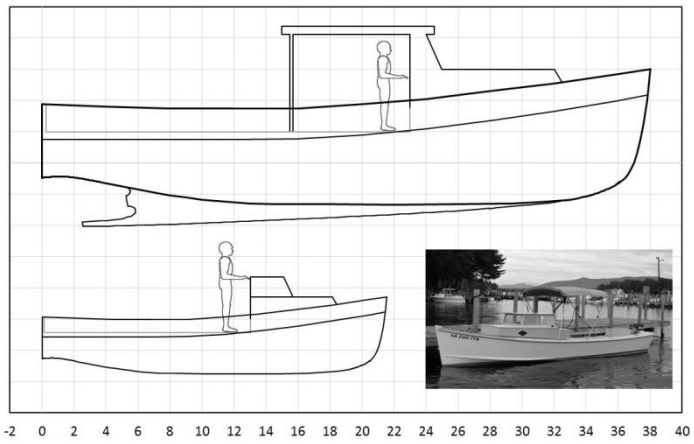

Figure 12: Comparison of fishing vessel design with technology demonstrator.

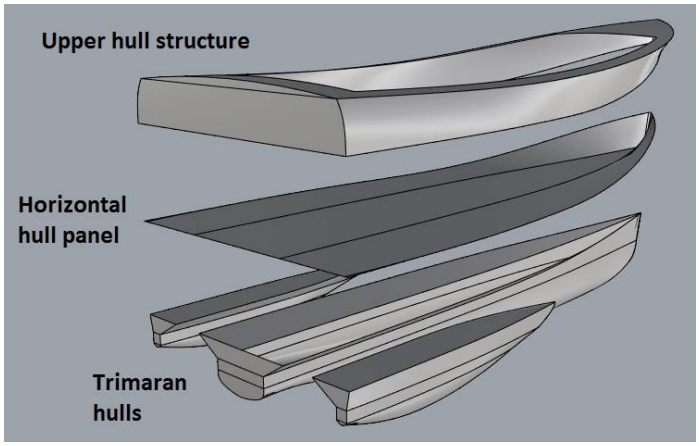

Figure 13: Construction breakdown of demonstrator to be built at The Landing School.

Education, Workforce development and STEM accomplishments

STEM Events:
Maine Maritime Academy is preparing plans to develop a STEM center on campus to inspire, engage, and educate students to prepare them for careers in maritime transportation. Plans are anticipated to be completed in July 2017 and funding development activities will commence in September 2017.

The medium-speed engine lab project provided hands-on learning for approximately 28 engineering students to assist in the design, construction, maintenance and operation of the laboratory systems. The students worked intermittent shifts with duties running parallel with their USCG licensing track and academic responsibilities.

In addition, METEL supported two part time student assistants.

Significant Results:
None to report at this time

Key Outcomes:
How have the results been disseminated?
Project 1: Diesel/Glycerin Emulsion fuel project
- One conference paper was published

Project 2: Hydrogen Injection Fuel Project
- Nothing to report for this period

Project 3: Forest Biomass Diesel fuel project
- Two articles were published in refereed journals

Project 4: Thermoelectric Exhaust heat recovery generator project
- Nothing to report for this period

Project 5: Continuous Emissions Monitoring System
- Nothing to report for this period

Project 6: Algae Based Glycerin fuel project
- Nothing to report for this period

Project 7: Development of Medium Speed Engine Testing
- Nothing to report for this period

Project 8: Sustainability Education and Laboratory Training for Workforce Enhancement
- Nothing to report for this period

Project 9: Efficiency Improvement of Workboats through Hull Form Optimization
- Nothing to report for this period

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
- Submit article to refereed journal on results of latest emulsion fuel testing focused on changes in soot composition and chemistry

Project 2: Hydrogen Injection Fuel Project

- Vary concentration of Hydrogen and monitor effects in Lab Dyno (on direct injection engine)
- Look at data from in-cylinder pressure monitoring in Lab Dyno(on direct injection engine)
- Conclude Hydrogen project

Project 3: Forest Biomass Diesel fuel project

- Hydro-treat 10 L of TDO oil for fractionation and blending
- Blend fractionated crude TDO oil for delivery to MMA
- Conduct economic sensitivities to distributed pre-processing of pyrolysis feedstocks for centralized pyrolysis processes
- Recruit a graduate student to work on either TDO or pyrolysis

Project 4: Thermoelectric Exhaust heat recovery generator project

- Future experiments will focus on producing materials with smaller, more uniform nanoparticles and on controlling annealing conditions to prevent oxidation and maximize electrical conductivity.

Project 5: Continuous Emissions Monitoring System

- Operate continuous emissions monitoring system during medium-speed engine operations and correlate engine-out emissions with local gas compositions.

Project 6: Algae Based Glycerin fuel project

- Utilize GCMS to measure the extracellular concentrations of glycerol and other dissolved organic compounds.

Project 7: Development of Medium Speed Engine Testing

- Complete initial client testing procedures and close out the project.

Project 8: Sustainability Education and Laboratory Training for Workforce Enhancement

- Continue STEM outreach activities with existing working groups

Project 9: Efficiency Improvement of Workboats through Hull Form Optimization

- Completion of detailed structural calculations for the 38 ft. fishing boat.
- Redesign of sidehull geometry to meet CFR 46 stability criteria.
- New concept design applying the technology to coastal ferries

Education, Workforce development and STEM:

- Developing STEM education center at Maine Maritime Academy who will collaborate with local stakeholders, including the Maine Ocean School, local High Schools to increase the number of interested young people in transportation careers.

2. PRODUCTS: What has the program produced?

Publications, conference papers, and presentations

Journal publications:

Project 1: Diesel/Glycerin Emulsion fuel project

- R.W. Kimball, B.G. Sarnacki, S.J. Eaton, J.A. Henry, T. Wallace and T. Lokocz. "Diesel Engine Emissions/Performance of Emulsion Marine Fuels". *Proceedings of the 17th Annual General Assembly of the International Association of Maritime Universities (IAMU AGA 17)* 2016.
- Two journal articles are currently in preparation

Project 2: Hydrogen Injection Fuel Project

- Nothing to report

Project 3: Forest Biomass Diesel fuel project

- S.J. Eaton and M.C. Wheeler. "Reactions and Kinetics of Alkaline-Earth Metal Levulinate and Formate Salt Decomposition". *Sustain. Chem. Eng.* **2017** 5(4), 3039-3045
- Carrasco, J.L., S. Gunukula, A.A. Boateng, C.A. Mullen, W.J. DeSisto, and M.C. Wheeler, Pyrolysis of forest residues: An approach to techno-economics for bio-fuel production, Fuel 193 (2017) 477-484.

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: Nothing to report

Other publications, conference papers and presentations: Oral/Poster Presentations: Nothing 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. It is kept current and updated minimally on a monthly basis.

Technologies or techniques Nothing to Report
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 (Full time)
# Hours worked during reporting period	1040 hrs
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	Dr. Brendyn Sarnacki
Program/Project Role	Research Engineer (Full time)
# Hours worked during reporting period	1040 hours
Contribution to Program/Project	METEL Research Engineer for all projects
Funding support	DOT UTC
Collaborated with individual in foreign country	No

Name	Travis Wallace
Program/Project Role	Research Engineer (Full time)
# Hours worked during reporting period	1040 hours
Contribution to Program/Project	METEL Research Engineer for all projects
Funding support	DOT UTC
Collaborated with individual in foreign country	No

Name	Richard Smith
Program/Project Role	Research Engineer (Part time)
# Hours worked during reporting period	420 hours
Contribution to Program/Project	METEL Research Engineer for all projects
Funding support	DOT UTC
Collaborated with individual in foreign country	No

Name	Dr. Joshua Henry
Program/Project Role	Research Engineer (Part Time)
# Hours worked during reporting period	520 hours
Contribution to Program/Project	METEL Research Engineer; TEG project and STEM Algae project
Funding support	DOT UTC
Collaborated with individual in foreign country	No

Name	Dr. Scott Eaton
Program/Project Role	METEL Senior Personnel, all projects
# Hours worked during reporting period	540
Contribution to Program/Project	Mechanisms of TDO, Emulsion Fuels
Funding support	DOT UTC 1 month (DOT)
Collaborated with individual in foreign country	No

Name	Dr. Clay Wheeler
Program/Project Role	UMaine Co-P.I.
# Hours worked during reporting period	202
Contribution to Program/Project	Lead P.I. for UMaine effort; Leading the TDO/FAsP project at UMaine
Funding support	0 month (DOT), 1.2 month (UMaine)
Collaborated with individual in foreign country	No

Name	Dr. William DeSisto
Program/Project Role	UMaine Senior Personnel
# Hours worked during reporting period	168
Contribution to Program/Project	Co- P.I. for UMaine effort; Co-supervising graduate student research.
Funding support	0 month (DOT) 1.0 month (UMaine)
Collaborated with individual in foreign country	No

Name	Nathan Hill
Program/Project Role	UMaine Research Technician
# Hours worked during reporting period	520
Contribution to Program/Project	Equipment design and fabrication. Production of TDO oil.
Funding support	3 month (DOT) 0 month (UMaine)
Collaborated with individual in foreign country	No

Name	Mubarak Khleewee

Program/Project Role	M.S. Student
# Hours worked during reporting period	520
Contribution to Program/Project	HDO of FAsP oil
Funding support	0 month (DOT) 0 month (UMaine)
Collaborated with individual in foreign country	No

Name	Abdulazeez Khleewee
Program/Project Role	M.S. Student
# Hours worked during reporting period	520
Contribution to Program/Project	HDO of phenol
Funding support	0 month (DOT) 0 months (UMaine)
Collaborated with individual in foreign country	No

Name	Raliat Alabi
Program/Project Role	M.S. Student
# Hours worked during reporting period	260
Contribution to Program/Project	High Pressure Pyrolysis
Funding support	3 month (DOT) 0 month (UMaine)
Collaborated with individual in foreign country	No

Name	Karl Olson
Program/Project Role	M.S. Student
# Hours worked during reporting period	520
Contribution to Program/Project	Alternative uses for glycerol
Funding support	6 month (DOT) 0 month (UMaine)
Collaborated with individual in foreign country	No

What other organizations have been involved as partners?
Organization: SeaChange Group LLC (SCG) , Brunswick Maine
Contribution to Project: SCG is providing the Diesel/Glycerin Emulsion fuels for testing in MMA's test engines and marine vessels. They finished their contract on 12/31/2016 to supply glycerin/diesel emulsion fuels and assist with testing at METEL

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?
Nothing to Report
What is the impact on other disciplines?
Nothing to Report
What is the impact on the development of transportation workforce development?

Nothing to Report

What is the impact on physical, institutional, and information resources at the university or other partner institutions?

Physical resources such as facilities, laboratories, or instruments;

What is the impact on technology transfer? Nothing to Report

What is the impact on society beyond science and technology? Nothing to Report

5.CHANGES/PROBLEMS

Nothing to report

6. SPECIAL REPORTING REQUIREMENTS

Nothing to report