5. Materials Technology

The Vehicle Technologies Office (VTO) supports research, development, demonstration, and deployment (RDD&D) of new, efficient, and clean mobility options that are affordable for all Americans. The office's investments leverage the unique capabilities and world-class expertise of the national laboratory system to develop new innovations in vehicle technologies, including: advanced battery technologies; advanced materials for lighter-weight vehicle structures and better powertrains; energy-efficient mobility technologies and systems (including automated and connected vehicles as well innovations in connected infrastructure for significant systems-level energy efficiency improvement); innovative powertrains to reduce greenhouse gas (GHG) and criteria emissions from hard to decarbonize off-road, maritime, rail, and aviation sectors; and technology integration that helps demonstrate and deploy new technology at the community level. In coordination with the other offices across the Office of Energy Efficiency and Renewable Energy (EERE) and the U.S. Department of Energy (DOE), VTO advances technologies that assure affordable, reliable mobility solutions for people and goods across all economic and social groups; enable and support competitiveness for industry and the economy/workforce; and address local air quality and use of water, land, and domestic resources. The Materials Technology subprogram supports VTO's goals of achieving 100% decarbonization of the transportation sector by 2050. This ambitious goal will be realized through the increased deployment of electric and hydrogen fuel cell vehicles. Materials play a significant role in increasing the efficiency of electric vehicles (EVs) through weight reduction and enabling faster charging and sensing technologies. The materials research also contributes to the goal of reducing GHG emissions and recyclability, helping reduce the overall embodied energy of vehicles.

Lightweight Materials activities support national laboratory, academia, and industry-led research in advanced high-strength steels, aluminum (Al) alloys, magnesium (Mg) alloys, carbon fiber (CF) composites, and multi-material systems. This includes projects addressing materials and manufacturing challenges spanning from atomic structure to assembly, with an emphasis on establishing and validating predictive modeling tools for materials applicable to light-duty and heavy-duty vehicles.

Lightweight Materials activities support these VTO program level goals:

- Enable a 25% weight reduction for light-duty vehicles including body, chassis, and interior as compared to a 2020 baseline by 2030, without significantly increasing costs; and
- Develop lightweight alloys with improved strength and fatigue performance for cast and additive manufacturing (AM) methods resulting in a 25% weight reduction in powertrain and suspension components by 2030.

Powertrain Materials activities similarly support research to develop higher performance materials needed by electric and hydrogen fuel cell vehicles to increase efficiency and decrease manufacturing cost, helping transition to all electric light duty vehicles by 2035. Weight reduction and electric powertrain system efficiency improvements for heavy-, medium-, and light-duty vehicles are being advanced through this work, addressing challenging components such as inverters, motors, and geartrains. Current priority focus areas for the subprogram include: (1) lightweight alloys with high fatigue strength for suspension components, (2) high-temperature materials for lighter brakes, (3) predictive models for powertrain materials, and (4) Integrated Computational Materials

Engineering (ICME) tools that use high-performance computing capabilities, multi-length scale (atoms to components) material models, and boundary layer resolved thermo-kinetic models.

Project Feedback

In this merit review activity, each reviewer was asked to respond to a series of questions, involving multiple-choice responses, expository responses where text comments were requested, and numeric score responses (on a scale of 1.0 to 4.0). In the pages that follow, the reviewer responses to each question for each project will be summarized: the multiple choice and numeric score questions will be presented in graph form for each project, and the expository text responses will be summarized in paragraph form for each question. A table presenting the average numeric score for each question for each project is presented below. If a reviewer believed that no score was needed, not applicable (N/A) is used.

Table 5-1 – Project Feedback

Project ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplish-ments	Collaboration	Future Research	Weighted Average
MAT146	Ultra-Lightweight Ductile Carbon Fiber Reinforced Composites	Seokpum Kim (Oak Ridge National Laboratory)	5-11	3.38	3.38	2.88	3.00	3.28
MAT159	Cost Effective Lightweight Alloys for Electric Vehicle Propulsion - Fundamental Fatigue and Creep in Advanced Lightweight Alloys	Amit Shyam (Oak Ridge National Laboratory)	5-15	3.63	3.50	3.00	3.17	3.45
MAT160	Cost Effective Lightweight Alloys for Electric Vehicle Propulsion - Hybrid Dispersion Strengthened Al Matrix Composites for Higher Efficiency EV powertrains	Mert Efe (Pacific Northwest National Laboratory)	5-20	3.40	3.50	3.10	3.00	3.41
MAT174	Carbon Fiber Technology Facility (CFTF)	Merlin Theodore (Oak Ridge National Laboratory)	5-25	3.00	2.83	3.17	2.67	2.90

Project ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplish-ments	Collaboration	Future Research	Weighted Average
MAT196	High-Temperature Carbon Fiber Carbonization via Electromagnetic Power	Felix Paulauskas (Oak Ridge National Laboratory)	5-29	3.33	3.67	2.83	2.00	3.40
MAT197	Multi-Functional Smart Structures for Smart Vehicles	Patrick Blanchard (Ford Motor Company)	5-33	3.75	3.75	3.75	3.33	3.71
MAT198	Development of Tailored Fiber Placement Multi-Functional High-Performance Composite Material Systems for High Volume Manufacture of Structural Battery Enclosure	Venkat Aitharaju (General Motors Company)	5-38	3.67	3.67	3.67	3.67	3.67
MAT199	Ultra-Lightweight Thermoplastic Polymer/Polymer Fiber Composites for Vehicles (Inter-Lab Project)	Kevin Simmons (Pacific Northwest National Laboratory)	5-43	3.67	3.50	3.00	3.00	3.46
MAT200	Additive Manufacturing for Property Optimization for Automotive Applications	Seokpum Kim (Oak Ridge National Laboratory)	5-47	3.00	3.00	3.20	2.90	3.01
MAT202	3D-Printed Hybrid Composite Materials with Sensing Capability for Advanced Vehicles	Rigoberto Advincula (Oak Ridge National Laboratory)	5-52	2.88	2.50	2.75	2.75	2.66
MAT203	Low-Cost High-Throughput Carbon Fiber with Large Diameter	Felix Paulauskas (Oak Ridge National Laboratory)	5-56	3.38	3.38	3.38	3.50	3.39

Project ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplish-ments	Collaboration	Future Research	Weighted Average
MAT205	Adopting Heavy-Tow Carbon Fiber for Repairable Stamp-Formed Composites	Amit Naskar (Oak Ridge National Laboratory)	5-61	2.88	3.00	2.88	2.17	2.88
MAT206	Soft Smart Tools Using Additive Manufacturing	Matthew Craps (Savannah River National Laboratory)	5-65	3.50	3.50	3.50	3.38	3.48
MAT207	Multi-Material Functional Composites with Hierarchical Structures	Christopher Bowland (Oak Ridge National Laboratory)	5-69	3.50	3.50	3.13	N/A	3.45
MAT208	Efficient Synthesis of Kevlar and Other Fibers from Polyethylene Terephthalate (PET) Waste	Daniel Merkel (Pacific Northwest National Laboratory)	5-72	3.50	3.67	3.00	3.25	3.51
MAT209	Bio-based Inherently Recyclable Epoxy Resins to Enable Facile Carbon-Fiber Reinforced Composites Recycling	Nicholas Rorrer (National Renewable Energy Laboratory)	5-76	3.38	3.50	3.25	3.25	3.40
MAT211	Sustainable Lightweight Intelligent Composites (SLIC) for Next-Generation Vehicles	Masato Mizuta (Newport Sensors Inc.)	5-80	3.40	3.60	3.80	3.50	3.56

Project ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplish-ments	Collaboration	Future Research	Weighted Average
MAT212	Integrated Self-Sufficient Structurally Integrated Multifunctional Sensors for Autonomous Vehicles	Amrita Kumar (Acellent Technologies Inc.)	5-84	3.30	3.30	3.10	3.25	3.26
MAT221	Lightweight and Highly Efficient Engines Through Al and Si Alloying of Martensitic Materials	Dean Pierce (Oak Ridge National Laboratory)	5-88	3.88	3.88	3.75	3.67	3.84
MAT222	Extending Ultrasonic Welding Techniques to New Material Pairs	Jian Chen (Oak Ridge National Laboratory)	5-93	3.25	3.13	2.88	2.50	3.05
MAT223	Extending High-Rate Riveting to New Material Pairs	Kevin Simmons (Pacific Northwest National Laboratory)	5-97	2.25	3.50	2.50	2.00	2.88
MAT224	Solid State Joining of Multi-Material Autobody Parts Toward Industry Readiness	Piyush Upadhyay (Pacific Northwest National Laboratory)	5-100	3.13	3.13	3.00	3.00	3.10
MAT225	Surface Modifications for Improved Joining and Corrosion Resistance	Yong Chae Lim (Oak Ridge National Laboratory)	5-104	3.17	3.50	3.50	2.83	3.33
MAT226	Machine Learning for Joint Quality and Control	Keerti Kappagantula (Pacific Northwest National Laboratory)	5-107	3.50	3.63	3.50	3.50	3.56

Project ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplish-ments	Collaboration	Future Research	Weighted Average
MAT231	Lightweight Metals Core Program Introduction	Glenn Grant (Pacific Northwest National Laboratory)	5-111	3.75	3.75	3.88	4.00	3.77
MAT235	Lightweight Metals Core Program - Thrust 4 - Residual Stress Effects	Ayoub Soulami (Pacific Northwest National Laboratory)	5-114	3.25	3.38	3.38	3.00	3.33
MAT236	Advanced Characterization and Computational Methods	Thomas Watkins (Oak Ridge National Laboratory)	5-117	3.75	3.88	3.25	3.25	3.69
MAT237	Materials Lubricants and Cooling for Heavy Duty Electric Vehicles	Jun Qu (Oak Ridge National Laboratory)	5-122	3.50	3.83	3.33	3.67	3.67
MAT241	Advanced Processing and Additive Manufacturing for EV Propulsion Advanced Ceramics and Processing for Wireless Charging Systems	Beth Armstrong (Oak Ridge National Laboratory)	5-126	3.75	3.50	3.00	3.50	3.50
MAT242	Advanced Processing and Additive Manufacturing for EV Propulsion Novel Ultra High Conductivity Composites for EVs	Tolga Aytug (Oak Ridge National Laboratory)	5-129	3.50	3.75	3.88	3.63	3.69

Project ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplish-ments	Collaboration	Future Research	Weighted Average
MAT243	Manufacturing Demonstration of a Large-scale Multi-material Passenger Vehicle Sub-system	Srikanth Pilla (Clemson University)	5-134	3.33	2.67	3.00	2.17	2.81
MAT244	Lightweight Metals Core Program P1A - Sheet Materials with Local Property Variation	Scott Whalen (Pacific Northwest National Laboratory)	5-137	3.60	3.70	3.50	3.00	3.62
MAT245	Lightweight Metals Core Program P1B - Form-and-Print - AM for Localized Property Enhancement of High-strength Al sheet	Alex Plotkowski (Oak Ridge National Laboratory)	5-141	3.50	3.25	3.50	3.50	3.41
MAT246	Lightweight Metals Core Program P1C - Local Thermomechanical Processing to Address Challenges to Implementing High Strength Al Sheet	Mert Efe (Pacific Northwest National Laboratory)	5-144	3.67	3.50	3.50	N/A	3.55
MAT247	Lightweight Metals Core Program P2A - Solid Phase Processing of Aluminum Castings	Saumyadeep Jana (Pacific Northwest National Laboratory)	5-147	3.75	3.75	3.50	N/A	3.71
MAT248	Lightweight Metals Core Program P2B - High Intensity Thermal Treatment	Aashish Rohatgi (Pacific Northwest National Laboratory)	5-150	3.00	3.00	3.50	N/A	3.07

Project ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplish-ments	Collaboration	Future Research	Weighted Average
MAT249	Lightweight Metals Core Program P2C - Cast-and-Print - AM for Localized Property Enhancement of Al castings	Alex Plotkowski (Oak Ridge National Laboratory)	5-152	3.50	3.25	3.25	3.00	3.31
MAT250	Lightweight Metals Core Program P3A - Cast Magnesium Local Corrosion Mitigation	Vineet Joshi (Pacific Northwest National Laboratory)	5-155	3.75	3.50	3.25	N/A	3.54
MAT251	Lightweight Metals Core Program P3B - Thermomechanical Property Modification of Magnesium Castings	Mageshwari Komarasamy (Pacific Northwest National Laboratory)	5-159	3.25	3.25	3.38	3.50	3.27
MAT252	Lightweight Metals Core Program - Thrust 4 - Materials Lifecycle	Jeff Spangenberger (Argonne National Laboratory)	5-163	3.10	3.10	2.90	3.25	3.09
MAT254	Conductive Lightweight Hybrid Polymer Composites from Recycled Carbon Fibers	Yinghua Jin (Rocky Tech Ltd.)	5-167	3.00	3.13	3.25	3.00	3.08
MAT257	Changing the Design Rules of Rubber to Create Lighter Weight More Fuel-Efficient Tires	Kurt Swogger (Molecular Rebars LLC)	5-170	3.40	3.50	3.30	3.38	3.44
MAT265	Low-Cost Multifunctional Composites from Recycled Materials for Lighter and Smarter Vehicles	Xiaodong Li (University of Virginia)	5-174	3.20	3.30	3.50	3.20	3.29

Project ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplish-ments	Collaboration	Future Research	Weighted Average
MAT266	Development and Manufacturing of Multifunctional Energy Storage Composites (MESC) for Automotive Vehicles	Amrita Kumar (Acellent Technologies Inc.)	5-179	3.67	3.50	3.50	3.50	3.54
MAT267	Multiscale Bioinspired Enhancement of Natural-Fiber Composites for Green Vehicles	Lorenzo Mencattelli (Helicoid Industries Inc.)	5-182	3.20	2.80	3.50	3.10	3.03
MAT268	Upcycling of Polymer Composites for Vehicle Decarbonization	Roger Crane (Composites Automation LLC)	5-186	3.30	3.60	3.70	3.10	3.48
MAT269	Producing Multifunctional Automotive Composites with Sustainable Plant Based Graphene	Daniel Mulqueen (Climate Robotics LLC)	5-190	2.50	2.75	3.13	2.67	2.73
MAT280	Materials and Manufacturing Innovation for Sustainable Automotive Composites: Thrust 1 - Innovative Low-Cost Carbon Fiber and Alternative Fiber Technologies	Amit Naskar (Oak Ridge National Laboratories)	5-194	3.38	3.25	3.00	3.25	3.25

Project ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplish-ments	Collaboration	Future Research	Weighted Average
MAT281	Materials and Manufacturing Innovation for Sustainable Automotive Composites: Thrust 2 - Multi-functional Materials and Structures	Christopher Bowland (Oak Ridge National Laboratories)	5-198	3.25	3.13	3.38	3.00	3.17
MAT282	Materials and Manufacturing Innovation for Sustainable Automotive Composites: Thrust 3 - Circularity and Sustainability of Polymer Composites	Kevin Simmons (Pacific Northwest National Laboratory)	5-202	3.63	3.75	3.38	3.63	3.66
MAT283	Materials and Manufacturing Innovation for Sustainable Automotive Composites: Thrust 4 - Polymeric Materials and Their Composites in Additive Manufacturing	Vlastimil Kunc (Oak Ridge National Laboratories)	5-208	3.17	3.00	3.17	3.00	3.06
Overall Average				3.36	3.38	3.28	3.12	3.34

Presentation Number: MAT146
Presentation Title: Ultra-Lightweight Ductile Carbon-Fiber Reinforced Composites
Principal Investigator: Seokpum Kim, Oak Ridge National Laboratory

Presenter

Seokpum Kim, Oak Ridge National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 75% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 25% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

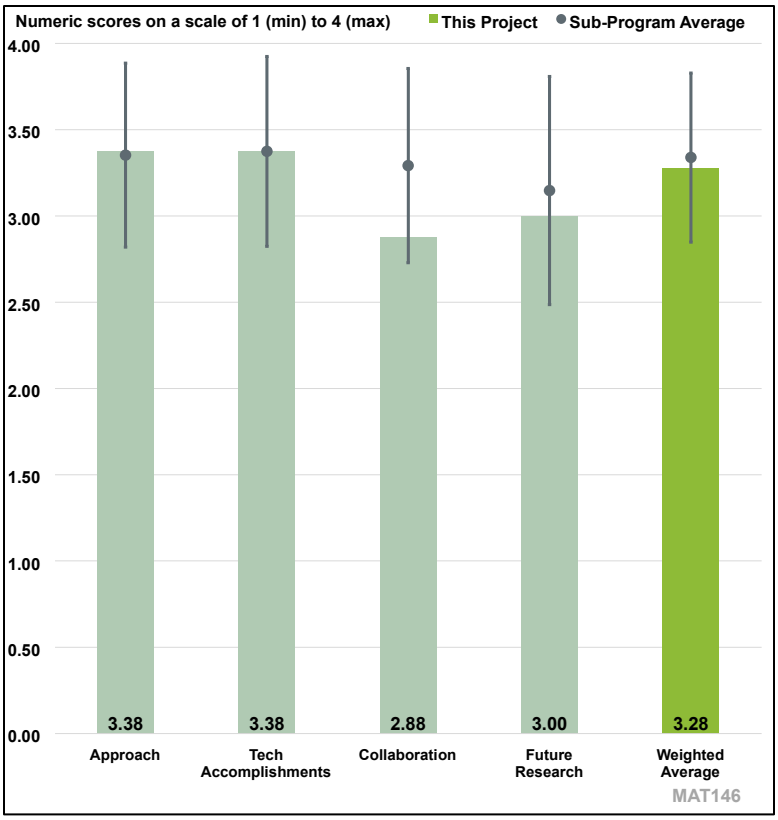

Figure 5-1. Presentation Number: MAT146 Presentation Title: Ultra-Lightweight Ductile Carbon-Fiber Reinforced Composites Principal Investigator: Seokpum Kim, Oak Ridge National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer stated that the presentation listed various technical barriers, and the team addressed the challenges with a well-planned and articulated technical approach. The well-designed micro-hierarchical architecture of the structures has helped to achieve higher mechanical properties out of a low-density material. However, there are some other technical challenges that need to be addressed in the coming year related to improving the accuracy, scale, and speed of the AM technique.

Reviewer 2

The reviewer explained that overall, this work aims to take an ultraviolet curable resin and three-dimensional (3D) print it to form structures that afford both strength and ductility. During the length of the project, the team has scaled up their production from the millimeter scale to the near meter scale. The approach is straightforward and well laid out. The reviewer noted that there are challenges that must be overcome in the work that include maximizing CF loading while still ensuring printability. The researchers also found that the composites were multifunctional because their resistance could be used to calculate their stress response. The reviewer noted that the researchers design in this space demonstrates that they could detect the stress response as a function of

orientation through their design and approach. The reviewer noted to the project team that it would be beneficial to follow the prescribed presentation template format for the Annual Merit Review (AMR) to make sure they are adequately addressing all questions and their approach thoroughly. As an example, no milestone table was shown in this work.

Reviewer 3

The reviewer stated that this project aims to address the technical barrier of designing lower-density materials with suitable mechanical properties, specifically materials with higher strength-to-weight and/or higher stiffness-to-weight ratios. The target is hybrid hierarchical CF-reinforced materials that are ultralight, strong, tough, and suitable for large-scale 3D printing. The reviewer stated that the project is well-designed, and the timeline is reasonably planned.

Reviewer 4

The reviewer agreed the project is well designed with a timeline that is reasonably planned and executed such that the milestones have all been achieved. The reviewer pointed out that the technical barriers have been addressed, and the development of the proposed system can be seen.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer asserted that the project achievements presented are well-aligned with the project milestones. They noted that prototypes have been produced, and samples are evaluated and characterized, which align with the project plan.

Reviewer 2

The reviewer agreed that the project accomplished its goals and demonstrated robust design and a characterization of the developed system. The reviewer noted that the researchers have described the barriers that they encountered in their work. The reviewer added that it would be easier to comment on the project progress if the team followed the presentation template approach prescribed for the AMR to discuss project milestones, go/no-go decisions, and the like.

Reviewer 3

The reviewer acknowledged the presented technical progress demonstrated a well-planned and well-executed project. The reviewer felt that the technical details in the presentation are thorough, and the project delivery is considered very successful.

Reviewer 4

The reviewer asserted that given that all the milestones identified have been achieved, the technical progress on this project has been excellent.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer noted that this project is in one of the four thrust areas and is well-coordinated among the different teams working on the other thrusts. Furthermore, the team has worked in collaboration with Nissan as an industrial partner.

Reviewer 2
The reviewer explained that the team includes Oak Ridge National Laboratory (ORNL) and University of California, Berkeley. The reviewer remarked that the collaboration, skill sets, and coordination have been demonstrated by the successful project delivery.

Reviewer 3
The reviewer noted that the team is at ORNL and thus there is a lot of interaction with that team. Additionally, during the presenter's future remarks, they commented that Nissan is interested in their approach. Otherwise, this was not explicitly addressed. The reviewer concluded by mentioning that the University of California, Berkeley manufactured the machines for this work.

Reviewer 4
The reviewer was critical that no information was presented in the slides on the collaboration between University of California, Berkeley and ORNL (the sponsoring organization). The reviewer commented that the reviewers learned during the question-and-answer period that ORNL provided guidance while University of California, Berkeley performed all the process development. However, it is not clear to the reviewer how the coordination was conducted through the project.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1
The reviewer described that the project proposed to develop multi-functionality for a self-sensing composite material. The preliminary work has been done, and the reviewer expects the team will achieve the proposed future goals.

Reviewer 2
The reviewer stated that the presenter mentioned that their Composite Core Program 2.0 project will work on further scale up and piezo electrics.

Reviewer 3
The reviewer described that the proposed future research includes demonstrating multifunctional self-sensing CF reinforced composites (CFRC) and developing a design and printing method with responsive (piezoelectric), structural (CFRCs or ceramic), and conductive (copper, liquid metal, silver, etc.) architected structures for smart sensing and actuation. This will be conducted in the Composite Core Program 2.0. The reviewer asserted that project has clearly defined the purpose of future work, which is advanced characterization, and the future work is likely to achieve its targets.

Reviewer 4
The reviewer pointed out that given that all the milestones have been achieved and the project is ending soon, the reviewer rated N/A for this question.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1
The reviewer stated the project is relevant because there is work on additive manufacture of high strength materials. The material structure has well-tailored material properties for specified industrial applications. The reviewer stated that with improved resolution, speed and quality, the AM technique can play a vital role in the manufacturing industry.

Reviewer 2

The reviewer agreed that this work is aligned with the DOE VTO Lightweight and Propulsion Materials subprogram's goals. Through their intelligent design, the researchers can use less material and ensure ductility, though the reviewer noted that the ductility was not explicitly shown compared to the strength. The reviewer agreed that this is aligned with the goals of addressing current issues associated with CFRCs.

Reviewer 3

The reviewer acknowledged that the project directly links to the VTO Analysis, Energy Efficient Mobility Systems, and Lightweight and Propulsion Materials subprograms and is considered to support the overall VTO objectives.

Reviewer 4

The reviewer asserted that this project is relevant to the composites research performed in the Lightweight and Propulsion Materials subprogram.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer noted that there are adequate financial, technical and equipment resources for the project.

Reviewer 2

The reviewer stated that the project budget seems sufficient for the work performed.

Reviewer 3

The reviewer noted that the resources seem sufficient to the scope and schedule of the project.

Reviewer 4

The reviewer affirmed that ORNL and University of California, Berkeley provide sufficient and powerful resources from manufacturing to characterization for the project to achieve the stated milestones in a timely fashion.

Presentation Number: MAT159
Presentation Title: Cost Effective Lightweight Alloys for Electric Vehicle Propulsion Fundamental Fatigue and Creep in Advanced Lightweight Alloys
Principal Investigator: Amit Shyam, Oak Ridge National Laboratory

Presenter

Amit Shyam, Oak Ridge National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 75% of reviewers felt that the resources were sufficient, 25% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

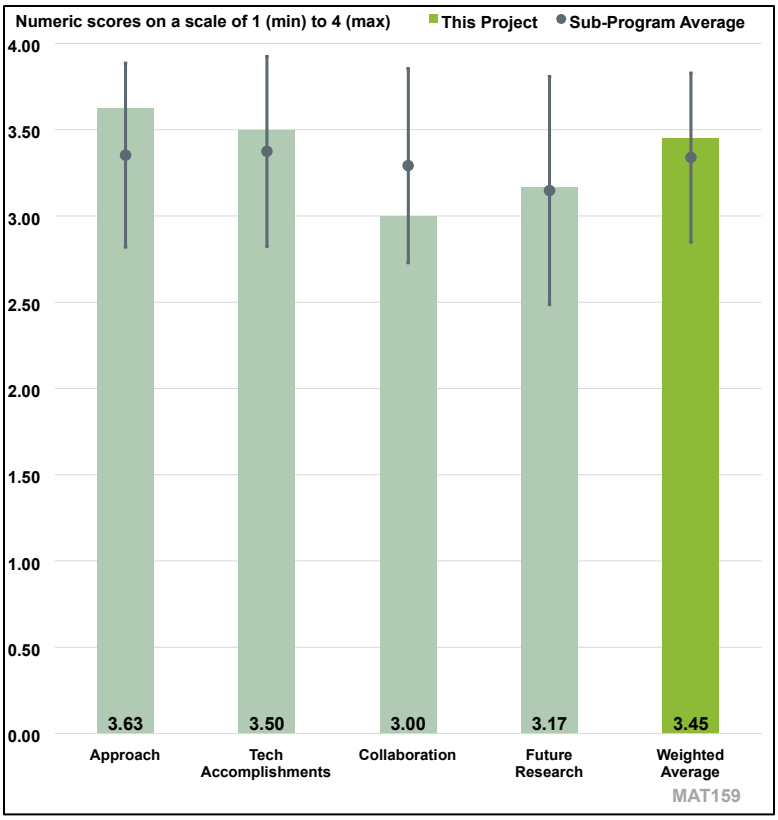

Figure 5-2. Presentation Number: MAT159 Presentation Title: Cost Effective Lightweight Alloys for Electric Vehicle Propulsion Fundamental Fatigue and Creep in Advanced Lightweight Alloys Principal Investigator: Amit Shyam, Oak Ridge National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer stated creep is a common engineering challenge that causes many issues and limits some innovation. The reviewer said the work here is excellent and this project holds potential to create a new space where these issues are controlled and could therefore facilitate additional innovation. The work is well defined and well executed. The publications related to this work will have high impact because this is a fantastic way to increase overall vehicle efficiency, and therefore also increase vehicle range which is the largest impediment to more widespread adoption of electric propulsion. Lightweighting is one of the most effective ways to increase both range and efficiency.

Reviewer 2

The reviewer affirmed the project addresses barriers necessary to enable widespread use of battery electric vehicles (BEVs) once BEVs are more widely available. However, the project does not enable the technology to go to market.

Reviewer 3
The reviewer stated this is a creep mechanism study of aluminum (Al)-copper (Cu)-manganese (Mn)-zirconium (Zr) alloy prepared by casting and AM methods. The team used the classic metallurgical methods to study the alloy's properties as well as the microstructural and phase distributions of the two alloys. The researchers then proposed two hypotheses to explain the observation.

Reviewer 4
The reviewer commented the approach used in this work is adequate to address the question raised by the project and to achieve the goals of the project. The project is adequately designed.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1
The reviewer remarked the project team's work in this space is very high quality. This is a well-executed project that has delivered at each milestone. The work on properties of the Al-Zr-tin (Sn) based electrical conductor alloy is superb and the need to optimize conductors in electric vehicles is critical. The need for lower-weight, higher-efficiency conductors is a large opportunity, and the project team has well documented the need for as well as the capability of this very attractive Al-Zr-Sn alloy.

Reviewer 2
The reviewer praised the project team's excellent work and noted substituting low-cost iron (Fe) for nickel (Ni) and cobalt (Co) will have increasing value as researchers will be competing for the resource with others who need Ni and Co for EV batteries. This is especially true for Co, due to its environmental impact and the political instability of its major producer, the Democratic Republic of Congo.

Reviewer 3
The reviewer stated for the cast sample, the project team found Fe is a cost-effective alternative to Ni and Co, albeit the amount of Cu needs to be increased to balance the Cu consumed by the newly formed Al-Cu-Fe intermetallic phase. The reviewer commented the project team found the AM sample exhibits the highest creep resistance at 400°C for a monolithic Al alloy and attributed the strengthening mechanism to the Orowan strengthening caused by the resistance of hard reinforcement particles to the passing of dislocations and the load-transfer strengthening mechanism that is transferred to the hard intermetallic particles.

Reviewer 4
The reviewer praised the researchers for their excellent work and acknowledged this work focuses on fundamental understanding, which will be used to guide more applied work. The researcher confirmed some questions remain to be answered or addressed in this or subsequent work such as:

(a) Is creep the right degradation mechanism to evaluate the brake rotor materials? The reviewer commented creep is usually good for evaluating materials and components under load at set (or variable) temperatures (usually high) for extended periods of time. Brake rotors are typically under load when brakes are applied, which is usually a matter of seconds. The reviewer would also like additional information regarding why the researchers chose this attribute for materials evaluation.

(b) In the Al-Cu-Mn-Zr (ACMZ) precipitation hardened materials, is creep resistance dependent on the presence of Al-Cu-Fe intermetallic compounds (IMCs)? The reviewer stated the research results

indicate ACMZ precipitation hardened materials will be demonstrably good for creep resistance but may have a negative impact on corrosion resistance. There is a long history documenting the effects of these IMCs on corrosion of the Al matrices. Al-Cu-Fe IMCs tend to cause trenching of the Al-matrix around it. An investigation of the effects of corrosion on rotors made from ACMZ material is warranted to make sure solving one problem (creep) does not inadvertently create another (severe/unacceptable levels of corrosion). This investigation should also be extended to the Al-cerium alloys.

(c) The reviewer acknowledged the last question they would like answered is “How does cost and target properties relate to the fundamental nature of the work as mentioned in (a) and (b) above?” Therefore, the following comment is not as critical as it would have been if the work were fully applied. The reviewer stated, nonetheless it would have been beneficial for the project team to have included an estimated cost of these new materials including a brief comparison with what was already obtained. The cost estimate would have provided researchers pursuing the work for applied purposes an idea of what challenges (if any) to keep in mind as they pursue full commercialization of the products to market. The reviewer also mentioned it would have been helpful for the project team to state the target properties from a performance perspective (e.g., expected operating window, hardness/ductility, wear resistance, corrosion resistance targets, etc.) for this project.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer observed that clearly the project teams all participating strongly and there was good cross company collaboration among these diverse teams.

Reviewer 2

The reviewer commented collaboration between the project teams appeared light and was primarily conducted at ORNL.

Reviewer 3

The reviewer remarked the team partnered with Northwestern University, but the role of the university is not clear.

Reviewer 4

The reviewer stated that the partners listed in this work include ORNL, Northwestern University and NanoAl, a limited liability corporation (LLC). Apart from the high-level task descriptions, this reviewer did not get a sense of the level of coordination between these partners during the presentation. This reviewer can only assume the coordination was adequate and seamless because the work has concluded. The presentation was not focused on showing collaboration, but on addressing progress made in one aspect of the work on brake rotors. The other aspects of the work were not addressed in the latest presentation.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer affirmed the proposed future research is relevant and meaningful. The work has clearly increased the project team’s insight, and they are addressing specific opportunities that can make a

real difference in the speed of the technology to market and increasing environmental conservation without sacrificing mobility.

Reviewer 2
The reviewer verified the proposed work is relevant.

Reviewer 3
The reviewer clarified the team will study the Al-conductor alloy's mechanical behavior in the next phase.

Reviewer 4
The reviewer commented that the possible corrosion issue with the two materials highlighted was not mentioned in the presentation, although the presenting researcher mentioned that it would be good to address this in future work. This reviewer agreed and remarked that other matrices apart from creep resistance should also be investigated or considered for materials that would pass or fail the selection criteria. The areas highlighted by the researcher should also be considered as potential future work areas.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1
The reviewer commented once again, the relevance of this project, as well as the program initiatives, are positioned to be able to allow these talented researchers to deploy technology which has a short runway to production and clear impact. This type of work is fundamental and doing it will have ripple effects in several adjacent areas which also may create new and unique further uses of the science. The project is clearly well aligned to the VTO Materials subprogram and is creating tangible value to the mobility industry.

Reviewer 2
The reviewer expressed many barriers must be overcome for BEVs to gain acceptance in the marketplace. The project addresses concerns once commercial manufacturing occurs.

Reviewer 3
The reviewer stated that the understanding of creep mechanism for the Al alloys will pave the way for the lightweight materials development.

Reviewer 4
The reviewer expressed this work is relevant to developing optimized materials for EV manufacturing and supporting their efficient operation.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1
The reviewer observed resources were indicated to be sufficient, high-quality data was well utilized, and all project milestones were met.

Reviewer 2
The reviewer affirmed resources did not appear to be a concern for the project.

Reviewer 3

The reviewer stated the team received $265,000 per year for the mechanism study and commented this amount is somewhat insufficient.

Reviewer 4

The reviewer remarked the project seems to have been completed without an additional request for funding.

Presentation Number: MAT160
Presentation Title: Cost Effective Lightweight Alloys for Electric Vehicle Propulsion Hybrid Dispersion Strengthened Al matrix composites for higher efficiency EV powertrains
Principal Investigator: Mert Efe, Pacific Northwest National Laboratory

Presenter

Mert Efe, Pacific Northwest National Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 80% of reviewers felt that the resources were sufficient, 20% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

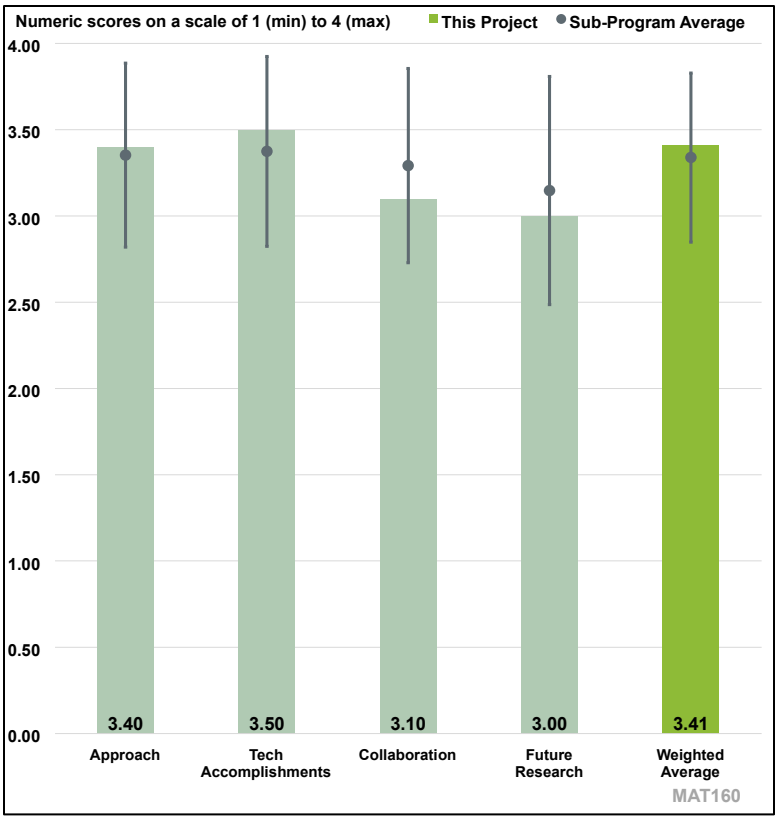

Figure 5-3. Presentation Number: MAT160 Presentation Title: Cost Effective Lightweight Alloys for Electric Vehicle Propulsion Hybrid Dispersion Strengthened Al matrix composites for higher efficiency EV powertrains Principal Investigator: Mert Efe, Pacific Northwest National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer remarked it is a great concept to use an Al metal matrix composite (MMC) to replace cast iron for brake pads. The friction consolidation of Al alloy 7075 with a titanium diboride (TiB_2) strengthening particle is an innovative approach to strengthen the Al alloys.

Reviewer 2

The reviewer said the scope is well documented and explained. Critical barriers are identified and clearly addressed, including cost and the performance of current materials. The challenge is to quantify the net gains available due to the decreased mass to offset the cost differential.

Reviewer 3

The reviewer commented the approach seems to be adequate and addresses most, if not all, technical issues presented in this project.

Reviewer 4

The reviewer said the project reached its objectives and goals in fiscal year (FY) 2023.

Reviewer 5

The reviewer said this project developed two different methods to fabricate an Al metal matrix composite (Al MMC) with various concentrations of TiB_2 flakes. TiB_2 is a ceramic material with relatively high strength and durability. The stir and squeeze casting at Loukus Technologies, Incorporated (Inc.) (LoukusTech) a collaborator, resulted in a lower cost method to compete with cast iron. Pacific Northwest National Laboratory (PNNL) developed a friction consolidation and forging method to create the composite. This method would result in near-net-shapes with high strengths. The reviewer said the project created and benchmarked MMC brake rotors against cast iron to compare characteristics.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer said this project completed all the stated milestones, including the production of a disc-shaped Al-MMC component that contains at least 8% by volume of micron- and submicron-sized reinforcing particles with less than 2% porosity. The team was able to demonstrate the production of composites by two different methods, stir and squeeze casting. The team created Al MMC brake rotors that resulted in a 2.7x lower wear rate than cast iron. Various alloys of the composite showed different coefficients of friction and wear rates. These processes could eventually result in lighter, more rugged brake rotors. The reviewer noted EV applications that use regenerative braking decrease the amount of energy that must be dissipated by the mechanical brakes by as much as 40%, so the thermal properties of an Al MMC would be sufficient. The lower wear rate of these rotors could improve maintenance intervals, lower corrosion rates, and decrease particulate material emissions. The reviewer said using Al MMC to replace cast iron electric motor components could result in considerable weight savings while maintaining strength and durability. The resulting volumetric torque density of an electric motor could potentially be increased by 400%.

Reviewer 2

The reviewer said the project has completed all milestones.

Reviewer 3

The reviewer noted that physical properties of the MMC's were well documented, and their performance was evaluated via bench testing. Grain refinement is a strong asset. The team's high strength Al MMC is a very positive accomplishment. The reviewer noted the effect of the oxidation layer on wear was not defined, this should be understood to see how it effects overall performance. The improved wear resistance compared to cast iron is a great accomplishment for this low weight option.

Reviewer 4

The reviewer noted the project demonstrated a squeeze casting process; validated the superior wear rate of the Al-MMCs; demonstrated the process of friction consolidation of an Al-MMC; and showed the impressive improvement in ultimate tensile strength, modulus, and elongation, albeit at the expense of ductility. But even at a great loss of ductility, for a brake pad application, this loss may not matter much, considering the target is cast iron.

Reviewer 5

The reviewer noted the project concluded in March 2024 and useful technical accomplishments were documented. These results will contribute towards achieving current and future materials development goals for VTO.

The reviewer said some other information that would have been good to know include residual stress and strain profiles of the discs produced on Slides 9-13, and whether other production methods would have been cheaper and faster in achieving/contributing to this goal. A full treatment of the interplay between the friction coefficient and wear rate of the materials evaluated, especially with brake pads optimized for ceramic (rather than for steel) rotors would have been useful as well as quantification of the importance of ductility for the various applications being considered. Low ductility does not necessarily mean that the materials are inadequate or have a performance deficit. This would depend on the application.

The reviewer said the impression given on Slide 15 (80% loss of ductility) seems to suggest that this loss is a performance deficit. The reviewer asked if this is true for all applications, in all cases.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer noted the collaboration between PNNL, ORNL, and LoukusTech gave the appearance that most of the effort was completed by the national laboratories.

Reviewer 2

The reviewer noted that LoukusTech is the industry partner. The team worked synergistically, with PNNL on friction consolidation while LoukusTech worked on the squeeze casting.

Reviewer 3

The reviewer commented coordination amongst the listed partners (PNNL and LoukusTech) seemed to have been adequate.

Reviewer 4

The reviewer remarked PNNL collaborated with LoukusTech to develop the technologies in this project. LoukusTech specialized in a process that can produce a functionally graded preform, placing a higher volume fraction of ceramic in one region, with reduced gradient elsewhere in the MMC. The reviewer said further details were not provided in this presentation.

Reviewer 5

The reviewer said publishing on a partner website does not document equal collaboration by the team. This could be better represented with a better understanding of where each set of data was generated, and where each analysis was performed. As presented, collaboration appears very PNNL-centric.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer said the work has ended and was reported as such.

Reviewer 2

The reviewer said “none,” project reached its objectives and goals in FY 2023.

Reviewer 3

The reviewer said the project has ended by the time of the review.

Reviewer 4
The reviewer commented the only future work proposed includes application of the current results in axial flux motor applications, which is being pursued in what appears to be a new project (Powertrain Materials Core Program 2.0 [PMCP 2.0]), which is focused on permanent magnet production. The reviewer recommended that the comments made in Section 4 should be considered for incorporation, as appropriate, into future work plans.

Reviewer 5
The reviewer stated, “N/A. This project has ended.”.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1
The reviewer remarked that the target values were exceeded for both applications of this technology, indicating there is significant opportunity in this area. This does fit well with the VTO Materials subprogram objectives, as it is simple to draw a direct correlation with the target values and the ability to increase efficiency with deployment.

Reviewer 2
The reviewer commented the project will reduce brake weight.

Reviewer 3
The reviewer said this work is important for its contribution towards optimized lightweighting and powertrain efficiencies in EVs.

Reviewer 4
Accelerating the development of lightweight alloys for EV propulsion for advanced EVs is a major thrust of the VTO Materials PMCP. Cost-effective lightweight alloys made from hybrid-dispersion strengthened Al MMCs has the potential to replace heavier cast iron components in vehicles. Al MMC brake rotors also have the potential to decrease particulate material emissions from brake dust. Al MMCs can offer multifunctionality for compact and high-power density components in gearboxes, electric motors, and differentials.

Reviewer 5
The reviewer said the project tangentially supports the development of BEVs. The work on the gears will have more impact than the rotor work.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1
The reviewer said $600,000 in two years was insufficient to create the Al-MMC materials, but the team managed to succeed.

Reviewer 2
The reviewer remarked resources appeared to be appropriate for the work performed, including sample creation, data generation, and analysis.

Reviewer 3
The reviewer said the project appeared to have the required resources to complete the work.

Reviewer 4
The reviewer commented the project was completed/concluded with the funding provided.

Reviewer 5
The reviewer said funding provided to this project was sufficient to meet the stated goals, milestones, and objectives.

Presentation Number: MAT174
Presentation Title: Carbon-Fiber Technology Facility (CFTF)
Principal Investigator: Merlin Theodore, Oak Ridge National Laboratory

Presenter

Daniel Webb, Oak Ridge National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 67% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 33% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

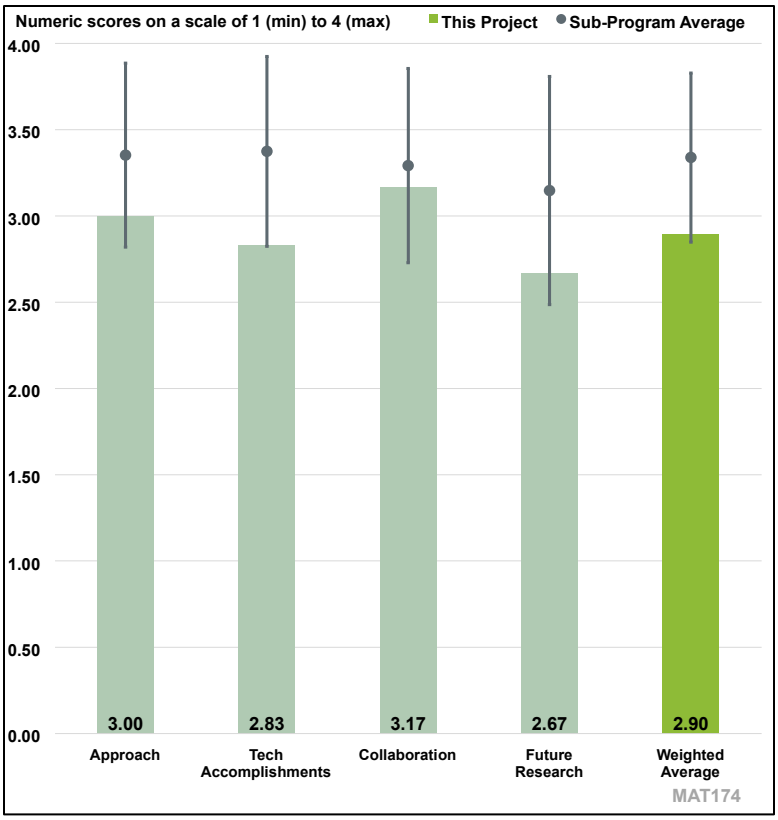

Figure 5-4. Presentation Number: MAT174 Presentation Title: Carbon-Fiber Technology Facility (CFTF) Principal Investigator: Merlin Theodore, Oak Ridge National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer noted that the project clearly presented the technical barriers and how the project is designed to meet those barriers. The motivation behind the approach was clearly communicated. However, the reviewer was confused about the length of this project. The "Overview" slide said the timeline is "Oct. 1, 2013, to present", so the reviewer was unclear if the work presented is just a one-year project. Also, the budget says "$1 million up to FY23" even though this project is presented in FY 2024, and the budget table lists much more money than $1 million. The reviewer asserted that in future AMR presentations, the researchers should clarify the exact funds for the project that is presented. The reviewer also remarked that it would also be better to have a research and development (R&D) staff member with more technical expertise to present the project at the next AMR.

Reviewer 2

The reviewer expressed that high quality mesophase pitch is critical for production of high-performance CFs. Deriving pitch from halogenated wastes secures the supply chain, decarbonizes the domestic CF industry, and achieves circularity. The reviewer praised that the project is well-

designed, and that the timeline is reasonably planned. The facility is critical for scaling up and technology transition to industry through industry partners.

Reviewer 3

The reviewer agreed that the project has made certain progress in addressing various challenges, however, there are still existing challenges that need to be addressed.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer asserted that the project is on track and making progress, adding that the newly built reactor processed 20 grams of isotropic pitch (a critical step) that will be further derived into the mesophase (50%) for the precursor fiber. The plan to scale up and lower the cost is promising. The reviewer highlighted that the process has low carbon emission compared to the traditional mesophase pitch production.

Reviewer 2

The reviewer noted that the project has multiple objectives under developing a low-cost CF fabrication method, however, the progress of the project appears to be ahead of schedule.

Reviewer 3

The reviewer indicated that satisfactory progress has been made to date for creating a reactor that converts the isotropic pitch to mesophase pitch, and all the milestones have been achieved. This project has shown satisfactory progress to start scaling up the process as outlined. However, due to this being a $1 million project, the reviewer expected a bit more to be accomplished and a bit more analysis of the pitch that was converted to show the homogeneity of the final product and how the mesophase content is quantified to validate that the reactor design is appropriate. The reviewer mentioned that the presentation was lacking data for characterizing the product after going through the reactor.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer noted that collaboration with one industrial partner, JR Automation, was mentioned for performing the design and scale-up of the developed process. The reviewer expressed that one thing that should have been addressed is the deadline date for JR Automation to deliver the reactors to show how the date fits into the project timeline.

Reviewer 2

The reviewer commented that the project is run through a collaboration between multiple stakeholders, including ORNL and University of Tennessee.

Reviewer 3

The reviewer pointed out that the project resulted in intellectual property and that the team will utilize existing collaborative partnerships in pitch and graphite foam to help the technology transition to industry. After scaling up, the mesophase pitch is anticipated to be of low cost and low carbon emission.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer stated that the future research is well-planned with clearly defined deliverables and timelines. With the success of a newly built reactor, the future work will achieve the project targets. The scaling up is going to help further reduce the cost.

Reviewer 2

The reviewer commented that the proposed future work was discussed in a couple bullets on the summary slide. However, more details could have been included about the future work to show the project targets and how those targets will be achieved. The reviewer explained that the proposed work mentioned was a bit vague. For example, one bullet in the future work is “carbon fiber structure property relationship determination from candidate pitches”; this bullet could have used much more explanation. The reviewer asked if the researchers are proposing to use the mesophase pitch and go through the entire CF production process during this project. That seems very ambitious.

Reviewer 3

The projected listed future works which the reviewer considered as the main goals of the project. With the existing time constraint and the depth of required work, the reviewer had reservations about the achievement of the project goal.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer agreed that this project is very relevant for producing an alternative CF precursor. This is important for VTO’s vehicle lightweighting efforts and this project could potentially drive down the cost of CF for more widespread adoption in vehicles.

Reviewer 2

The reviewer believed the project is highly relevant for developing a low-cost and energy saving production process that aligns with the objective of VTO Materials subprogram.

Reviewer 3

The reviewer commented that the excessive cost of CFs hinders their applications in automotive composites. The reviewer explained that the precursor is about 50% of the CF cost and the project aims to produce mesophase pitch from halogenated wastes, lowering the precursor cost and resultant CF cost and enabling the use of CFs in automotive composites for lightweighting and decarbonization.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer agreed that there are sufficient technical, financial and facility resources to achieve the objective set.

Reviewer 2

The reviewer stated that the CFTF has the resources sufficient for the project to achieve the stated milestones in a timely fashion.

Reviewer 3

The reviewer commented that the funds are excessive for this project. The reviewer opined whether they interpreted the presentation correctly that this is a one-year project valued at $1 million. If so, those funds seem a little excessive for the scale of this project and what has been achieved so far. If this is a longer-term project, then that should be clarified at the next AMR and that would change the evaluation of the resource utilization.

Presentation Number: MAT196
Presentation Title: High Temperature Carbon Fiber Carbonization via Electromagnetic Power
Principal Investigator: Felix Paulauskas, Oak Ridge National Laboratory

Presenter

Felix Paulauskas, Oak Ridge National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

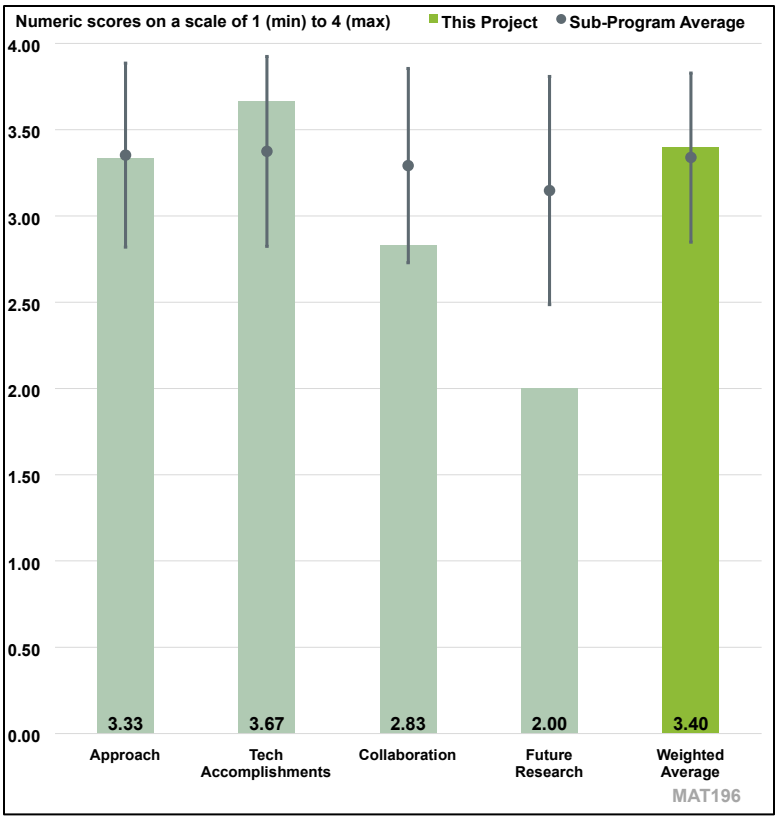

Figure 5-5. Presentation Number: MAT196 Presentation Title: High Temperature Carbon Fiber Carbonization via Electromagnetic Power Principal Investigator: Felix Paulauskas, Oak Ridge National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer explained that the technical barriers of reducing energy consumption, total cost of CF, and increased overall throughput are addressed in the project through a novel approach of using electromagnetic (EM) energy to provide a low-energy, high-temperature source to directly couple and indirectly heat a low-temperature carbonized fiber to produce a fully carbonized fiber. This approach also allows for operating a process at atmospheric pressure. The goal is to reduce energy consumption by 20% which will realize about a 5% reduction in the cost reduction for the overall manufacturing process and produce equal or better-quality CF. The reviewer agrees that this approach fully supports the VTO goals of reducing energy and improving the manufacturing process. This project has built on the research performed since 2015 and ends in 2024, so no timeline was presented, only FY 2024 milestones. The project was originally well designed, but unforeseen circumstances with equipment needed for the subsystems created a significant slippage in the project timeline.

Reviewer 2

The reviewer noted that the proposed work is focused on dielectric heating technology with the scope based on fundamental theories of EM energy. However, the reviewer asked what the EM power/energy difference between low temperature carbonization (LTC) and high-temperature carbonization (HTC) is, and asked how it will work if higher power is used in LTC.

Reviewer 3

The reviewer commented that the project was well designed with clearly defined performance goals and a baseline (Hexcel AS4 fiber) to compare. While the chosen baseline fiber is a high performance (aerospace) grade fiber rather than a comparable industrial grade fiber, the project team identified clearly that their process and the resulting CF is targeted for industrial applications where more variance and "lower" performance would be acceptable. This reviewer agreed that during the multi-year project, the principal investigator (PI) encountered multiple challenges including a global pandemic and challenging equipment failures. The reviewer applauded the persistence of the project team that resulted in accomplishing the project goals and is to be commended. The HTC phase of carbon conversion that was used to focus on the energy-intensive and time-consuming conventional process and to shorten residence time which reduces the total energy required is clearly an improved approach to expanding capacity and reducing total cost and environmental impact of CF production. The project execution was well done. Given the complexities of the HTC process using EM-coupled dielectric heating, the reviewer appreciated the multiple process parameters that the project team were able to explore. The reviewer suggested that it would be just more informative if the presenter had expanded on the theoretical (or notional) impact of the chosen process settings (LTC and HTC line speeds). The reviewer noted that the process stretch conditions were held constant and the identification of optimal process conditions for the LTC and HTC elements followed by a series of tests with variable stretch/temperature conditions is well done.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer explained that because of equipment problems, the system had to be rebuilt, which was not part of the original project plan and created delays in the schedule. Once the system was online, progress was good. Line speeds of 40 in/min and 20 in/min with set stretch and temperature conditions resulted in exceeding the VTO Materials subprogram targets of 550 ksi tensile stress and 29 Msi modulus. The reviewer noted that the energy consumption for conventional HTC industrial furnaces is likely in the range of 2.27-4.34 kWh/lb. EM energy in a high-temperature application was used to produce four tows with 1.98 kWh/lb of energy (in contrast to 2.27-4.34 kWh/lb for conventional processes), which is conservatively 30% lower than conventional high-temperature conversion applications. The reviewer highlighted that this is well above the original goal of 20% reduction in energy consumption.

Reviewer 2

The reviewer stated that the project completed all milestones, and the final report was submitted in December 2023.

Reviewer 3

The reviewer remarked that more comment is necessary given that the project team met or exceeded the minimum performance goals established at the onset of the work. The combination of tensile strength, modulus, and total energy consumed is a compelling result. The reviewer asserted

that congratulations is due to the PI's involved. The reviewer noted that it is understood that stretch and temperature conditions are proprietary elements of the processing. The reviewer suggested that it would have been helpful to clarify in the HTC8 results that the orange, yellow, and purple trials were differentiated as being all run at a LTC line speed of 40 in/min and an HTC line speed of 20 in/min (unique from HTC6 trials). The reviewer assumed this was the case and stretch/temperature conditions were the only differential in these trials.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer expressed that collaboration was minimal and only included ORNL and one industry source, 4X Technologies, LLC (4XT). There was no involvement with academia or other external entities, which may not have been required because of the advanced stage of the research.

Reviewer 2

The reviewer expressed that it was somewhat disappointing and concerning that the equipment challenges were so dominant in the timeline for execution. The implication is there are significant hardware challenges associated with this technology. The reviewer noted that little has been said about technical details associated with the extensive time lapses required to remediate the equipment. The reviewer asserted that the only reasonable conclusion is a disconnect among the team members, but the reviewer noted that this is an inferred conclusion and not one clearly stated by the PI. Given the achievements of the project team, it is difficult to be critical but resulted in this reviewer giving a relatively low score based on this inferred conclusion.

Reviewer 3

The reviewer remarked that the role of 4XT was not mentioned clearly throughout the presentation but was acknowledged at the end with some tasks.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer noted that no future research was presented; however, the technical accomplishments indicated that using a better generator technology with a better yield will strongly impact the net energy required, which implies that future work may be needed.

Reviewer 2

The reviewer was more concerned about the lack of future recommendations contained in the project summary given the positive results yielded by the project and meeting all technical goals for fiber performance coupled with energy reductions.

Reviewer 3

The reviewer believed that this question was not applicable.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer agreed this project is relevant and directly supports the overall VTO Materials subprogram objectives of reducing energy consumption and improving production volume.

Specifically, the project addresses the Materials subprogram technical objectives of weight reduction >25%, strength of >250 ksi, and modulus of >25 Msi.

Reviewer 2
The reviewer stated the project is very much relevant to the mission of the VTO Materials subprogram.

Reviewer 3
The reviewer explained that the project holds the promise to significantly reduce the energy required in the HTC zone of CF processing as well as increasing the rate (or shortening the time) required for processing large tow industrial CF. The reviewer observed that both outcomes, if commercialized and entered for serial production, supports specific VTO Materials subprogram objectives to expand the use of CF materials in automotive and energy applications through a reduction in the cost of these highly specific property materials. Similarly, increasing capacity of manufacturing to expand availability and lower embodied energy (thus reducing GHG emissions) will support stated goals to improve energy efficiency for commercial automotive and transportation sectors.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1
The reviewer summarized that the project resources were $3.5 million over four years ($875,000 per year) for one national laboratory and one supplier. The reviewer stated that the resources are considered sufficient because of the materials and equipment requirements to achieve the stated milestones in a timely manner.

Reviewer 2
The reviewer stated that the resources are adequate.

Reviewer 3
The reviewer explained that the project team in collaboration with a commercial supplier of equipment met all the technical and performance goals stated at the outset of the project. While the team was hampered by a combination of technical challenges (e.g., rebuild of HTC chamber) and delays related to a global pandemic, the researchers were able to close out the project without additional funding requests (using a no-cost time extension of the project). The reviewer concluded that by stating this clearly, the resources were sufficient.

Presentation Number: MAT197
Presentation Title: Multi-Functional Smart Structures for Smart Vehicles
Principal Investigator: Patrick Blanchard, Ford Motor Company

Presenter

Patrick Blanchard, Ford Motor Company

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

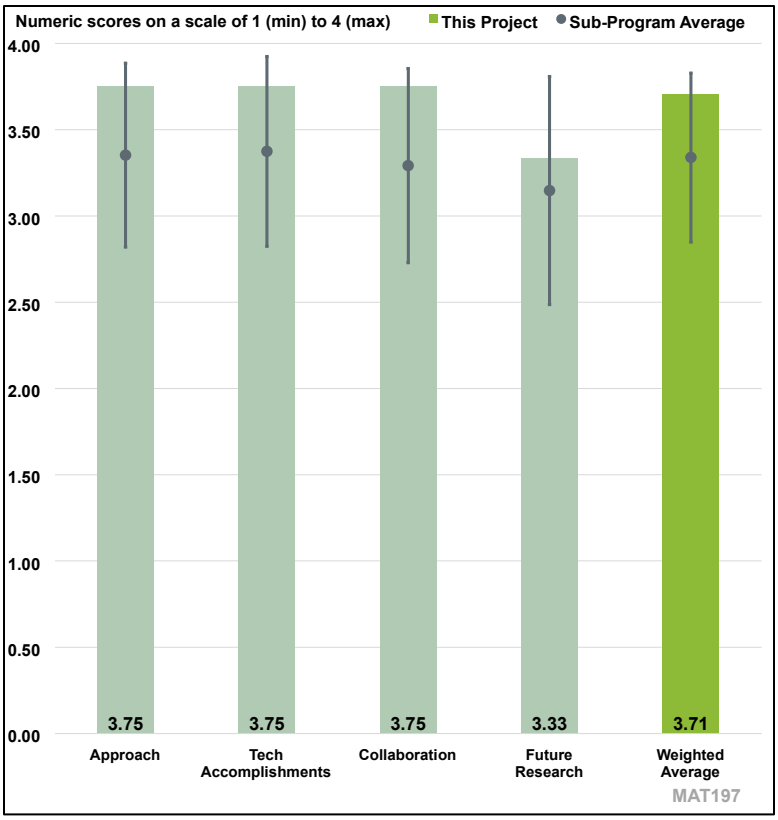

Figure 5-6. Presentation Number: MAT197 Presentation Title: Multi-Functional Smart Structures for Smart Vehicles Principal Investigator: Patrick Blanchard, Ford Motor Company

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer commented that this project encompasses wide ranging work plans and targets that were logically laid out, tracked, and completed with a nice “real” demonstration article. The reviewer noted that it would be good if more projects were like this one in terms of clear objectives and tangible impacts. The reviewer felt that the targets were sufficiently challenging for incorporation of advancing multiple materials and processes of broad interest to vehicle applications. Although the reviewer imagined the tooling was relatively expensive, showing conclusive capabilities of this approach over projections was good.

Reviewer 2

The reviewer explained that this work attempts to translate continuous and discontinuous fibers into an actual vehicle part which was done. The design of the part is intricate, including the smart use of fiber types to translate stresses as needed. The reviewer acknowledged that even with an 11 co-current workstream schedule, the team documented the work and their collaborations well.

Reviewer 3

The reviewer remarked that for the complexity of the project and the interaction of many groups, this project was very well designed and conducted. The timeline was followed extremely well until the

very end and was slowed due to testing availability although most tests will be completed at no additional costs. The reviewer praised that shifting away from AM to a lower cost, more conventional process, for certain parts was an excellent decision allowing the project to stay on track and not become diverted.

Reviewer 4

The reviewer described that the project illustrated a complex set of interactions that were followed through a well-designed project and in a reasonable amount of time. There was a no-cost time extension contract modification executed due to resource availability, but the plan is to be completed by the end of the calendar year 2024. The project integrated several electronic systems into an injection molded component and evaluated the cost and weight savings. The project nearly completed all their tasks, and the overall management of the project was orchestrated well.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer indicated that much has been accomplished in advancing technologies; however, the reviewer was unclear as to how much can actually be transferred to the automotive community, pathways were demonstrated towards the critical lightweighting mission with approaches that appear to be scalable and are moving towards the ability to buy their way into production. The reviewer suggested that it would have been good to get a better sense of Ford Motor Company's (Ford) assessment of the likelihood for implementation and potential timeline for doing so.

Reviewer 2

The reviewer stated that the work was well documented and impressively achieves VTO Materials subprogram targets around mass savings and cost. The reviewer noted that with the research team's final prototype part, they have 30+% mass reduction at competitive costs and less than 3-minute part-to-part manufacture time. Overall, the approach is impressive. The only area the reviewer identified for more work is the recycling portion, as it appears to be done with a little brute force. There are probably better methods for recovering fibers.

Reviewer 3

The reviewer explained that the overall project achieved many sub-accomplishments that can be used for other projects such as better processing for hollow parts, use of recycled materials, and integrated sensors.

Reviewer 4

The reviewer summarized that the project's successful execution demonstrated a weight reduction of nearly 40% for a slight cost increase over the baseline metallic part. The multifunctional use of the component consolidated several features that provided structural health monitoring (SHM) and embedded electronics, increasing the component's functionality, and reducing part count for assembly. The reviewer summarized the technical accomplishments that achieved automation using robotics to achieve less than a three-minute cycle time and a future direction that looks to achieve nearly a two-minute cycle time.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer praised that this project was an excellent job of bringing together a talented team and effectively integrating separate activities into an impressive relatively complex demonstration.

Reviewer 2

The reviewer described that this project defines the team in early slides and how the team collaborated, which was impressive to the reviewer to see this, especially from an industry project.

Reviewer 3

The reviewer explained that this was a large-scale project with many contributors over four years. The reviewer asserted that the project management was excellent and accomplished the goals when they needed to be completed.

Reviewer 4

The reviewer noted that the project had several partners with a specific role for each partner. The project lead did an excellent job coordinating the activities and collaborating with each partner in their specific discipline. The reviewer noted that the integration of national laboratories and academic resources with the timing of the industrial lead can be challenging, and the project demonstrated success on each element of the project.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer observed that the project is ending this calendar year, and the remaining work is to be completed with a no cost extension that focuses on completing the design, validation, and testing using facilities at Ford. Efforts will include sun load testing, air bag deployment, steering column, dynamic impact, dimensional checks, and noise, vibration, and harshness. The reviewer noted that the project will most likely complete these last few tasks since all the molded components are complete and delivered for the testing and validation work.

Reviewer 2

The reviewer observed that it would have been informative to hear about the implementation plans and, more importantly, the identification of any deficits still needing to be addressed as next steps.

Reviewer 3

The reviewer noted that the future work was focused just on the end of this project and was looking at component testing. The reviewer stated that this is appropriate for an AMR presentation, but the question is how this work is translatable beyond this current work. The reviewer noted that the researchers mentioned that an implementation phase may be next.

Reviewer 4

The reviewer commented that until the testing is over, the fact that is somewhat unknown is whether Ford will use the entire concept or not as they go through their stage gate process. The reviewer feels that Ford is likely to use this concept, but the decision to commercialize or to not is unknown.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer believed this is an excellent example of advancing technologies and providing an effective demonstration of what can be accomplished with a wide-ranging research program that DOE has assembled in coordination with industry, academia, and the national laboratories. While it would be impossible to have many projects resulting in similar demonstrations such as this, the reviewer desires to have such demonstrations periodically to motivate the automotive community to better envision potential real-world solutions as endpoints for disparate pieces of technology. This project demonstrated a good balance of technology development resulting in actual hardware that appears closer to implementation than some advanced concept demonstrators.

Reviewer 2

The reviewer remarked the project is extremely relevant, noting that the team used metrics to show that they are achieving goals around weight saved, cycle time, and actual part manufacture.

Reviewer 3

The reviewer did not mention program relevance but explained that one project objective was to develop lightweighting technology which was accomplished. Another objective was to add sensor capacity to monitor part stability and other required functions, which was accomplished.

Reviewer 4

The reviewer implied program relevance by stating that the project meets the overall VTO Materials subprogram objectives through reducing weight with around $2/lb cost saved. The project is determined to be a success for the VTO Materials Composites Core Program (CCP).

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer explained that this was a relatively expensive project that perhaps limits the breadth of other projects possible. Apparently, there is a much more dominant trend towards spreading research projects too thinly and maybe sometimes to interesting areas that have limited application. The reviewer noted that having at least a few projects like this one helps the supporting research community to see examples of where their research can be applied. Achieving a balance of having more medium funding level projects of maybe $500,000 to $1,000,000 per year should be a programmatic objective which the reviewer thinks would result in greater impact towards the DOE mission in this area.

Reviewer 2

The reviewer applauded that the team executed their project extremely well. Even though this might get more funding than most projects presented at the AMR, the resources were used extremely well.

Reviewer 3

The reviewer stated that, as this complex project was done except for some tests, the project resources were adequate. The scheduling for final testing delayed reporting the results for several months but this was not a significant issue.

Reviewer 4

The reviewer agreed that the project was well-executed, meeting milestones in a timely fashion except for the resource limitation at the industry lead, who will complete the remaining few items by the end of 2024.

Presentation Number: MAT198
Presentation Title: Development of Tailored Fiber Placement Multi-Functional High-Performance Composite Material Systems for High Volume Manufacture of Structural Battery Enclosure
Principal Investigator: Venkat Aitharaju, General Motors Company

Presenter

Venkat Aitharaju, General Motors Company

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

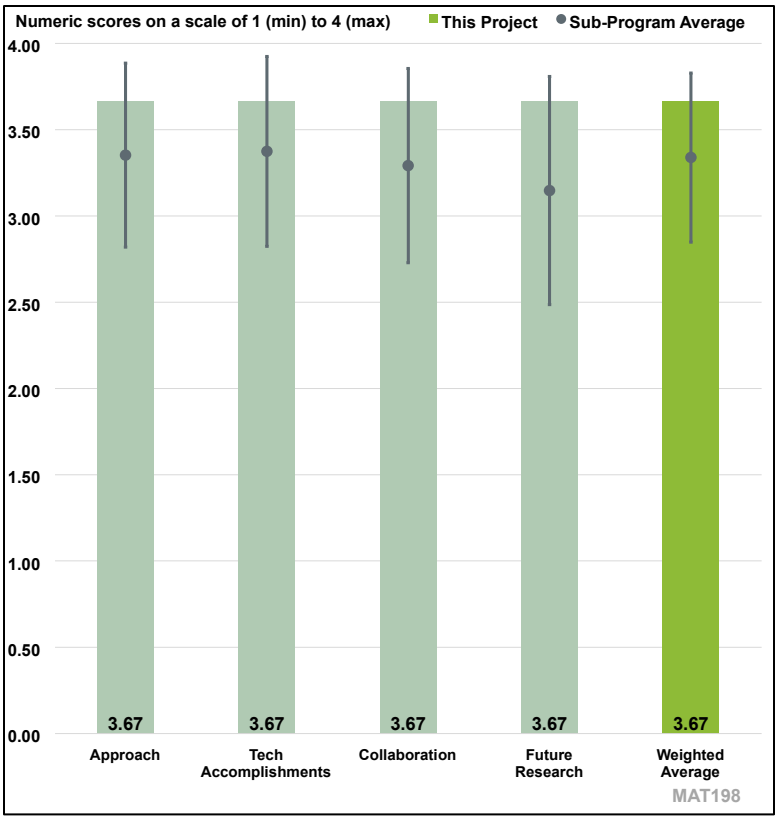

Figure 5-7. Presentation Number: MAT198 Presentation Title: Development of Tailored Fiber Placement Multi-Functional High-Performance Composite Material Systems for High Volume Manufacture of Structural Battery Enclosure Principal Investigator: Venkat Aitharaju, General Motors Company

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer explained that the project team has proposed and executed an ambitious project applying three critical high-rate production methods to process novel material systems to a critical automotive component necessary for electrification of the transportation sector. The integration of hybrid (glass/carbon) reinforcements with fire resistant matrices (phenolic) and SHM methods is ambitious. The reviewer mentioned that coupling artificial intelligence (AI)/machine learning (ML) technology with predictive modeling tools results in an ambitious program that advances several important technologies.

The reviewer felt that the SHM integration has not been fully engineered, and particularly the way such a technology would be used in a commercial application to inform the user or service center on the condition of the battery enclosure or specific components. Similarly, little has been revealed about the approach and methods used for training the system through ML and use of AI to inform manufacturing operations. Regardless, the reviewer stated that the approach used by the project team is very strong and should yield meaningful results.

Reviewer 2
The reviewer expressed that the project is taking into consideration all the critical issues to be a successful project such as lightweighting, monitoring, fire resistance, ability to manufacture, and cost reduction. The schedule is on time and on budget and the team is waiting for tooling to be built. The leader involved the expertise of quite a group of experts on each aspect of the project and led them to put all the aspects of the project together. The reviewer noted that the part developed is a critical safety component, so getting the design for replacing the metal part is a major endeavor.

Reviewer 3
The reviewer stated that the project completed several challenges associated with the deep-drawn molding processing, integration of the SHM system, and development of a commingled carbon/glass tow that is used as a sensor in the part. The work successfully overcame the challenges of developing a nice battery tray with integrated structural features. The reviewer remarked that the team accomplished the development of a self-health sensing technology that can be scaled for cost-effective high-volume manufacturing. Further accomplishments were developed using the AI/ML method developed. High-pressure resin transfer molding (HP-RTM) process monitoring was installed on the machine, and work continued for validation and improvements. The reviewer described that the AI/ML capability also developed and validated a novel AI/ML-based multi-scale structural performance model. The list of the accomplishments was well-documented in the presentation.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1
The reviewer stated that the project team has made excellent progress in the prior year with a design path that accomplishes targeted weight savings and performance requirements for thermal, impact and electromagnetic interference (EMI) protection of the structural enclosure. The structural models were validated by sub-scale (e.g., a miniature battery enclosure prototype) manufacturing and impact testing was completed and results compared favorable to a significantly more massive steel design. The reviewer praised that the design and demonstration of a viable integrated strain sensing system is quite novel. The reviewer noted that the preliminary testing results at the coupon level (meso-scale) are promising but suggested that further refinement is needed.

The reviewer noted that the approach to create technical preforms using a hybrid reinforcement scheme of fiberglass and selective reinforcement with carbon is a solid approach to ensure meeting cost goals while similarly meeting weight and performance requirements. The reviewer's only concern was the researcher's claim that 80% of the work is accomplished but the ambitious tasks of manufacturing a the full-scale "final composite battery enclosure assembly", along with demonstrating the use of AI/ML techniques and completing crash testing, still needs to be completed. The reviewer cautioned that these tasks appear to be costly aspects of the project with a mere 20% of the effort (funding?) remaining. Meeting cycle time requirements for the tray component is ambitious.

The reviewer noted that there does not appear to be any documentation regarding the manufacturing of the tray preform. That would include the cycle time needed for the tailored fiber placement process and the economics of this approach.

Reviewer 2
The reviewer stated that the technical accomplishments for the complex project are very impressive. Several accomplishments, such as the self-health sensing, the AI performance, and the HP-RTM

process modeling will allow the one-step molding to be used in other applications besides the battery enclosure project. The reviewer apprised that the apparent 40% reduction of weight versus a goal of 25% is a massive overachievement. The reviewer expressed that if the process cycle time can be shown to be less than three minutes to make quality parts, this project will be a big winner.

Reviewer 3

The reviewer described that the project designed and developed approaches in molding deep-drawn molding technologies for battery trays with integrated sensors in the composite. All the partners provided their expertise with preform development and fabrication, sensor development, and SHM integration with AI/ML. The reviewer stated that the project was successful in completing their milestones and working to wrap-up the remaining task objective for the year. The reviewer recognized that the team accomplished self-health sensing technology that can be scaled for cost-effective high-volume manufacturing. Further accomplishments were developed using the AI/ML method developed. HP-RTM process monitoring was installed on the machine, and continued validation and improvements were made. The reviewer described that the AI/ML capability also developed and validated a novel AI/ML-based multi-scale structural performance model. The reviewer pointed out that the list of accomplishments was well documented in the presentation.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer described that this technically complex project, combined with a broad array of novel integrated technologies demands a cohesive project team. The reviewer highlighted that the demonstrated technical accomplishments of the project suggest that each specialized team member is making appropriate contributions to this collaboration. The reviewer praised that the project management and leadership by the PI appears to have kept this program on track, though the reviewer noted that the final 20% needed to complete the program within budget is a concern or question. The reviewer stated that the only weakness that can be identified relates to the lack of detail in the use of the AI/ML methods to inform the processing. The reviewer is very interested in the final reporting on the use of these methods to ensure consistent manufacturing and continuous improvement in manufacturing processes that utilize these technologies.

Reviewer 2

The reviewer praised that the project management is excellent to keep three universities and three suppliers working together to deliver the on-time needed results. The reviewer noted that an advantage for the project management is that they work for the end-use customer. The reviewer mentioned that this project is quite impressive with the many requirements using experts in the various technologies from disparate entities.

Reviewer 3

The reviewer described that the collaboration team is made up of academics and industrial partners. Each partner is contributing to the project and is providing valuable inputs in preforming, sensors, modeling, and fabrication integration of the sensors. The reviewer expressed that the collaboration of the team is demonstrated through the accomplishments in the design and development of the features and components to date. The reviewer described that the researcher’s presentation, as well as a sensor demonstration to the presentation room attendees, well defined the product of the team’s work embedded in a composite sample.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer noted that the proposed future work is ambitious (considering it is a mere 20% of the total work), but successful completion will clearly result in meeting all the goals originally proposed for the project. The reviewer found no deficiency (other than concerns for the extent of the remaining work required given both funding level and schedule). The reviewer concluded by offering the research team a "well done."

Reviewer 2

The reviewer described that the next phase is to complete the project by making parts and checking cycle times, quality, and performance. The reviewer expressed that this should be very exciting. The reviewer suggested that the team might benefit by having an alternative approach if there is a processing issue. For example, what is the plan if the cycle time is longer than three minutes?

Reviewer 3

The reviewer described that for the remainder of the year, the team will build the tools, manufacture components for building, and evaluate the assembly. This is the final objective of the project and is a culmination of the work being pulled together and demonstrated. The reviewer noted that the project is on track to be completed by the end of the year.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer described that the current program relates to four of the six VTO subprograms identified as relevant to the VTO goals. Successful commercial deployment of advanced lightweight battery enclosures will impact cost, performance, and reliability of these critical components. The reviewer stated that the results will impact performance of the Batteries subprogram, reduce cost and expand the pace of technology addressed in the Electrification subprogram, provide more benefits for the Energy Efficient Mobility Systems subprogram, and result in validating new materials for the Materials subprogram that integrate SHM to improve long-term reliability by identifying problems before they become critical. The reviewer concluded by affirming that the relevance of this project is not in question.

Reviewer 2

The reviewer expressed that lightweighting with no increase in safety risk is a major goal of the VTO Materials subprogram to improve the economics of using EVs and this project meets that criterion.

Reviewer 3

The reviewer stated that the project meets the objective of 40% weight reductions and built-in sensor technology for the batteries and for the health monitoring of the enclosure. The reviewer described that the demonstration of the design shows progress in achieving weight reduction goals for vehicles and progresses technology for battery vehicles with safety sensors both for batteries and for the structural health of the battery containment.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer agreed that the resources appear sufficient based on the reporting of the PI. However, the remaining work to be conducted appears extensive and one may worry that the final manufacturing demonstration (three-minute cycle time) and technologies to be highlighted (SHM, AI/ML, and crash validation) are in danger of being underfunded, or fall short of completion, due to an over-compressed schedule. The reviewer is anxiously anticipating the final reporting.

Reviewer 2

The reviewer stated that the project is on schedule with no apparent need for more resources,

Reviewer 3

The reviewer remarked that the project has been well-funded and appears to have sufficient resources to complete the remainder of the tasks this year to demonstrate the build, to complete the assembly, and to perform the testing.

Presentation Number: MAT199
Presentation Title: Ultra-Lightweight Thermoplastic Polymer/Polymer Fiber Composites for Vehicles (Inter-Lab Project)
Principal Investigator: Kevin Simmons, Pacific Northwest National Laboratory

Presenter

Kevin Simmons, Pacific Northwest National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

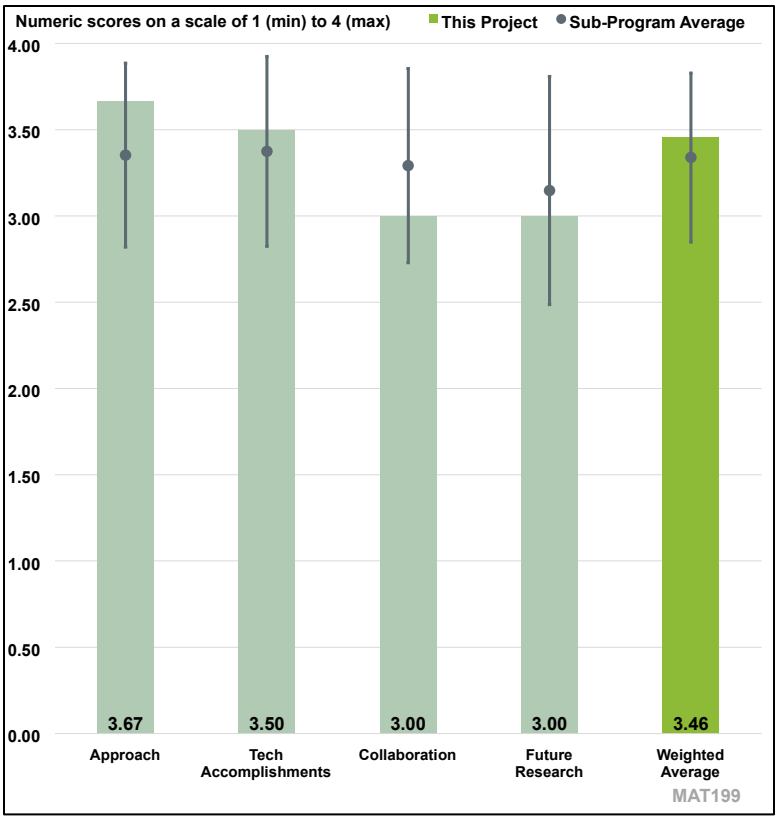

Figure 5-8. Presentation Number: MAT199 Presentation Title: Ultra-Lightweight Thermoplastic Polymer/Polymer Fiber Composites for Vehicles (Inter-Lab Project) Principal Investigator: Kevin Simmons, Pacific Northwest National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer described that the challenges and hypothesis were defined, a literature search was conducted, and validation work planned to prove the hypothesis. The reviewer noted the well-defined responsibilities between PNNL and ORNL. The reviewer noted a solid focus on fabricated high-performance fiber and optimization of the fabrication process to be able to maintain the higher performance properties of the fiber while gaining good fiber/matrix adhesion.

Reviewer 2

The reviewer described that the technical barriers were clearly discussed in the Overview slide, and the subsequent slides discussed how those barriers were addressed. The project was well designed and had a clear timeline with measurable targets. The reviewer observed that most of the milestone targets were clearly quantitative, so it was easy to evaluate their success, and they had good property targets. However, the reviewer stated that Milestone 11 could be more quantitative for how success was measured for demonstrating recyclability.

Reviewer 3

The reviewer described that the researchers identified three technical barriers: low-cost high-volume manufacturing, low-cost CF, and recyclability. The recyclability aspect of this work is a major selling point but was not addressed thoroughly in Slide 8, nor at all in the remaining technical challenges. The reviewer described that polymer-fiber-reinforced polymers, which have been around for quite some time and are commercially available, have seen renewed interest due to increasing consciousness around sustainability. So, the reviewer suggested that a better understanding of the quality of the recycled materials and challenges need addressed.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer simply stated that the researchers met their milestones.

Reviewer 2

The reviewer pointed out that each milestone was addressed, and the technology was developed and advanced. The reviewer stated that the thermoplastic fiber/thermoplastic matrix composites produced showed significant property improvements over the thermoplastic alone.

Reviewer 3

The reviewer acknowledged that all the milestones were met for this project, so excellent progress was made. The reviewer mentioned that some results even went beyond the outlined milestone criteria to further demonstrate the success of the developed composites. The reviewer mentioned that one aspect that was lacking was a final estimate of the cost of the developed polymer/polymer composites. A cost target was mentioned in the relevance slide, so the reviewer was interested to see if the researchers' composite reached that target.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer acknowledged that the project had an excellent collaboration with ORNL that leveraged its fiber and composites expertise. However, the reviewer criticized that the project was lacking an industrial partner or collaboration outside of national laboratories.

Reviewer 2

The reviewer noted that there is a good workflow between ORNL and PNNL. The reviewer suggested that it would be nice to see more industry engagement or even just identification of where these materials might be drop-in replacements on vehicles now. The reviewer asked if these would be applicable for battery cases on EVs.

Reviewer 3

The reviewer noted the well-defined responsibilities outlined between PNNL and ORNL, with clear understanding of the core capabilities each was bringing to the project. The reviewer believes that a future step to consider would be getting an industry partner that can work to validate the technology in a commercially viable part.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer noted that the project has ended.

Reviewer 2

The reviewer is anticipating the results of the complex shape demonstrations for molding. The reviewer was not sure of the relevance of the cooling rate or low temperature fracture testing. The reviewer suggested testing for other characteristics like heat deflection temperature and creep.

Reviewer 3

The reviewer expressed that the project clearly defined a purpose for the future work which makes sense. The future work included investigating other thermoplastics that will increase a potential property profile that can be achieved. The reviewer noted that one concern with some of the polymers discussed for future work would be cost, even with polypropylene (PP). If you move from non-isotactic grades, then the cost will increase, e.g., commodity isostatic PP and polymers like polyphenylene sulfide are more expensive than polyolefins. In addition to the items outlined during the presentation, the reviewer thinks that future research should include validation of a bi-component fiber containing a lower melt-point sheath on a higher melt temperature core. The reviewer suggested that this could be done with high-density polyethylene / linear low-density polyethylene (LLDPE), in combination with ultra-high-molecular-weight polyethylene (UHMWPE)/LLDPE, then use the matrix material as an LLDPE. For PP, the reviewer thinks that sticking with homopolymers makes sense but if a bi-component fiber is used, a PP random copolymer can be applied to the skin with a lower melting point and then a random copolymer can be used for the matrix.

Processing temperatures would still need optimization, but the reviewer believes that this would help maximize properties imparted by the fibers by improving fiber/matrix adhesion. The reviewer suggested that the research should also include evaluation of different molecular weights of polyethylene for the matrix to increase wettability/adhesion, reduce voids, and increase the overall properties of the composite. Converting the matrix materials into powder sounds like a great idea to the reviewer. Overall, the reviewer noted significant potential in developing this technology further.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer agreed that this project is very relevant and aligns well with the VTO Materials subprogram objectives for lightweighting vehicles. The reviewer noted that the project utilized polymer/polymer composites to produce high specific strength materials that could replace more costly materials, and these composites have the added advantage of being recyclable.

Reviewer 2

The reviewer stated that this project is relevant to the VTO Materials subprogram objectives of vehicle lightweighting and alternatives to CF composites.

Reviewer 3

The reviewer described that the project enables the development of low-cost, lightweight, high-strength materials for automobiles. The recyclability aspect also helps with future circularity objectives.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer stated that since the project has ended with all milestones met, the funds seemed sufficient.

Reviewer 2

The reviewer agreed that the resources are sufficient to achieve the stated objectives.

Reviewer 3

The reviewer stated that the resources were adequate.

Presentation Number: MAT200
Presentation Title: Additive Manufacturing for Property Optimization for Automotive Applications
Principal Investigator: Seokpum Kim, Oak Ridge National Laboratory

Presenter

Seokpum Kim, Oak Ridge National Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

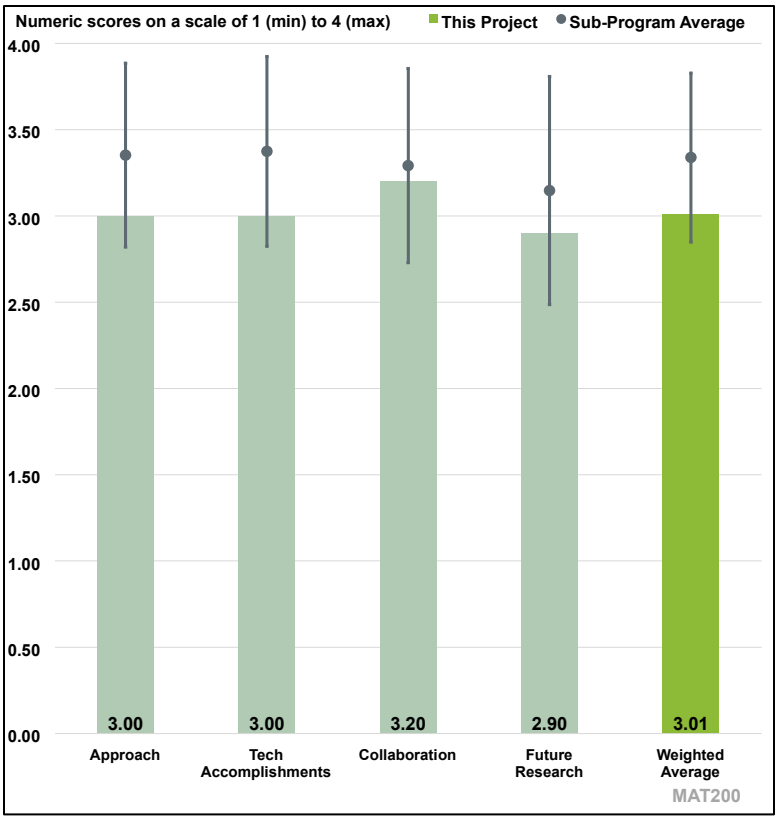

Figure 5-9. Presentation Number: MAT200 Presentation Title: Additive Manufacturing for Property Optimization for Automotive Applications Principal Investigator: Seokpum Kim, Oak Ridge National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer agreed that the approach is sound and will result in solving most of the project challenges, if not all.

Reviewer 2

The reviewer observed that the approach is articulated well. The inverse design approach is interesting and is becoming popular for the discovery of innovative designs, materials, and processes. The reviewer asked if the inverse design is taking data purely from simulations and not from experiments. If so, the reviewer opined that the inverse approach relies on simulated data and continues to scout for innovative designs and materials in virtual space without practical validation. The reviewer asked if the innovative design meets the criteria set by the inverse approach, why there is a need to create a refined design which may be an overkill and waste of resources. The reviewer also criticized that the refined model selection seems to be arbitrary.

Reviewer 3

The reviewer stated that the project is well designed from various perspectives, including material selection, AI/ML integration, AM, testing, and further optimization. The AI/ML-assisted design aspect

is particularly intriguing and innovative. The reviewer commented that the intricate designs produced through AM demonstrate significant potential. However, the reviewer noted a point to consider is how these designs can be effectively incorporated into current volume production, because AM is currently a time-consuming process. Exploring how the project can accommodate future potential for volume production to ensure scalability would be beneficial. The reviewer agreed that the timeline is reasonably planned.

Reviewer 4

The reviewer criticized that the material properties are quite poor due to the material selection. The reviewer asked why the researchers used such a poor material when other better materials, at similar cost, are available and might be used in production. The reviewer observed that a ML approach does not quite appear to be ML. This work is doing a traditional optimization problem and calling it ML since the problem is over constrained. The ML algorithm is being trained by simulations which are innately inaccurate. The reviewer asked how this approach can be used to produce confident optimizations. The reviewer pointed out that the selection of the properties seems arbitrary. The optimization process uses an arbitrary input to design the material design. The reviewer cautioned that the average impact force of an impact loading cannot be used since the force present due to the impulse nature of the impact will be drastically underrepresented. The reviewer stated that it is very hard to believe a 26 miles per hour impact with a pole will cause a peak load of under one megapascal (MPa) force.

Reviewer 5

The reviewer stated that the project is well planned. The reviewer noted that some of the tasks are too constrained to realize the potential of the technology being pursued, especially where the discussion around the ML programs were more optimization-oriented problems than AI-based discoveries.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer stated that the milestones are on track.

Reviewer 2

The reviewer stated that the research team seems to have achieved most of the milestones associated with the project plan. There seems to be a delay in getting real-size sample test results from the industrial partner, but everything else seems to be on track.

Reviewer 3

The reviewer noted that satisfactory progress has been made on the project to date. The project work is 85% complete and has many moving parts including AI, testing and fabrication components. The reviewer noted that the researcher’s explanation of the critical aspects of the work missed a few details because of time constraints. The reviewer suggested that the PIs should keep this in mind the next time they present the work, including defining all the acronyms and pointing out aspects of the work (or methodologies) that have been abandoned since the inception of the project. The reviewer described that understanding the reasoning behind some of the testing and parameters evaluated/investigated would also be very helpful for the audience and reviewers in future presentations.

The PIs are commended for employing AI/ML in the design/architecture and especially in the manufacturing of their vehicle part. However, the reviewer cautioned that the interplay between process control and the ML method(s) needs to be further elucidated. Their audience needs to be clear about the limitations of this approach on part production, performance, and reproducibility. The reviewer acknowledged that the authors attempted to elucidate this last point, however, more detail would be helpful to close this loop/aspect of the work. The reviewer asserted that a cost analysis with a value proposition of this approach to manufacturing the part in question needs to be included in the work. The reviewer acknowledged that the PI mentioned that the cost analysis is forthcoming in the future. Slide 9 has a mix of “Nm” and “mm” as units. Please be consistent with the units used in the future to forestall confusion. The reviewer highlighted that to many people NM is newton meters and mm is millimeters. One unit is force, and the other measures distance, so it is confusing when both are used in the same column.

Reviewer 4

The reviewer suggested that the material selection process could be more thorough, especially when selecting and combining different plastic materials and using them as the matrices in a composite. The complementary mechanical properties and the compatibility of the chosen plastics are both important considerations.

Reviewer 5

The team is making progress, but the reviewer does not believe that the technical approach is a good one. The reviewer criticized that there is also very little comparison to traditional materials currently used for this purpose.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer pointed out that little was said about the specific contributions of each partnering team member (Ford, University of California Los Angeles, and University of California Berkeley) beyond the high-level summaries on Slide 20. The reviewer stated that one can only surmise that the collaboration has served its purpose, because 85% of the work has been completed.

Reviewer 2

The reviewer observed that the collaboration is well coordinated. The reviewer suggested that it would be good for the researcher to mention the individual aspects of contributions throughout the presentations.

Reviewer 3

The reviewer described that the project is developed in collaboration with Ford and the University of California Los Angeles. Ford provided the design and testing requirements, while University of California Los Angeles offered ML support. The reviewer agreed that these contributions complement the capabilities of the leading ORNL team.

Reviewer 4

Given that the lead organization is performing follow-on work based on the results from one of the sub-contractors, the reviewer commented that the coordination between the team appears to be excellent.

Reviewer 5

The reviewer's understanding was that the team was taking more time than expected to provide materials for testing to Ford and, therefore, there may be some breakdown in the schedule that was not clearly articulated.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer noted that the proposed future work will contribute to meeting project goals. The reviewer suggested that the authors should consider the comments made about the interplay between AI/ML and process control in Section 4 of this review in their future work.

Reviewer 2

The reviewer commented that the pending tasks and timeline are on track and planned well.

Reviewer 3

The reviewer described that the project has clearly defined future work, targeting the 3D printing of a full-scale bumper and its performance evaluation, which seems achievable.

Reviewer 4

The reviewer said that the proposed future research is the entire project. The stated future work includes: (1) full-scale printing of a performance-optimized, multi-material lattice, structure-based frontal bumper (a few bumpers are already printed) and (2) mechanical testing of lattice structures and performance evaluation of a full-scale bumper.

Reviewer 5

The reviewer commented that the future work is reasonably highlighted and discussed.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer agreed that this project contributes toward materials manufacturing and optimization for vehicles.

Reviewer 2

The reviewer stated that the project supports the VTO Materials subprogram objectives.

Reviewer 3

The reviewer simply stated that the project is relevant.

Reviewer 4

The reviewer agreed that conceptually, the project is relevant, but the execution may pose a missed opportunity.

Reviewer 5

The reviewer highlighted that the design aspect could greatly benefit the VTO Materials subprogram mission of reducing component weights while still meeting performance requirements. However, the reviewer cautioned that it is important to further consider and evaluate whether the AM approach can reduce manufacturing costs, given the long production times and limited scale production associated with this method.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer noted that the funding appears to be adequate for this work.

Reviewer 2

The reviewer affirmed that the project has adequate resources to successfully execute the project.

Reviewer 3

The reviewer agreed that the resources are sufficient.

Reviewer 4

The reviewer did not believe the team is using a ML approach but rather a simple optimization. The reviewer further criticized that the selection of materials is poor and felt that the loading used for the design to be impossible for a car hitting a pole at 26 miles per hour. Lastly there is no comparison to traditional manufacturing methods, or the time required to fabricate a part which is most likely impossible for the automotive industry.

Reviewer 5

The reviewer believed that this question was not applicable.

Presentation Number: MAT202
Presentation Title: 3D Printed Hybrid Composite Materials with Sensing Capability for Advanced Vehicles
Principal Investigator: Rigoberto Advincula, Oak Ridge National Laboratory

Presenter

Karen Cortes Guzman, Oak Ridge National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 75% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 25% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

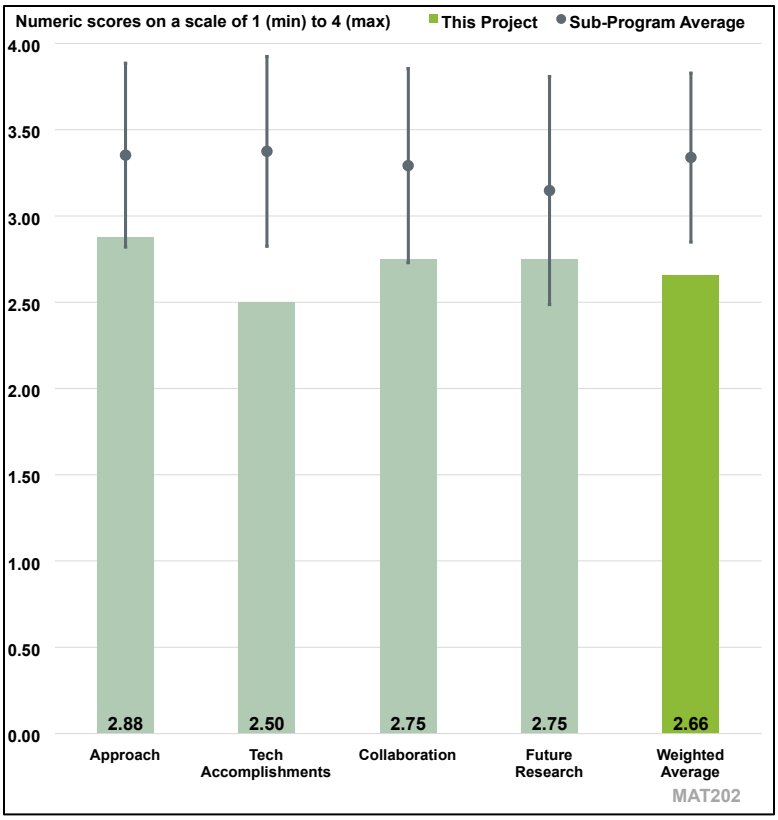

Figure 5-10. Presentation Number: MAT202 Presentation Title: 3D Printed Hybrid Composite Materials with Sensing Capability for Advanced Vehicles Principal Investigator: Rigoberto Advincula, Oak Ridge National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The project is very well designed, but the reviewer imagined the four designed tasks are supposed to have transitions between each other that would enable decent quality 3D-printable composites with sensing capabilities.

Reviewer 2

The reviewer agreed the project clearly outlined the technical barriers and had a good execution plan to address those barriers with a reasonable timeline. The team did a decent job dividing the tasks to be performed by the collaborators and clearly showed who was performing what task. To improve the presentation for future use, the reviewer suggested that including the challenges and barriers from the U.S. DRIVE Materials Technical Team Roadmap report that was mentioned in the AMR instructions document would be beneficial.

Reviewer 3

The reviewer described that the project aims to develop a 3D printing process for integrating a sensing layer within a composite layer. Various materials and 3D printing methods have been

developed, including 3D printing of continuous fiber composites, zinc anodes, and polyvinylidene fluoride (PVDF)-Mxene composites. The reviewer stated that while these developments are significant and demonstrate technical advancement, their alignment with the central goal of the project is loosely demonstrated. The reviewer recommended a more concentrated approach to strengthen the focus of the research and ensure that all efforts are directed towards the main objective.

Reviewer 4

The reviewer criticized that the strength and modulus goals are extremely low. This can be obtained with a non-continuous fiber composite. The reviewer asserted that the interfacial measurements are clearly wrong since the interfacial strength is higher than the matrix shear strength. This is possible with a functional gradient, but this is not the case here. The reviewer asked about the type of sensor being developed. The reviewer also asked why molybdenum disulfide (MoS_2) and PVDF would form a sensor, since the PVDF will be non-polar alpha phase and the MoS_2 is not piezoelectric. The reviewer highlighted that this is not well thought out and would indicate a lack of understanding of piezoelectric materials. The reviewer also mentioned that the results did not include error bars on the strength and modulus data.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer described that four main tasks are demonstrated. Task 1 focuses on CF surface modification and its interactions with resin systems. However, the reviewer highlighted that the improvement in tensile properties after the surface modification is limited with tensile strength increasing only from 62 MPa to 65 MPa. Task 2 Involves computational studies of fiber-matrix interface interactions in both the sensor layer (PVDF-MoS_2) and composite layer (epoxy-CF). The reviewer agreed that this seems to be well-developed. Task 3 developed 3D-printing techniques for continuous fiber epoxy composites. The reviewer was unclear as to whether this is another type of composite layer or if the previous epoxy and milled CF composite was only for studying interface interactions. Task 4 focused on the fabrication of continuous sensor-embedded polymer/CF composite 3D printing. The reviewer agreed that this task is well-aligned with the project plan.

Reviewer 2

The reviewer commented that the team presented some excellent technical accomplishments that appeared to meet most of the milestones for the project. The milestone table clearly shows the milestone progress, but the reviewer suggested that it would also be good to include the milestone on the slides with data to show what the milestone criteria was achieved. The reviewer had difficulty determining what accomplishments were achieved previously and what accomplishments were new for this year. The reviewer suggested that in future presentations, the use of “Previous Accomplishment” should be noted on the slides that were from past years of the project. This way reviewers can judge what was done in the most recent year of work.

Reviewer 3

The reviewer criticized that this project has made little progress towards the goals. Work has been done on each task, but efforts are weakly related to the objective. For instance, the reviewer asked how will working with a non-piezoelectric structure demonstrate a sensor. The reviewer commented that if the team does not understand piezoelectricity, then they should seek support from someone who does. The reviewer cautioned that the 3D-printing methods do not make much sense. The

interfacial functionalization is weak and poorly characterized. The reviewer noted that the team must have access to x-ray photoelectron spectroscopy to perform a true analysis.

Reviewer 4

The reviewer commented that it seems like the four tasks have progressed independent of each other. The material systems being evaluated do not have much overlap. The reviewer was not clear on how the transitions will proceed from task to task. The reviewer expressed that some of the constituent component choices are also puzzling. Several milestones still need to be achieved with minimum time and resources remaining in the project charter.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer noted that the project consisted of a good collaboration between ORNL, the University of North Texas, and University of Oklahoma. However, the reviewer would have liked to have seen some involvement from private industry to demonstrate the path toward deployment for the developed technology.

Reviewer 2

The reviewer described that this project is a collaborative effort between the ORNL and University of North Texas teams. The ORNL team focuses on developing materials and 3D printing techniques, while the University of North Texas team provides computational modeling support. The reviewer suggested that involving an industry partner could be beneficial, as they could offer materials design guidance and industry-specific specifications, further enhancing the project's relevance and application.

Reviewer 3

The reviewer cautioned that the actual coordination is not clear, just that the team meets every two weeks.

Reviewer 4

While it seems like the project partners meet regularly, the disjointed information in individual slides led the reviewer to believe that there may not be more effective information transfer between tasks. Apparently, the interfacial developments seen in Task 1 are not the focus of modeling in Task 2 - and so on. Not just frequent, but more effective coordination might be required.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer stated that the future research is clearly defined and well-targeted towards achieving the objectives for this project.

Reviewer 2

The reviewer noted that a clear future research work plan was presented. Because the project will be ending soon, the future work proposed is reasonable for the period remaining, so the reviewer believes this is an achievable plan. The reviewer suggested that to improve the future work plan, more quantifiable metrics would be good to be able to judge the success of the future work plan.

Reviewer 3
The reviewer was critical stating that the future work is also ad hoc. The reviewer asked why the team is switching to MXenes, etc. (which are not going to be piezoelectric) from the piezoelectric materials. They also asked how a genetic algorithm will help the 3D printing; a structure was never demonstrated just a line.

Reviewer 4
The reviewer highlighted that at this stage, the future work outlined might not sufficiently achieve the final targets of the project.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1
The reviewer agreed that this work supports the VTO Materials subprogram objective of vehicle lightweighting by addressing issues with fiber-matrix adhesion, continuous-fiber 3D printing, and integrated sensing. The fiber adhesion work is especially relevant to the automotive industry to progress towards lighter vehicles.

Reviewer 2
The reviewer noted that the project supports the overall objectives of the VTO Materials subprogram.

Reviewer 3
The reviewer simply stated that composites and multifunctional materials are relevant.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1
The reviewer commented that this project is nearing the end of its timeline, so few tasks are remaining. The funds seem sufficient to complete the remaining tasks under a one-year, no-cost extension period.

Reviewer 2
The reviewer stated that the resources are sufficient for the project.

Reviewer 3
The reviewer observed that the work is not homogenous and too many separate and confusing tasks are being performed that do not support the others.

Presentation Number: MAT203
Presentation Title: Low-Cost High-Throughput Carbon Fiber with Large Diameter
Principal Investigator: Felix Paulauskas, Oak Ridge National Laboratory

Presenter

Felix Paulauskas, Oak Ridge National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 75% of reviewers felt that the resources were sufficient, 25% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

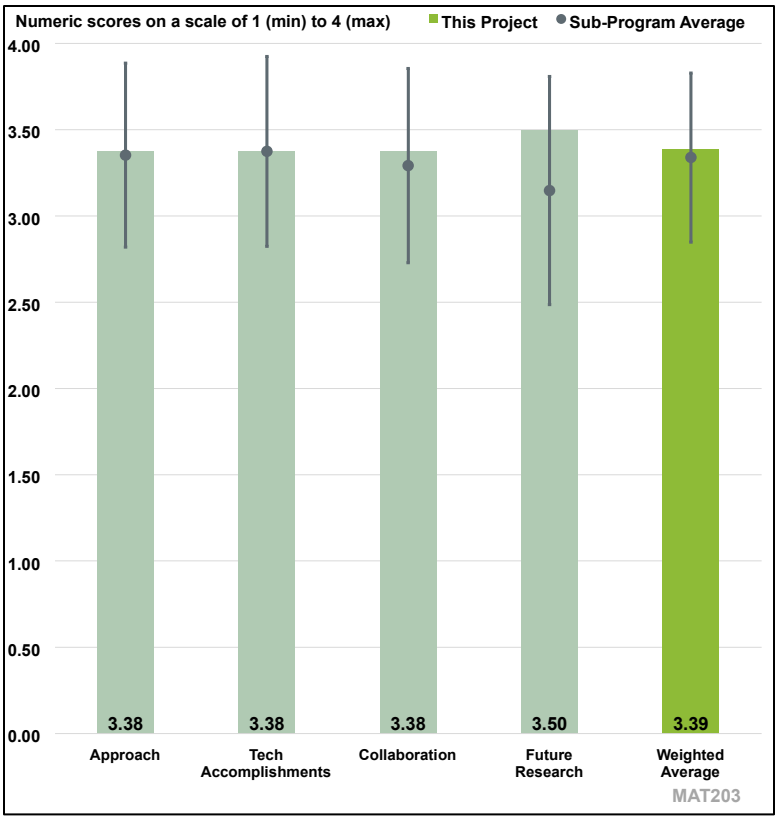

Figure 5-11. Presentation Number: MAT203 Presentation Title: Low-Cost High-Throughput Carbon Fiber with Large Diameter Principal Investigator: Felix Paulauskas, Oak Ridge National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer described that this project addresses the technical barriers of the cost of CF feedstock and production, and the availability of lower-cost CF at a level necessary for a large-scale impact in lightweight vehicle production. Although there was no Gantt chart or specific project schedule presented, the project appears to the reviewer to be well-designed from the aspects of establishing a baseline for 25% larger effective diameter CF converted from a textile-grade precursor that will meet the minimum DOE performance requirements of 250 ksi strength, 25 Msi modulus, and 1% strain-to-failure as well as projected cost savings due to enhanced production speeds. This was followed by producing CF with at least 50% larger diameter than a baseline fiber and minimum performance requirements of 350 ksi, 33 Msi, and 1% strain and a cost target of 25%–30% or greater savings using large-diameter CF. The project would then demonstrate and evaluate the new CF produced at as close to pilot scale as practical and test composite articles made with a production-type process to demonstrate the advantages of using large-diameter CF to achieve the performance requirements. The reviewer agreed that this appears to be a reasonable approach to meeting the project goals within the given timeline.

Reviewer 2
The reviewer noted that the project aims to produce low-cost CFs with large diameters. The project is well designed with a reasonably planned timeline.

Reviewer 3
The reviewer highlighted that the team has access to great experimental facilities which have been used to execute the approach of the project. The reviewer noted that the project is built on many years of experience which is reflected in the approach to the project.

Reviewer 4
The reviewer described that small diameter polyacrylonitrile (PAN) precursor fibers are expensive and that large diameter PAN fibers with lower cost take longer for conversion (oxidation and carbonization) time. The reviewer stated that the project team, in collaboration with 4XT and 4M Carbon Fiber Corp., (4M), processed the large-diameter fibers with plasma treatment, remarkably reducing the conversion cost and lowering the carbon footprint. The reviewer said that the researchers have the plan to build (with industry partners) a line in the United States to produce high-quality, large-diameter PAN fibers.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1
The reviewer described that although there were several project delays because of precursor and equipment availability, the major technical accomplishment in the final year of this project was completion of the production of the dry spun precursor fiber at ORNL and 4XT using advanced plasma oxidation, conventional carbonization, and advanced plasma surface treatment. The results showed that the precursor fibers could be produced with average diameters of 8 micrometers (μm) (a 37% increase over a minimum CF diameter of 5 μm for commercial fibers), an average strength of 363 ksi, and an average modulus of 27 Msi which exceeds the VTO Materials subprogram requirements of 250 ksi and 25 Msi. The reviewer applauded that this is an excellent accomplishment. The work in progress includes introduction of a new commercial precursor supplier and testing of demonstration articles from production preforming and molding processes which could result in another significant technical accomplishment.

Reviewer 2
The reviewer expressed that progress has been significantly delayed due to the industry partner’s inability to supply the fiber precursor. As a result, the progress has been limited.

Reviewer 3
The reviewer noted that the team has accomplished the major technical goals of producing larger diameter fibers by a process which may be economically feasible and scalable. The reviewer stated that it is still to be proven that the technical accomplishments for this project are fulfilling the economic targets set forth in the project.

Reviewer 4
The reviewer pointed out that the project is on track and has made progress. The resultant CFs meet the performance of the VTO Materials subprogram minimum requirements (250 ksi strength, 25 Msi modulus, and 1% strain-to-failure).

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer praised that the collaboration is outstanding because it included a national laboratory lead (ORNL), a manufacturer (4XT), three suppliers (Dralon, Dolan, and Sudamericana de Fibras), and academia (University of Tennessee). The reviewer noted that the responsibilities for each partner appear to be well-defined. The reviewer described the team roles including, ORNL provided project management, CF and composite evaluation and economic assessment; 4XT provided development, demonstration, and deployment of the advanced oxidation process, the suppliers provided precursor materials, and the university demonstrated article fabrication and compared the fibers to baseline materials.

Reviewer 2

The reviewer commented that the collaboration has been great. 4XT/4M provided a critical conversion technique - plasma treatment - that shortened the conversion time and cost, and reduced carbon emissions.

Reviewer 3

The reviewer suggested that the collaboration could have been more effective if all partners had been able to work efficiently and according to the plan.

Reviewer 4

The reviewer agreed that the project seems to be well-coordinated but has been hampered by the departure of a key partner (Dralon) which led to change of the partner contribution in the project. The reviewer was somewhat surprised that only one supplier is fully suited as supplier of the base fiber for the process. The reviewer remarked that even if one other supplier has been identified the materials are not optimal. The reviewer cautioned that this might raise questions about the robustness of the supply chain for the proposed process.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer commented that although the project is ending in FY 2024, the future research focuses on concerns of long-term availability of a dry-spun CF and the possibility of using a combination of lower-cost fibers and advanced conversion technologies to produce a broader range of fiber diameters with equal or improved performance characteristics. The reviewer noted that the recommendations also included an evaluation of resin infusion processes to potentially improve interfacial properties.

Reviewer 2

The reviewer acknowledged that the future research plan is clearly defined and, if successful, could achieve the targets.

Reviewer 3

The reviewer agreed that the proposed future work makes sense but asserted that it will be essential that a realistic technical cost analysis is performed to give a first indication of the viability of the process.

Reviewer 4

The reviewer pointed out that all the proposed testing was completed by the AMR date, and that a cost/performance analysis remains to be completed by early fourth quarter of FY 2024.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer agreed that this project is relevant and directly supports the overall VTO Materials subprogram objectives of reducing the cost of CF precursors and improving production and availability of low-cost CF. The project also addresses the VTO Materials subprogram technical objectives of weight reduction >25%, strength of >250 ksi, and modulus of >25 Msi.

Reviewer 2

The reviewer stated that the project supports the overall VTO Materials subprogram objectives and will be significant if the project could develop low-cost CFs with high performance.

Reviewer 3

The reviewer explained that for specific low-cost applications where performance reliability is not of ultimate importance, the fiber produced could be of interest. However, the reviewer noted that this is ultimately dependent on the cost targets being reached, which is still to be proven. The reviewer stressed that it will also be of major importance that the scaling to larger volume production is feasible. Proven performance/cost will be essential to position these fibers in the ranking position between conventional CF and glass fiber composites for the very cost-sensitive automotive applications.

Reviewer 4

The reviewer agreed that CFRCs are needed for automotive lightweighting and decarbonization. The excessive cost of CFs hinders their applications in the automotive industry. Large diameter precursor fibers are low cost, enabling CFs and composites in lightweight vehicles. The reviewer agreed that the project supports the overall VTO Materials subprogram objectives.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer described that the project resources were $1.5 million over four years ($500,000 per year with a no-cost extension of one year) for one national laboratory, one manufacturer, three suppliers, and one university because funding was limited to ORNL, 4XT, and the University of Tennessee. The reviewer stated that the resources are considered sufficient because of issues with the availability of the materials which delayed achieving the stated milestones in a timely manner.

Reviewer 2

The reviewer highlighted that the supplier of the CF has been the bottleneck to achieving the stated milestones in a timely fashion and an alternative vendor should be found.

Reviewer 3

The reviewer stated that the project is hosted in a renowned facility, so there is no reason to question that the adequate resources are available.

Reviewer 4

The reviewer observed that ORNL and 4XT/4M have sufficient resources for the project to achieve the stated milestones in a timely fashion.

Presentation Number: MAT205
Presentation Title: Adopting Heavy-Tow Carbon Fiber for Repairable Stamp-Formed Composites
Principal Investigator: Amit Naskar, Oak Ridge National Laboratory

Presenter

Amit Naskar, Oak Ridge National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 50% of reviewers felt that the resources were sufficient, 25% of reviewers felt that the resources were insufficient, 25% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

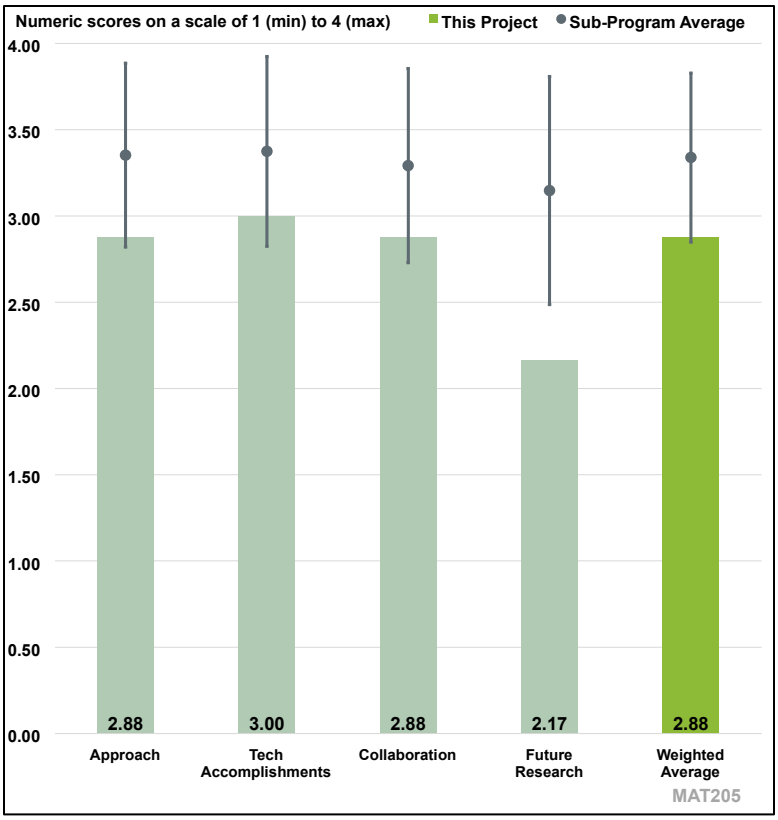

Figure 5-12. Presentation Number: MAT205 Presentation Title: Adopting Heavy-Tow Carbon Fiber for Repairable Stamp-Formed Composites Principal Investigator: Amit Naskar, Oak Ridge National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer described that overall, this project aims to use CF and PP to make recyclable composites. Ideally, the presence of the CF can lead to crystallization of PP on its surface and result in better properties. The reviewer agreed that the project clearly lays out both the milestones and scientific approach in a clear fashion, where the project narrative builds off the previous steps. The reviewer described that the researchers noted that the material was recyclable a couple times but did not show recyclability. The reviewer agreed that the thermoplastic nature of these materials should enable the recycling but asked if recycling affects the material performance at all.

Reviewer 2

The reviewer stated that the first objective of improving interfacial adhesion seems to be met using controlled crystallization and cooling of the composite; but the reviewer stated that there was no mention of the repairable aspect and no cost analysis to show the 30%–50% reduction in costs.

Reviewer 3

The reviewer commented that one of the technical barriers identified is rapid cycle time for high volume production, but a major conclusion of the work was that the process should be slowed down to achieve the best properties. The reviewer mentioned that this seems to be at odds with what they would want to do next. Moreover, the reviewer added that the researchers stated that the "current fiber surface treatment methods are developed for epoxy matrices and are not applicable for thermoplastics with less polarity than the epoxies," but the reviewer did not think this is entirely true as companies like Michelman offer many sizing agents tailored to both thermoplastic and thermoset resins.

Reviewer 4

The reviewer criticized that this presentation was extremely hard to gain any information from because of poor figures, labels, and bullet points. The hypothesis that crystallization will improve performance is not clear from the data when a quenched sample (e.g., iPP-CF30) has high strength and equivalent interlaminar shear strength compared to the isothermal sample and all are lower than air. The reviewer added that there was no measurement of the interfacial properties, so it cannot be concluded that the interface is affected. Additionally, all measurements are bulk. The reviewer pointed out that interlaminar shear strength is not an interfacial test - it is an interlaminar test - and there is no interlaminar region in this composite. The reviewer asked if the authors checked to see if the failure was in shear since the reviewer imagined this as a ductile failure with no crack generation and therefore more a measure of the matrix properties. The reviewer also asked what the lines represent on Slide 10 since there is no legend.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer described that even though the work seems to be extremely based on fundamental science, they were able to show a clear translation of the crystallization kinetics. The reviewer commented that the work on the Nylon 6,6 was a little bit confusing because results did not follow the same trend as the PP. The reviewer noted that showing multiple relevant materials was good.

Reviewer 2

The reviewer praised that the technical quality (the science) is very good. However, the reviewer mentioned that no interfacial chemistries were developed, as proposed in the original work, but the composite production is well aligned with lightweighting and material development initiatives, especially with regards to the non-woven wet-lay process which would enable the reuse of recycled fibers (CF or glass) as well as inherently discontinuous fibers like hemp.

Reviewer 3

The reviewer applauded that avoiding the use of sizing agents by carefully controlling the cooling rate was very clever. With the gain in properties, the question of cost versus competition was not addressed. The reviewer highlighted that another objective that was not addressed directly is the repairable aspect mentioned in the project proposal and title. The reviewer remarked that addressing these issues in the presentation would have been very helpful.

Reviewer 4

The reviewer labeled the accomplishments as "fair" since the data is not convincing that the desired behavior is being achieved and the mechanical testing methods used will not show the behavior.

The reviewer expressed that the presenter did not provide a clear plan to achieve the desired program goals.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer commented that the presenter noted that the project team includes Endeavor Composites, and their process was used to accomplish some of the initial blending. Collaboration beyond that was not clear to the reviewer.

Reviewer 2

The reviewer noted that the project is in collaboration with University of Tennessee, Knoxville, and Endeavor Composites (a Tennessee local start-up).

Reviewer 3

The reviewer described that the team is small, and it was difficult to see how Endeavor Composites is a team member. The reviewer added that Endeavor Composites was added in response to questions from the 2023 VTO AMR, but that it is hard to see how they offer support to the objectives, either in commercialization or the R&D.

Reviewer 4

The reviewer remarked that the effort was missing an end-use industrial partner who could have helped with the cost issue. The team made some timely progress on understanding crystallization impact showing good collaboration.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer described that the project team stated that the project is concluding and ran out of time in their presentation to describe this portion. The reviewer is unclear about how this work will translate to an actual product or further technology development.

Reviewer 2

The reviewer requested that the researcher please address what is motivating the use of large fiber tows for automotive applications. The future direction should expand beyond processing-property relationships that are relatively well understood for polymer composites. Also, for a non-woven wet-lay process, the reviewer thought that there could be an analogous study to the high-fiber tow by really testing the limits of how much CF you can put into the composite and the process itself adaptable to water-based surface treatments that could improve wettability, which was noted as an issue for the higher fiber loadings. The reviewer suggested that showing the actual demonstration pieces of the composites produced would be ideal to better understand the relative advantages for developing these materials and where they would be used in a car.

Reviewer 3

The reviewer stated that the project is ending, but there is no clear plan for future work, just a description of challenges.

Reviewer 4

The reviewer simply stated that the project is complete.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer asserted that the impact of the relevance could be increased if the descriptions of an application or future work were clearer.

Reviewer 2

The reviewer stated that the development of processes that enable the reuse of various fiber forms is well-aligned.

Reviewer 3

The work on thermoplastic composites is relevant, but the reviewer was not sure about heavy-tow materials.

Reviewer 4

The reviewer commented that improving thermoplastic composites that are more easily recycled if they have the needed properties for use is helpful to VTO.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer remarked that there is no reason to believe the resources would be excessive or insufficient. The project team made reasonable progress given its scope.

Reviewer 2

The reviewer simply stated that the resources were sufficient.

Reviewer 3

The reviewer concluded that since only one of the three objectives were met, there might have not been enough resources.

Reviewer 4

The reviewer was critical that the work has not generated remarkable results for $1.5 million in funding.

Presentation Number: MAT206
Presentation Title: Soft Smart Tools Using Additive Manufacturing
Principal Investigator: Matthew Craps, Savannah River National Laboratory

Presenter

Matthew Craps, Savannah River National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

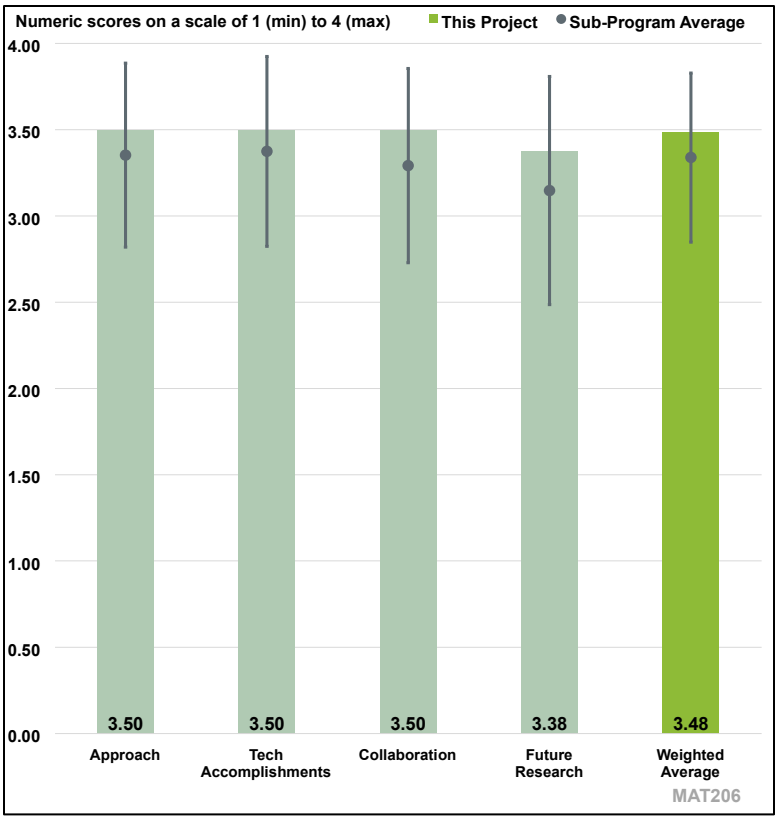

Figure 5-13. Presentation Number: MAT206 Presentation Title: Soft Smart Tools Using Additive Manufacturing Principal Investigator: Matthew Craps, Savannah River National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer described that the team clearly presented the technical barriers this project would address. They also did an excellent job justifying the need for thermos-stamping due to the energy benefits compared to compression molding and autoclaving. The reviewer, however, was confused by the timeline of the project compared to the milestone table. The milestone table shows that the milestones were all completed as of 3/29/2024, but later in the presentation, a no cost extension is being requested to extend the project into FY 2025. The reviewer understood the justification for this extension, but the extension needs to have some associated milestones.

Reviewer 2

The reviewer explained that the project aims to develop 3D-printing technology for soft smart tooling, which could significantly reduce the time, cost, and GHG emissions of the automotive tooling process. The project is well designed, covering materials development (e.g., carbon nanotube [CNT]-coated continuous fiber filament [CCF] filament development) and processing techniques (e.g., 3D printing of tooling as well as thermocouple sensors compatible with the composite). The timeline seems reasonable, although there was some delay due to the co-PI's relocation.

Reviewer 3

The reviewer commented that this project aims to address the technical barrier of the extensive time spent engineering filament coating scale-up and optimizing annealing parameters with CNTs. The project is well designed, and the timeline is reasonably planned.

Reviewer 4

The reviewer agreed that the development of smart tooling for composite part fabrication is an excellent goal, and smart tooling will offer significant benefits to enhance part manufacturing rate via microwave heating. The approach involves 3D printing of CF impregnated tows that are decorated with CNT suspended ink for enhanced microwave susceptibility leading to rapid curing of composite. No doubt this is a good approach. The reviewer clearly observed that the temperature can be increased quickly via application of microwaves. The reviewer noted, however that the presenter did not discuss how the temperature distribution would be further controlled.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer described that the team presented noteworthy progress on the project plan and appears to have met all the milestones for the project. There were several different topics that were covered within the presentation, such as scaling up the fiber coating process, ink development for printed thermocouples, and cyclic testing of the 3D-printed tool. The reviewer liked that there was both a life cycle analysis (LCA) and techno-economic analysis (TEA) included within this work to validate this approach. The reviewer desired to see a higher loading in the cyclic tests since 1kN seems a little low for this large of a tool.

Reviewer 2

The reviewer highlighted that significant technical progress has been achieved. Scalable CNT-coated CCF filament development, thermocouple design for asymmetric tooling, 3D-printable ink development for thermocouple sensors, and 3D printing techniques for CCF composite tooling with compatible printed thermocouples have all been successfully demonstrated. Both a LCA and a TEA were also performed. The scanning electron microscope image on Slide 7 shows well-aligned CNT bundles. The reviewer asked if these are CNTs aligned as shown even after the 3D-printing process or does this microscopic image simply show that part of the thermocouple contains CNTs, without necessarily indicating that they are aligned as shown in the picture.

Reviewer 3

The reviewer remarked that the technical progress demonstrated a well-planned and well-executed project. The reviewer suggested that the uniformity of the coating might be a challenge during the scale-up process, but it seems the process is under control and monitored. The reviewer felt that the technical details in the presentation were thorough, and the project delivery was considered successful.

Reviewer 4

The reviewer noted that the project is complete, and the tooling manufacturing has been demonstrated and life-cycle energy analysis has been conducted. The reviewer offered that the CNT supply chain and cost may impact tooling manufacturing cost.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer acknowledged the team consisted of excellent collaboration between a national laboratory, a university, and private industry. Including private industry with the fiber coating work and demonstrating some scale-up potential really helps justify the commercialization potential of the developed technology.

Reviewer 2

The reviewer commented that the project is conducted through collaborations between the lead Savannah River National Laboratory (SRNL), the University of Delaware Center for Composite Materials, and Mainland Solutions. They have clearly defined roles and complementary expertise.

Reviewer 3

The reviewer described that the team includes SRNL, University of Delaware, and Mainland Solution LLC. The collaboration, skill sets, and coordination have been demonstrated by the successful project delivery.

Reviewer 4

The reviewer noted that the external collaborator has moved his laboratory and set up was delayed. Nonetheless, the project is complete.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer explained that the team laid out a good amount of future work to be completed, and there was a clear purpose for each task. The future work appears achievable within the timeline that consists of a no cost extension through the middle of FY 2025. The reviewer stated that it was mentioned that there has been a delay in the subcontract to the University of Delaware that slowed down that portion of work, but those specific tasks were not mentioned. The reviewer suggested that the presenter should have given some specifics about the University of Delaware tasks.

Reviewer 2

The reviewer agreed that the proposed future work is closely aligned with the project goal and well planned.

Reviewer 3

The reviewer commented that the proposed work is a needed continuation in addition to the success of the current project and could further answer the remaining questions. The project clearly defines the purpose of future work, and the future work is likely to achieve its targets.

Reviewer 4

The reviewer described that the plan for manufacturing a polyether ether ketone/CF/CNT composite tooling and the potential impacts were discussed.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer agreed that this project is relevant to VTO objectives and is very relevant to the automotive industry to increase the efficiency of fabricating thermos-stamping molds. The developed technology could reduce the cost and lead time to manufacturing molds thus improving vehicle manufacturing efficiency.

Reviewer 2

The reviewer acknowledged that the project supports the overall VTO Materials subprogram objectives. 3D printing is highly suitable for producing smart composite tooling for automobile parts due to its ability to create customized, lightweight designs with integrated smart features, reduced lead times, cost efficiency, and material versatility. The reviewer agreed that this technology also enhances performance, precision, and sustainability in the manufacturing process.

Reviewer 3

The reviewer described that the project directly links to the VTO Analysis, Energy Efficient Mobility Systems, and Materials subprograms and is considered to support the overall VTO objectives.

Reviewer 4

The reviewer remarked that the development of smart tooling for composite part fabrication will offer significant benefits to enhance part manufacturing rate. Although LCA data with energy benefit in processing cycle was presented, recycling potential of these parts still need to be addressed.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer stated that a no cost extension was requested to complete some work into FY 2025 and the funds seem sufficient to meet the stated remaining tasks.

Reviewer 2

The reviewer simply stated that the resources are sufficient.

Reviewer 3

The reviewer explained that SRNL, University of Delaware, and Mainland Solution LLC provide sufficient resources from manufacturing to characterization for the project to achieve the stated milestones in a timely fashion.

Reviewer 4

The reviewer commented that the resources for this project were adequate, and the project is complete.

Presentation Number: MAT207
Presentation Title: Multi-Material Functional Composites with Hierarchical Structures
Principal Investigator: Christopher Bowland, Oak Ridge National Laboratory

Presenter

Christopher Bowland, Oak Ridge National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 75% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 25% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

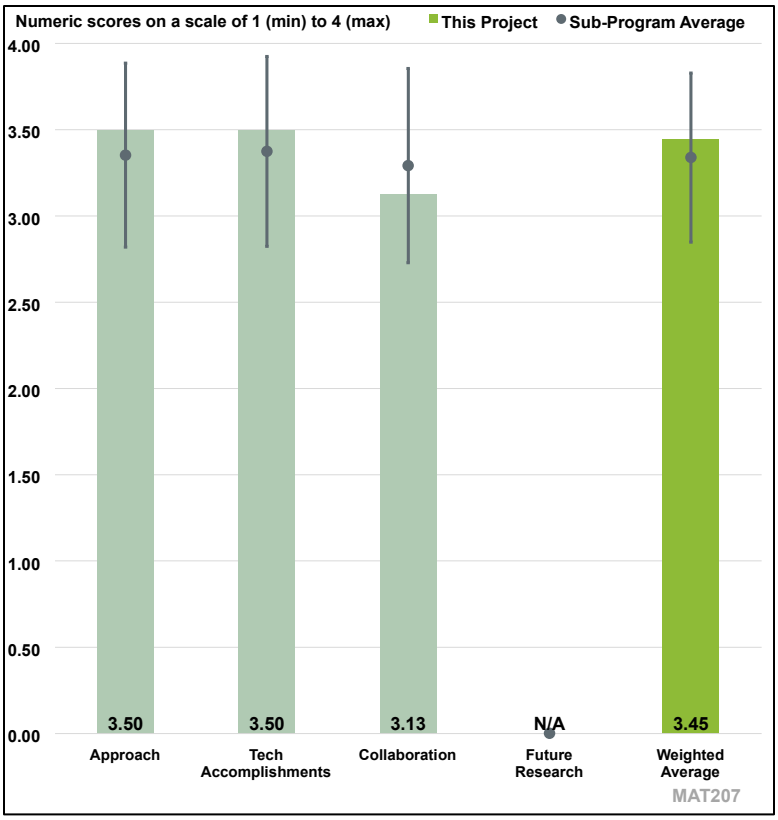

Figure 5-14. Presentation Number: MAT207 Presentation Title: Multi-Material Functional Composites with Hierarchical Structures Principal Investigator: Christopher Bowland, Oak Ridge National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The project listed a couple of points as a barrier. From the presentation, the reviewer observed that most of the barriers are addressed. However, there are some which are not considered or are not presented, particularly those related to a self-sensing capability.

Reviewer 2

The reviewer noted that the approach is well planned and executed that has led to meeting the milestones.

Reviewer 3

This project aims to address the technical barrier of the critical challenge for multi-material systems: “Nondestructive evaluation (NDE) and Life Monitoring.” The reviewer explained that other challenges include enhancing crash energy management, optimizing mass reduction, and improving the recycling of CF materials. Integrating passive sensing into fiber-reinforced composites helps improve the system-level strength-to-weight ratio and provides data to better model the service life and detect damage to the composite. The reviewer pointed out that the project is well designed, and the timeline is reasonably planned.

Reviewer 4

The reviewer stated that the team achieved their objectives adjusting to the issue of geometry with dip coating to switch to PAN electrospinning. The project was a bit delayed due to the pivot, but the greatly improved interfacial adhesion was a great result.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer commented that the project followed the planned timeline and completed as scheduled.

Reviewer 2

The reviewer noted that the project accomplished the proposed milestones.

Reviewer 3

The reviewer stated that the technical progress demonstrated a well-planned and well-executed project. An in-depth study on nanofiber diameter and alignment on nonwoven CF mats has been performed associated with a TEA. The reviewer felt that the technical details in the presentation are thorough, and the project delivery was successful.

Reviewer 4

The reviewer praised that boosting the interfacial adhesion from a 20-60% improvement is a major change. The PAN process seems to be well understood, and the new products can be readily scaled, which is another objective of this project. The reviewer also noted that detecting damage using voltage sensing is another objective achieved.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer noted that the project has multiple collaborators included Columbia University as subcontractor and Enfluxx Tech providing license for passive sensing.

Reviewer 2

The reviewer stated that the collaborations were well laid out, and that each partner has a specific task they accomplished.

Reviewer 3

The reviewer described that the team includes ORNL and Columbia University. The collaboration, skill sets, and coordination have been demonstrated by the successful project delivery.

Reviewer 4

The reviewer stated that this project was led mostly by ORNL.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer simply stated that the project has ended.

Reviewer 2
The reviewer noted that the project is now completed, so no proposed future research was discussed.

Reviewer 3
The reviewer said that there is no remaining proposed future research for this project.

Reviewer 4
The reviewer pointed out that there is no future research to be supported by DOE, however there should be future licensing opportunities to generate more work based on this project.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1
The reviewer agreed that the project aligns with the VTO Materials subprogram objective for developing smart composite structures.

Reviewer 2
The project supports the overall VTO Materials subprogram objectives.

Reviewer 3
The project directly links to the VTO Analysis, Energy Efficient Mobility Systems, and Materials subprograms and is considered to support the overall VTO objectives.

Reviewer 4
The reviewer agreed that the stronger and lighter weight composite with sensing is extremely valuable to the composites needed for EVs. The technology was selected to be in the FedTech program which helps support its relevance.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1
The reviewer agreed that sufficient resources were available including financial, technical, and equipment (from the collaborators).

Reviewer 2
The reviewer stated that the project had sufficient resources that helped to achieve and accomplish the milestones.

Reviewer 3
The reviewer remarked that ORNL and Columbia University provide sufficient and powerful resources from manufacturing to characterization for the project to achieve the stated milestones in a timely fashion.

Reviewer 4
The reviewer stated that the program is complete and there was no need for more resources.

Presentation Number: MAT208
Presentation Title: Efficient Synthesis of Kevlar and Other Fibers from Polyethylene Terephthalate (PET) Waste
Principal Investigator: Daniel Merkel, Pacific Northwest National Laboratory

Presenter

Daniel Merkel, Pacific Northwest National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

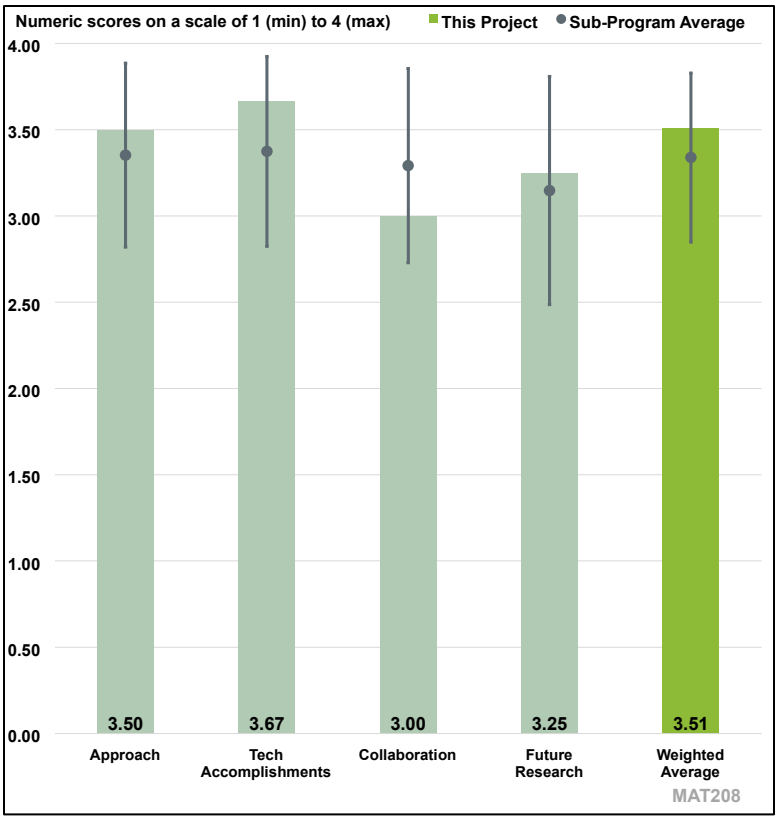

Figure 5-15. Presentation Number: MAT208 Presentation Title: Efficient Synthesis of Kevlar and Other Fibers from Polyethylene Terephthalate (PET) Waste Principal Investigator: Daniel Merkel, Pacific Northwest National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer stated that the PNNL team seems to have a clear understanding of the project and have executed it well. The researchers also did a cost analysis to show the benefits from their polyethylene terephthalate (PET)-based aramid fiber development.

Reviewer 2

The reviewer described that this project addresses the technical barriers of the excessive cost of precursor materials and CF conversion to produce composites at high-volume production rates that will achieve weight reductions of up to 60%–70% over current baseline materials. The reviewer explained that the approach is to use direct depolymerization of PET waste plastic, generation of terephthalolyl chloride (TCI), and repolymerization using an aromatic diamine to produce a lower cost polyaramid fiber. This process has the advantages of faster reaction rates and easy removal of contaminants. The reaction product would then be used to fabricate unidirectional composites, and a TEA of the PET-derived fiber would be compared to virgin sources. The reviewer said that although there was no project schedule Gantt chart presented, the project milestone descriptions provided insight to a well-designed approach and a reasonable timeline for the three-year project to achieve

the project objectives of demonstrating the synthesis of aramid polymers and fibers from PET plastic waste, demonstrating a low-cost route to producing aramid fibers, and developing composites containing PET-derived aramid fibers.

Reviewer 3

The reviewer praised the excellent approach with upcycling of PET waste via depolymerization followed by polymerization of polyaramid for fiber manufacturing. Feasibility of this approach has been demonstrated (although the fiber properties remain very poor).

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The team successfully completed their milestones even though one of their primary team members left during the project, established a process to develop the fibers, clearly demonstrated performance as compared to current state of art commercial versions, and showed a 20% cost reduction for aramid fibers using their method.

Reviewer 2

The reviewer explained that the primary project objective was to demonstrate the synthesis of aramid polymers and fibers from PET plastic waste. PET was obtained from mixed-waste PET beverage containers with contaminants at ~10 wt.% that was mostly PP labels and colorant dyes. The PET was depolymerized to generate TCl and then the TCl was polymerized with six different diamines to produce polyaramids at an 85% synthesis yield. The reviewer noted that this technical accomplishment achieved the primary objective. The reviewer stated that a high molecular weight polymer with 40 repeating units was synthesized in quantities ≥20 g. The resulting inherent viscosity (molecular weight) increased 25% to values typically used for fiber spinning.

A PET-derived fiber was produced with a diameter ≤20 µm which is larger than the typical CF feedstock and better for carbonization. The project also demonstrated additional technical accomplishments of achieving 100% increase in modulus by high temperature drawing, up to 30% cost reduction for PET-derived terephthalic acid with plastic recycling credits, up to 20% cost reduction for PET-derived aramid fiber with plastic recycling credits, a 40% cost reduction of PET-derived aramid fibers as compared to commercial Kevlar para-aramid, and a 13% reduction in GHG emissions for PET-derived terephthalic acid compared to the commercial enzymatic process. The reviewer praised that all are considered significant and outstanding technical accomplishments considering the budget and timeline for this project.

Reviewer 3

The reviewer stated that nearly an equivalent molecular weight of polyaramid (~4 deciliters per gram intrinsic viscosity) was prepared and spun into fiber form with 15-20 µm filament diameter. The reviewer mentioned that for some reason the filaments are not strong enough to display good tenacity. The reviewer observed that it was very likely the rudimentary spinning device did not deliver high enough fiber orientation.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer stated that the team is mostly from PNNL, with no industry partners. The reviewer highlighted that a commercial perspective from industrial partners will be beneficial in moving forward in the next phase.

Reviewer 2

The reviewer stated that there was no collaboration slide presented, nor was collaboration discussed probably because of the technical readiness level (TRL) for this research. The PNNL research team consisted of eight co-PIs and internal collaboration appears to be good because of the technical accomplishments that were achieved.

Reviewer 3

The reviewer noted that the project involves a single entity, PNNL and that a Collaboration and Coordination slide was not presented.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer described that the team was uncertain about the possibility of creating a process for scale up of the aramid fibers. It is possible that scale up will be addressed in a different project.

Reviewer 2

The reviewer commented that although this project was completed at the end of FY 2023, future research was proposed for recovery of paraphenylene diamine from waste sources to achieve further cost/emissions benefits in synthesis process and evaluating other PET-derived fibers. The presenter indicated that this future work would continue under the Composites Core Program 2.0 Thrust III Circularity in FY 2024.

Reviewer 3

The reviewer described that the second phase of this project has been included in the newly established Composite Core Program 2.0.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer stated that cost reduction of materials that can be used in composites is a key focus area for VTO.

Reviewer 2

The reviewer agreed that this project is relevant to the DOE VTO Materials subprogram objectives of developing low-temperature and high-strength hybrid composite systems for vehicle components, reducing current cost barriers to implementing aramid fiber composites in automotive applications, and recycling of materials to support clean energy and a circular carbon economy through reduced material and energy costs.

Reviewer 3

The reviewer agreed that the project is relevant because of the upcycling of PET to value-added polymer and fiber product. These fibers can be used in automotive composite manufacturing.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer stated that PNNL seems to have all the capabilities and resources to conduct the project efficiently.

Reviewer 2

The reviewer stated that the funding amount of $820,000 over three years is considered sufficient for the level of research that was needed to complete this project and meet the milestones within the performance period.

Reviewer 3

The reviewer simply stated that the resources are sufficient for this project.

Presentation Number: MAT209
Presentation Title: Bio-based Inherently Recyclable Epoxy Resins to Enable Facile Carbon-Fiber Reinforced Composites Recycling
Principal Investigator: Nicholas Rorrer, National Renewable Energy Laboratory

Presenter

Nicholas Rorrer, National Renewable Energy Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 75% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 25% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

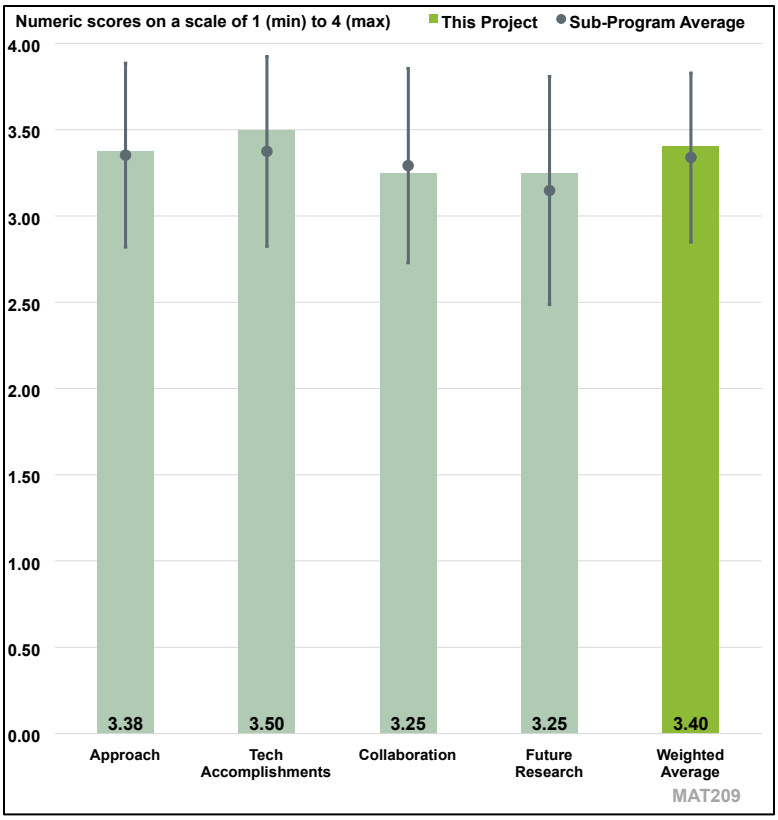

Figure 5-16. Presentation Number: MAT209 Presentation Title: Bio-based Inherently Recyclable Epoxy Resins to Enable Facile Carbon-Fiber Reinforced Composites Recycling Principal Investigator: Nicholas Rorrer, National Renewable Energy Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer expressed that the pathway to recycling and recovery offers potential, but the application space may be limited by the thermal properties of the bio-derived resins. The reviewer stated that automotive structures often require painting to meet long-term corrosion and surface finish requirements. Therefore, material subjected to these processes must be able to tolerate the higher temperatures encountered during electrocoat and paint bake processes.

Reviewer 2

The reviewer noted that barriers were addressed by the work scope and approach.

Reviewer 3

The reviewer applauded that the work is technically excellent and important considerations like aging/weathering and recyclability of the materials for the application were included in the design of experiments.

Reviewer 4

The reviewer described that sourcing, recyclability and reusability is addressed through application of the National Renewable Energy Laboratory (NREL) variation on polyester covalently adaptable networks (PECAN) resin that was developed for wind blades and other applications. The project was executed following a clear plan, however the approach focused more on advancing the science of PECAN resin rather than addressing automotive related challenges. Processing material with continuous fiber cloth is relevant only to the highest performance, lowest volume, vehicles. Screening tests to standard potential exposures for the resin (fluids, temperatures etc.) were not considered in this work.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer noted that all project goals have been completed per the original intent.

Reviewer 2

The reviewer commented that the project accomplishments demonstrated the versatility of the resin and composites, and the TEA shows a cost advantage.

Reviewer 3

The reviewer praised that the technical progress is exceptional for the budget having demonstrated both large scale parts and comprehensive LCA/TEA.

Reviewer 4

The reviewer commented that scientific technical accomplishments were addressed but cautioned that the connection to automotive challenges is tenuous.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer highlighted that extensive collaboration with feedstock producers was demonstrated. However, additional engagement with end user candidates could have provided additional insight.

Reviewer 2

The reviewer asserted that the collaboration is broad and not project specific, but generally expected to provide industry-relevant input and guidance.

Reviewer 3

The reviewer commented that the project appears to be well aligned with the major Bio-Optimized Technologies to keep Thermoplastics out of Landfills and the Environment or BOTTLE consortium. The reviewer was surprised this technology has not been accepted by wind energy applications which would consume substantial amounts of this type of resin and apply to a large end-of-life waste-to-life use problem where the resin would be well suited.

Reviewer 4

The reviewer commented that the project would have benefited from direct industry feedback.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer said that, although the project has reached its conclusion, the proposed future work has potential to expand the commercial opportunities. The project PI should consider application of the bio-derived resins to short-fiber chopped composites. The reviewer noted that woven material formats continue to be cost prohibitive for high-volume automotive applications.

Reviewer 2

The reviewer thought that one area of improvement would be to better explain how this work aligns with vehicle manufacturer interests and expectations since the reviewer's perception of vehicle original equipment manufacturers (OEMs) is that they are leaning heavily towards thermoplastics that can be more easily fit into the recycling infrastructure. From the collaborator list/technical direction, the reviewer was unclear about the potential of this material to be recycled. Someone once said there is a difference between being recyclable and being recycled. The reviewer asked where the material would go if it ended up at a sorter.

Reviewer 3

The reviewer simply stated that the project has ended.

Reviewer 4

The reviewer simply stated that the project is complete.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer agreed that the project goals are aligned with the VTO mission statements.

Reviewer 2

The reviewer commented that the project is relevant to the VTO Materials subprogram objectives (improved composites, lightweighting, recycling).

Reviewer 3

The reviewer agreed that these types of resin systems would greatly enable the recovery of CF at the end of life of parts.

Reviewer 4

The reviewer agreed that the work is relevant to the VTO Materials subprogram objectives, however the specifics of the projects could be more applicable to the automotive needs.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer commented that, given that the project completed, sufficient resources were deployed to meet the stated milestones.

Reviewer 2

The reviewer thought that the resources were sufficient.

Reviewer 3

The reviewer described that $1.5 million was expended on incremental improvements of NREL's PECAN resin, thermoforming trials, experiments, and analysis. The funds were sufficient to perform this work.

Reviewer 4

The reviewer noted that the funding level appears excessive for the work presented relative to other projects.

Presentation Number: MAT211
Presentation Title: Sustainable Lightweight Intelligent Composites (SLIC) for Next-Generation Vehicles
Principal Investigator: Masato Mizuta, Newport Sensors Inc.

Presenter

Masato Mizuta, Newport Sensors Inc.

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 80% of reviewers felt that the resources were sufficient, 20% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

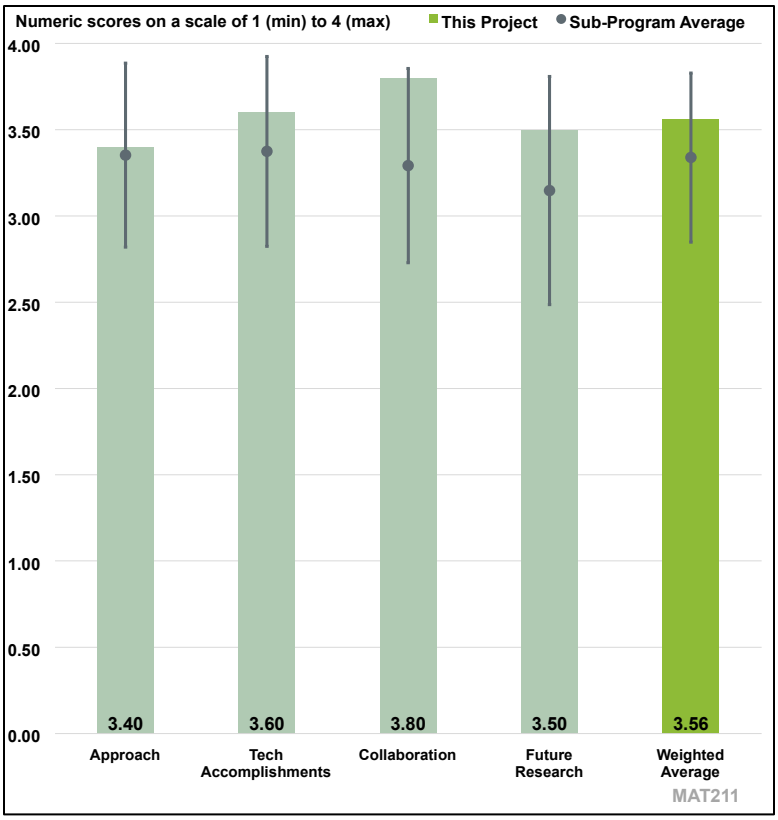

Figure 5-17. Presentation Number: MAT211 Presentation Title: Sustainable Lightweight Intelligent Composites (SLIC) for Next-Generation Vehicles Principal Investigator: Masato Mizuta, Newport Sensors Inc.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer stated the technical barriers include high fiber costs and fiber damage detection. The project certainly addresses damage detection, but the impact on fiber cost is not clear.

Reviewer 2

The reviewer stated the project approach is good. The project team incorporates a Sustainable Lightweight Intelligent Composites (SLIC) sensor strip to vehicle parts using a sheet molding compound (SMC). The sensing capability seems already proven, and the focus is to determine how to incorporate it into vehicle components in cost-effective and energy efficient ways. While general milestones are reasonable, the milestones are not SMART (Specific, Measurable, Achievable, Relevant, and Time-bound). The milestones should include quantifiable targets. For example, there was some uncertainty about the cost competitiveness. Considering commercialization, cost is one of the most important aspects. And because the technology seems to have performance, cost reduction will be key for practical deployment. Collaboration with Teijin Automotive Technologies provides satisfactory progress toward realistic commercialization.

Reviewer 3

The reviewer commented that this project identifies high fiber cost and difficulty with damage inspection as the two key barriers to target. Task 1 has a component for developing a hybrid composite battery enclosure but there was no mention of how the excessive cost will be addressed in this project. The entire presentation was centered around health monitoring and sensing.

Reviewer 4

The reviewer stated the research approach is good, and it includes design and fabrication of the battery enclosure, and development and integration of the sensor system. The integration of sensors with SMC is very interesting.

Reviewer 5

The reviewer commented that Phase IIB of the project aims to integrate two types of sensors into one strip using corrugations in the front section of the shield panel. The project is on track and making progress in terms of tasks and deliverables.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer stated that the work demonstrates an effective method for damage detection.

Reviewer 2

The reviewer commented that, considering the project has just started, satisfactory progress has been demonstrated from the Phase I effort. The incorporation of a SLIC sensor using SMC for the underbody impact shield was successfully performed. While the process needs refinement, good data including piezoelectric sensor test data have been obtained.

Reviewer 3

The reviewer remarked that the technical progress seems good compared to the project plan considering this project is a fresh start.

Reviewer 4

The reviewer enquired about the pressures that the sensor withstood and sought clarification on pressure limitations for SMC fabrication. The reviewer expressed concern about whether the sensor would conform to a curved geometry or get damaged.

Reviewer 5

The reviewer noted the project started in January 2024 and design tasks in Task 1 and manufacturing procedures in Task 2.1 are in progress. The project achieved one-step sensor/composite molding.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer noted that the team collaboration includes industry partners and commercial manufacturers who actively contribute to the effort.

Reviewer 2
The reviewer commented that the team collaboration is excellent. The involvement of Teijin Automotive Technologies and Owens Corning is very good. They are key players for commercialization.

Reviewer 3
The reviewer acknowledged that this project is supported by three entities, all from industry. Tejin Automotive Technologies seems responsible for composite manufacturing and Owens Corning for impact testing. The presenter discussed coordination efforts during the presentation. However, including a research institute would be very helpful in addressing technical challenges.

Reviewer 4
The reviewer mentioned that the team collaboration is excellent and included very frequent interactions between partners.

Reviewer 5
The reviewer commented that the team collaboration between Newport Sensors, Teijin Automotive Technologies and Owens Corning has been great.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1
The reviewer commented that the proposed future work appears to address the technical barriers and challenges relevant to the project.

Reviewer 2
The reviewer stated that the general directions of the project approach are good, however, some details could be more carefully defined, examples include what is needed to make the technology more cost effective and what performance targets are required to make the technology commercially viable. To bring this technology to commercialization, these details may need to be mapped out and clearly defined.

Reviewer 3
The reviewer commented that the future work plan seems reasonable and aligns with the project goals. Likely, the project targets will be achieved in a timely manner.

Reviewer 4
The reviewer remarked that the future scope is planned well and, if successful, would be relevant to the objectives of the project.

Reviewer 5
The reviewer commented that the proposed future research has clearly defined tasks and deliverables and will likely achieve its targets.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1
The reviewer noted that the project is relevant to VTO Materials subprogram for composites.

Reviewer 2
The reviewer commented that a capability for sensing technology is important for lightweight materials. Damage sensing is an important aspect for various vehicle parts beyond lightweight materials.

Reviewer 3
The reviewer noted that this project supports the overall VTO Materials subprogram objectives, especially from the multifunctional material and self-sensing perspectives.

Reviewer 4
The reviewer commented that the project supports the overall VTO Materials subprogram objectives.

Reviewer 5
The reviewer acknowledged that current autonomous vehicles rely on optical, laser and radar sensors, which can still miss blind spots. The proposed SLIC sensors can detect impact, damage, and thus enable true autonomous functions.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1
The reviewer commented that additional resources would help offset the excessive cost of fabrication and sensor design and help show additional relevance outside of a single demonstration component.

Reviewer 2
The reviewer noted that the project resources are sufficient.

Reviewer 3
The reviewer commented that the project resources are sufficient to achieve the stated milestones in a timely fashion.

Reviewer 4
The reviewer stated that the project resources are adequate.

Reviewer 5
The reviewer commented that Newport Sensors, Teijin Automotive Technologies, and Owens Corning have the resources sufficient for the project to achieve the stated milestones in a timely fashion.

Presentation Number: MAT212
Presentation Title: Integrated Self-sufficient Structurally Integrated Multifunctional Sensors for Autonomous Vehicles
Principal Investigator: Amrita Kumar, Acellent Technologies Inc.

Presenter

Amrita Kumar, Acellent Technologies Inc.

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

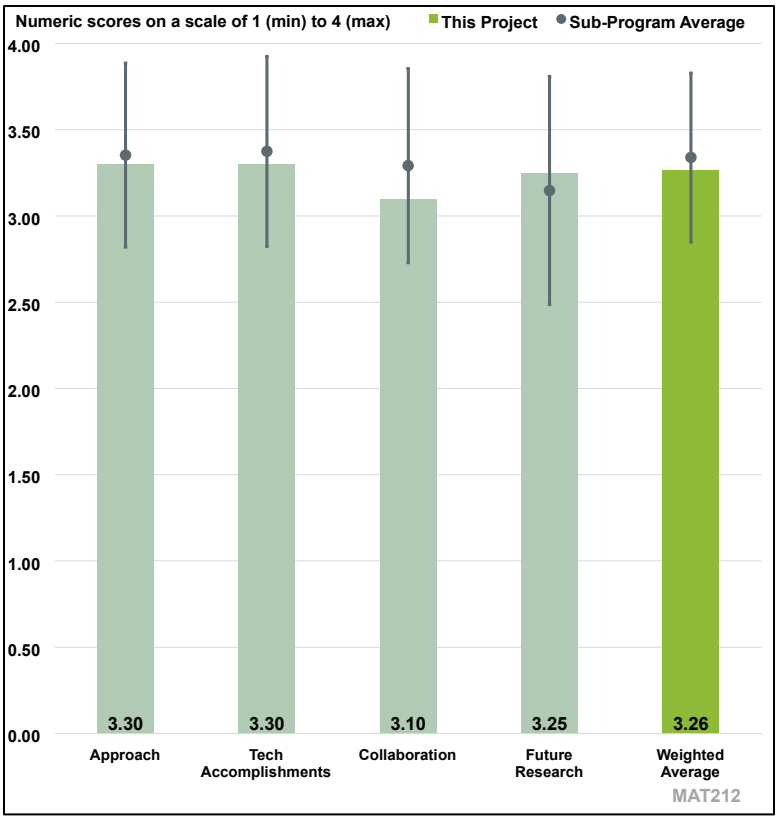

Figure 5-18. Presentation Number: MAT212 Presentation Title: Integrated Self-sufficient Structurally Integrated Multifunctional Sensors for Autonomous Vehicles Principal Investigator: Amrita Kumar, Acellent Technologies Inc.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer stated the research approach was reasonably described for both the impact sensor and battery energy management portions of the work, although it was not clear why these topics were combined in this completed project versus separated from the energy management portion of the recently initiated MAT 266 project. Both areas can positively impact DOE mission areas by enhancing pedestrian safety, saving weight, and increasing structural efficiency.

Reviewer 2

The reviewer commented that the project is complete, and the approach was well outlined to accomplish the proposed milestones and objectives.

Reviewer 3

The reviewer commented that the approach to perform the work is good and is supported by experience in the field. The project case studies appear to somewhat defocus the project.

Reviewer 4

The reviewer commented that the technical approach related to the application of frequency appears to discriminate the difference from the impact modality. Passive sensing requires little to no power and could be readily implemented in vehicles. Although the project was completed on time, the reviewer was unclear about what novel activities were essential to re-contextualize this data from prior efforts. As a bumper technology, what can be done to improve safety at the point of impact? Of course, the sensor would be triggered by some sort of hood response to prevent injury to the pedestrian's head, but this has not been properly considered in the scope of work. Also, this technology has been developed for some time. The novelty of this work pertains to discriminating the type of impact through sensor spatial distribution and algorithmic signal interpretation. The reviewer was unclear as to what is currently limiting deep market penetration of this technology by now.

Reviewer 5

The reviewer commented that the approach was well thought out and executed. The project used an actual bumper from Ford and generated relevant results. The work is licensed and is now progressing in another project.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer mentioned that significant data has been acquired and analyzed. For example, sensor data related to identifying differentiating frequency ranges for several types of impact. Response times with this technique of three milliseconds versus competitive techniques at approximately five milliseconds were highlighted by the presenter. The reviewer also stated that the structural load capability of the energy storage system was briefly mentioned but not highlighted during the discussion of the results, so the accomplishments are not clear. Advancements related to the energy management system are also unclear.

Reviewer 2

The reviewer commented that the use of a real bumper and simulated pedestrian mock-up for understanding the sensor network is very interesting.

Reviewer 3

The reviewer commented that the main accomplishments achieved in collaboration with Stanford some years ago made it difficult to determine what was uniquely developed within this project. The accomplishments within this project and the MAT266 project seem difficult to identify.

Reviewer 4

The reviewer mentioned that the team adhered to the product plan and clearly showed a working concept and the support from industry should lead to a marketable product. The reviewer remarked the work could be impactful if it reduced pedestrian injury and death during collisions especially for autonomous vehicles.

Reviewer 5

The reviewer stated that the team distinguished a human leg impact from other objects within 3 milliseconds, which is faster than the current state-of-the-art technologies and added that the project is a success as a Phase 2 Small Business Innovation Research (SBIR) initiative.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer commented that, considering both areas have benefitted from outside collaboration with Ford on the sensor portion and Stanford on the energy storage portion, the relative contributions of each collaborator was unclear. The reviewer questioned whether Ford provided significant technical contributions in addition to supplying the test bumpers and how Stanford's consulting in advancing the energy storage system beyond providing the initial technology license was applicable. Both partners could be very valuable in going forward in optimizing these systems towards commercialization; Tillotson Pearson Incorporated Composites (TPIC) was mentioned as actively partnering in the MAT 266 presentation.

Reviewer 2

The reviewer stated that the team worked very closely together and observed that Ford appears to be very much involved with the project.

Reviewer 3

The reviewer commented that the team seems to have built a strong relationship with both Stanford and Ford. However, it is difficult to evaluate the impact of the collaboration.

Reviewer 4

The reviewer commented that the project would benefit from additional, more in-depth collaboration with a Tier 1 manufacturer, however, these can be admittedly difficult to arrange.

Reviewer 5

The reviewer commented that there were tangible contributions from the partners and for a SBIR Phase 2 effort, this project was well coordinated.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer stated that although this project has ended, it appears that the MAT266 project is enhancing the energy storage system beyond the current capabilities of the MAT212 project, but it would have been interesting to see the potential next steps with the sensor approach.

Reviewer 2

The reviewer commented that there is no future research, but the team is part of a new DOE project to advance the manufacturability at scale.

Reviewer 3

The reviewer stated that even if the future work of this project seems relevant, it is intertwined with other DOE projects, so a clear picture of the future of this specific project is difficult to comment on.

Reviewer 4

The reviewer affirmed that the project is complete.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer previously stated that both areas can positively impact DOE mission areas by enhancing pedestrian safety, saving weight, and increasing structural efficiency.

Reviewer 2

The reviewer commented that the project supports the VTO Materials subprogram objectives.

Reviewer 3

The reviewer remarked that the project has great technical relevance with opportunities in several other areas. However, the ultimate relevance can first be evaluated once a clearer picture is presented regarding the cost for scaling and implementation.

Reviewer 4

The reviewer commented that the project provides a unique and potentially highly impactful route to improving EV safety and operability on the road. High profile accidents could impact the public opinion on VTO objectives in the future and therefore this a synergistic activity that imparts multi-functionality to the glider front end.

Reviewer 5

The reviewer commented that the program is relevant to the VTO Materials subprogram.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer commented that the adequacy of the resources was hard to judge, considering the differences of the two focus areas. Another reviewer remarked that most of the effort was devoted to testing and analyzing data versus advancing the technologies, but this seems very reasonable for this type of project. Considering the lack of detail regarding next steps, the positive results seem to bode well for continuing interest.

Reviewer 2

The reviewer stated that the resources are adequate.

Reviewer 3

The reviewer commented that the project seems to be supported from several DOE sources. Thus, the needed resources seem well addressed.

Reviewer 4

The reviewer commented that for an industry project the resources were well allocated and used appropriately to achieve a targeted task. The reviewer was somewhat unclear about what development was included in this scope, however, the resources appeared proportional.

Reviewer 5

The reviewer commented that the resources were sufficient for this project.

Presentation Number: MAT221
Presentation Title: Lightweight and Highly Efficient Engines Through Al and Si Alloying of Martensitic Materials
Principal Investigator: Dean Pierce, Oak Ridge National Laboratory

Presenter

Dean Pierce, Oak Ridge National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

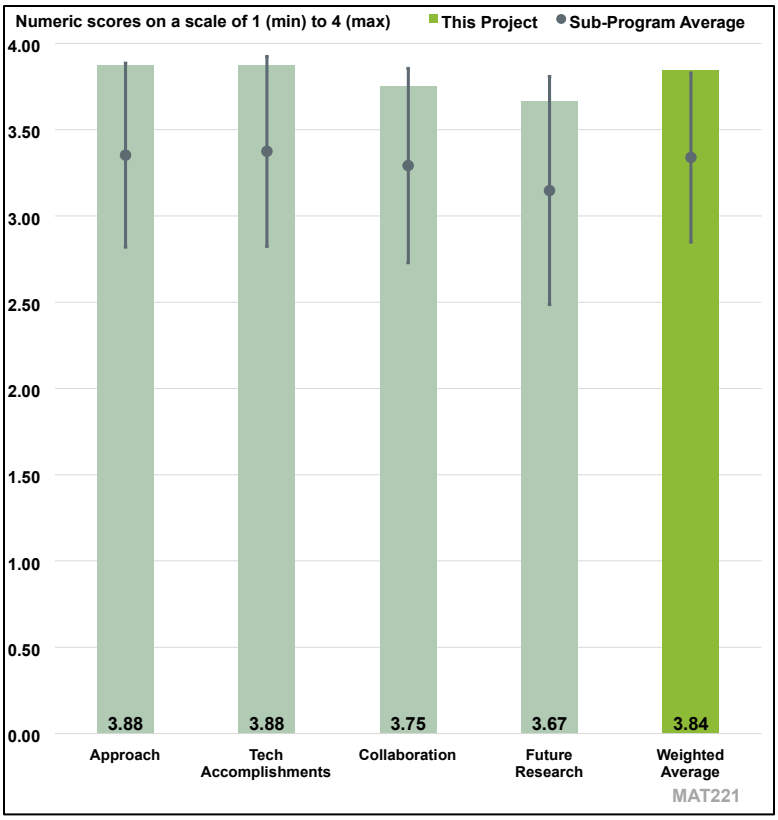

Figure 5-19. Presentation Number: MAT221 Presentation Title: Lightweight and Highly Efficient Engines Through Al and Si Alloying of Martensitic Materials Principal Investigator: Dean Pierce, Oak Ridge National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer detailed that the project addresses challenges in the heavy-duty vehicle sector to improve state-of-the-art diesel engines and improvements needed to efficiently use lower carbon fuels applications. This is needed since the heavy-duty vehicle sector is difficult to electrify with significant trade-offs occurring between battery weight, payload weight, and vehicle range.

Near term applicability of this improved material will help reduce the consumption of fossil fuels while better batteries or other zero emission technologies for long-haul trucking are developed. The project also has possible application to hydrogen fuel system components since it resists hydrogen embrittlement. The work being done by this team will lay the groundwork for improved materials needed to help incorporate low carbon fuels in over the road trucks. Using alloys can increase strength and oxidation benefits but results in a decrease in thermal conductivity which raises piston temperature. The reviewer said the project has successfully identified and optimized the material to use for piston crowns. This material is machinable, weldable, and at an acceptable price point. These new piston materials are needed to operate in these more severe engine conditions that occur in high efficiency and low carbon fuel combustion environments.

The reviewer said that by leveraging ICME, laboratory scientists designed approximately 35 alloys that could withstand the conditions encountered in these higher temperature engines. The best candidate alloy was identified (G3-5M). The 5.5-year project created the material through identification to optimization to a commercial ready material that can be used as a roadmap for other material development projects.

Reviewer 2

The reviewer said the background and challenges of this component are well documented and presented. This data is relevant to the project and explains the intent and possible benefits. Computational modeling of the candidate alloys clearly allowed an accelerated timeline, and the team used this ability to move this material through to deployment in an engine test very quickly with reliable results. The reviewer remarked that thermal properties of the pistons are critical to efficiency, and this is a clear opportunity to increase that efficiency. Great cyclic oxidation work at two temperatures in early work drove the ability to specify and create a 1500-pound heat of this alloy for actual engine testing.

Reviewer 3

The reviewer remarked the project seeks to address optimization of properties of piston crown steels, machinability/weldability/affordability, scaling steel to larger sizes, and achieving higher power density. The project will be important to enable hydrogen fueled engines.

Reviewer 4

The reviewer remarked the team aims to solve the dilemma of the piston crown steel. On one hand the steel needs high strength and oxidization resistance and on the other hand, it needs thermal conductivity to limit the piston temperature. The team developed the G3 steel, assessed it, and found significant improvement of the 4140 alloy.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer said this project again shows the value of ICME and the ability to develop new materials needed for higher efficiency operations in both combustion and electrical systems. G3-5M was evaluated to document the key material properties needed for higher piston temperatures. An 85% increase in strength was demonstrated over 4140 steels at 600°C. A 28% increase in strength over H11 (5-chromium tool steel) despite much lower alloy content. High cycle fatigue is preferred rather than tensile strength because of the piston application. A G3-5M heat-treated alloy exhibited a significant improvement in fatigue strength at elevated temperatures. Test results showed a 107% increase in fatigue strength versus 4140 and 30% increase versus H11 in fatigue strength at 600°C after heat treating for 500 hours at 600°C.

G3-5M extends the oxidation resistance to about 575°C and demonstrates modest increases in thermal conductivity over H11. Friction welding characterization showed that post weld heat treatment is needed to reduce high interfacial hardness. The G3-5M material was of such interest to Cummins that they took on a significant additional cost to complete the peak power overfuel test. The reviewer pointed out that the G3-5M materials successfully passed this enhanced test which indicated Cummins is likely to bring this material to the commercial marketplace. G3-5M has a better trade-off between thermal properties, strength, and oxidation resistance over state of the art steels.

Reviewer 2
The reviewer remarked the technical work is high quality and on target. The work presented is clear and concise, creating efficiency opportunities. Very impressive for this project to take this from a computational model to a heat of steel and then on to a functioning component in a running engine such that the actual real effect can be quantified.

Reviewer 3
The reviewer said the team did an excellent job. The highlights include how the G3 steel exhibits an 85% increase in strength over 4140 steel at 600°C and G3 heat exhibits 107% increase in fatigue strength at 600°C compared to 4140 after aging at 600°C for 500h. G3 steel extended the oxidation resistance to about 575°C compared to 4140 and modest increases in thermal conductivity over H11. The G3 alloy can be nicely welded to medium alloy steel by rotary friction welding. G3-5M shows no severe damage after a modified 500h pure plant oil engine test beyond typical oxidation. The G3 steel successfully passed modified peak power overfuel test with enhanced severity. The team also understood the origin of these fantastic properties: the novel thermal processing and the alloy chemistry allowing the ultra-fine microstructure to form.

Reviewer 4
The reviewer commented the project is complete.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1
The reviewer said the team worked with Cummins, and Cummins contributed $1 million in cost share, twice the original planned cost share.

Reviewer 2
The reviewer found it was clear that all the stakeholders were participating, proposing, and evaluating several different iterations of alloys via computational models, then moving the new proposed alloy through the steel mill, validating the expected physical properties of the heat of steel, then sending the material to the piston manufacturer, then finished pistons to the engine manufacturer where it was ultimately tested. Very impressive!

Reviewer 3
The reviewer noted strong industry involvement with Cummins.

Reviewer 4
The reviewer noted the alignment of the project team with ORNL, and the team was able to leverage their unique capabilities with other related projects under Thrust 4 of the Powertrain Materials Core Program (PMCP) 1.0 to maximize DOE’s investment. ORNL has established mechanisms needed to commercialize this technology through Cooperative Research and Development Agreements (CRADAs) with industry partners like Cummins. The reviewer said these arrangements are needed to help bring this material to the commercial marketplace. The CRADAs between Cummins and ORNL and the partnership established with Mahle, a prototype piston manufacturer, will permit the successful transition to a commercialized product.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer said that using this alloy for piston caps in hydrogen-powered internal combustion engines is an interesting opportunity for an adjacency of this steel. Other low carbon fuels are also indicated for additional impact of the material; this is important as the industry strives to lower carbon emissions using existing capital assets. The reviewer said opportunities were discussed for further refinement of the model and, therefore, the alloy.

Reviewer 2

The reviewer remarked that although this project is complete, researchers can use the knowledge gained in this project to determine possible application for EV powertrains to support the new direction of the PMCP 2.0 that is focused on identifying new materials for EV powertrains. This material also appears to be well suited for low carbon fuels like hydrogen, and applications in hydrogen-fueled internal combustion and hydrogen fuel cell vehicles. Possible applications for hydrogen engines include injectors, dies, valves, and elevated temperature fasteners. The G3 material will need to be produced economically at scale at a steel mill.

Reviewer 3

The reviewer said the project is complete. The project identified efforts that can be done to evaluate the suitability of this alloy for pistons of green-fueled (hydrogen, ammonia, natural gas) internal combustion engines and other applications (injectors, dies, valves, high-temperature fasteners).

Reviewer 4

The reviewer said the project has ended.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer said this is clearly a win in the Energy Efficient Mobility Systems subprogram space and is also relevant to the DOE Decarbonization of Off-Road, Real, Marine, and Aviation (previously the Advanced Engine and Fuel Technologies subprogram). The reviewer said this type of development is critical to maintain mobility while decreasing environmental impact of the industry. The ability to continue to increase the efficiency of internal combustion engines is directly transferrable to this same style hardware operating on sustainable or low-to-no carbon fuels, given the industry options that can positively impact the environment immediately.

Reviewer 2

The reviewer remarked the project will help to enable engine development to meet the objectives to decarbonize the on-highway fleet. The effort helps to overcome material barriers to enable hydrogen combustion.

Reviewer 3

The reviewer said the ability to improve piston performance is critical for improving heavy-duty vehicle performance.

Reviewer 4

The reviewer remarked the project is directly relevant to the VTO Materials subprogram objectives.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer said this project again illustrates the unique value of ICME and the PMCP (both 1.0 and 2.0 phases). This project has overcome material challenges encountered during high-efficiency combustion. The performance characteristics of this alloy permits engine builders to adapt their engines to use low-carbon fuels. The use of CRADAs should continue to be encouraged to allow industry to invest in this promising research. DOE should continue research to determine other possible applications for this alloy for low carbon and hydrogen fuel applications by leveraging its unique performance characteristics.

Reviewer 2

The reviewer said it was very impressive that the team was able to take this all the way to testing and validating in an engine after starting with a clean sheet alloy development. The team obviously was very efficient.

Reviewer 3

The reviewer remarked the lab and industry partners have excellent resources to complete this effort.

Reviewer 4

The reviewer noted that Cummins spent significant amount of its own resources on this project.

Presentation Number: MAT222
Presentation Title: Extending Ultrasonic Welding Techniques to New Material Pairs
Principal Investigator: Jian Chen, Oak Ridge National Laboratory

Presenter

Jian Chen, Oak Ridge National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

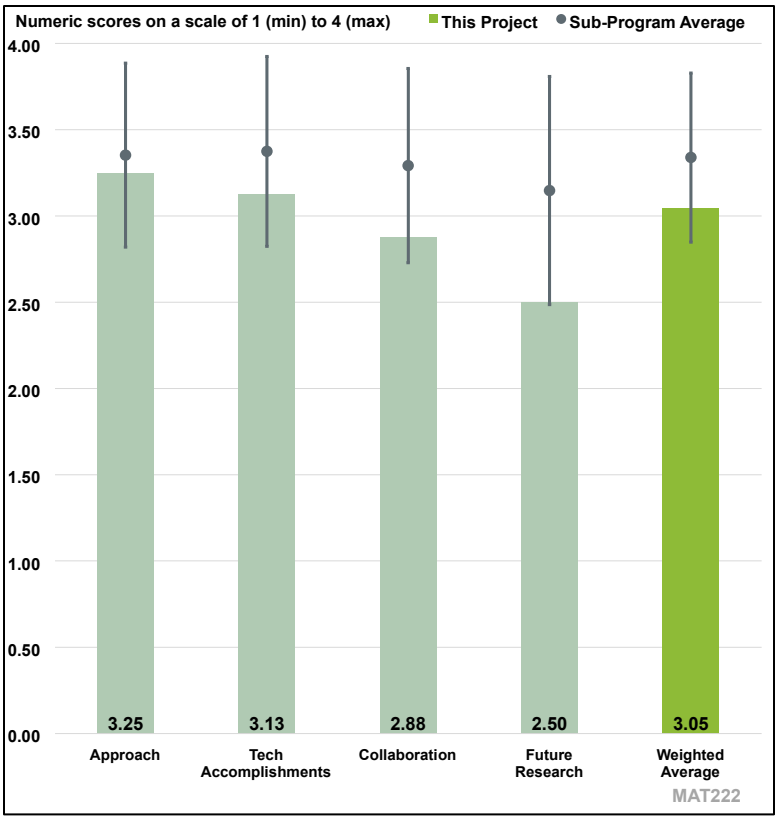

Figure 5-20. Presentation Number: MAT222 Presentation Title: Extending Ultrasonic Welding Techniques to New Material Pairs Principal Investigator: Jian Chen, Oak Ridge National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer remarked that, in four years, the project has successfully demonstrated ultrasonic joining as an effective method for several new material pairs—similar and dissimilar.

Reviewer 2

The reviewer noted that the project has done a decent job in addressing the issue of multiple ultrasonic welds in a structural component.

Reviewer 3

The reviewer said that the root cause to challenges in in-series joining quality was not evident or expressed. The close-loop control strategy seemed ad-hoc without pre-established correlation to support the close-loop control strategy that was presented.

Reviewer 4

The reviewer commented that the technical barriers are sufficiently identified and defined to begin experimentation. Detail of the specific process variables and controls are defined in the body of the presentation. The timeline is organized in a logical fashion and contains enough detail. The decision to prioritize Mg-steel joining over Mg-Al and Al-steel is unusual.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer commented that the team has made very good progress, especially in identifying the factors that can improve the repeatability of a joint made in series.

Reviewer 2

The reviewer remarked that the analysis of the microstructure and method of bonding of each joint was well studied and clearly documented. The strength targets were reasonably set and appear to have been adequately met. The project is proceeding according to the schedule in the plan with no significant shortcomings. In light metal joining, the forging force, or processing load as it is referred to in this project, is a significant process parameter. The reviewer stated that although ultrasonic spot welding (USW) accurately lists a low processing load as an advantage, not using it as a process variable may have limited the optimization of the process.

Reviewer 3

The reviewer observed that the slides state that the milestone for “Establishment of correlation between in-situ process parameters and joint quality” has been completed but no data was presented. Unfortunately, this seems to be a significant finding and the basis for the team’s purported control logic.

Reviewer 4

The reviewer pointed out that the root cause to challenges in in-series joining quality was not evident or expressed. The close-loop control strategy seemed ad-hoc without pre-established correlation to support the close-loop control strategy that was presented.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer remarked that collaboration and coordination appeared to meet expectations.

Reviewer 2

The reviewer observed while the presentation mentioned partners, it was not clear from the slides or the delivery which of the laboratories performed what work. More elucidation might be helpful.

Reviewer 3

The reviewer remarked that the work conducted by each laboratory is relevant and none of the tasks appear to have been created solely to give the laboratory something to do. The micrographs and chemical analysis gave some interesting insight into the method of joining and could suggest potential future project opportunities with respect to surface preparation and/or alloy development.

Reviewer 4

The reviewer said rather than collaborating on the singular USW process, ORNL and PNNL chose to investigate two alternatives with the greatest weight on the ORNL alternative. The reviewer felt this is a dilution of effort and focusing all resources on a singular topic would have been more effective. For example, PNNL has experience with algorithm development for friction stir welding (FSW) control, which could have been brought to bear on the USW control logic development. The reviewer believed that this would be better to create critical mass.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer believed that given the project is almost ending, the future work outlined is a good summary for the project charter.

Reviewer 2

The reviewer remarked that none of the future research topics are incorrect. A focus on difficult-to-weld combinations may limit the applicability of the technique in near-term applications because automakers will typically not design with such a joint combination without years of experience with less difficult joints. Studying more process variables, such as process load, may be valuable to define the process window more fully before attempting ML for optimization.

Reviewer 3

The reviewer believed work is needed to show that the proposed approach to closed-loop control is generally applicable to other stack designs.

Reviewer 4

The reviewer said the four topics should be narrowed to just one - ML. The varied material combinations can be part of the ML scope since the applicability of the model will need to be assessed. Joint strength characterization should be part of a higher TRL project focused on a specific application driven by an industry partner. The reviewer remarked a second topic could be looking at where the greater energy input is absorbed within the structure since the control algorithm increased the overall energy needed to create a weld. Understanding the boundary conditions and where the energy goes is critical for any application. A third topic could be the impact of changing the knurling pattern on the tooling and its effect upon the ML algorithm.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer said this technology supports the concept of the right material in the right form in the right application which ultimately supports mass savings.

Reviewer 2

The reviewer remarked that multi-material joining is a very relevant area of research for automotive manufacturing and design.

Reviewer 3

The reviewer noted this is a clear and fundamental project in support of the VTO Materials subprogram objectives. Robust and energy-efficient joining methods between light metals and between light metals and steel are relevant and will remain so.

Reviewer 4

The reviewer had no comment.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer believed that sufficient resources have been available for the project team to achieve their goal of an adaptive control of USW as a function of sequence. Again, this is at a low

Manufacturing Readiness Level (MRL) and significant work lies beyond raising the MRL, but this is out of scope of the current work.

Reviewer 2
The reviewer believed more resources should have been applied in closed-loop control development. The reviewer did not know if those resources were available to this team.

Reviewer 3
The reviewer said the team members and equipment are effectively executing the project. An increased contribution of light metal welding expertise from the industry partners could be helpful to ensure that the correct process parameters are addressed.

Reviewer 4
The reviewer had no comment.

Presentation Number: MAT223
Presentation Title: Extending High-Rate Riveting to New Material Pairs
Principal Investigator: Kevin Simmons, Pacific Northwest National Laboratory

Presenter

Kevin Simmons, Pacific Northwest National Laboratory

Reviewer Sample Size

A total of two reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 50% of reviewers felt that the resources were sufficient, 50% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

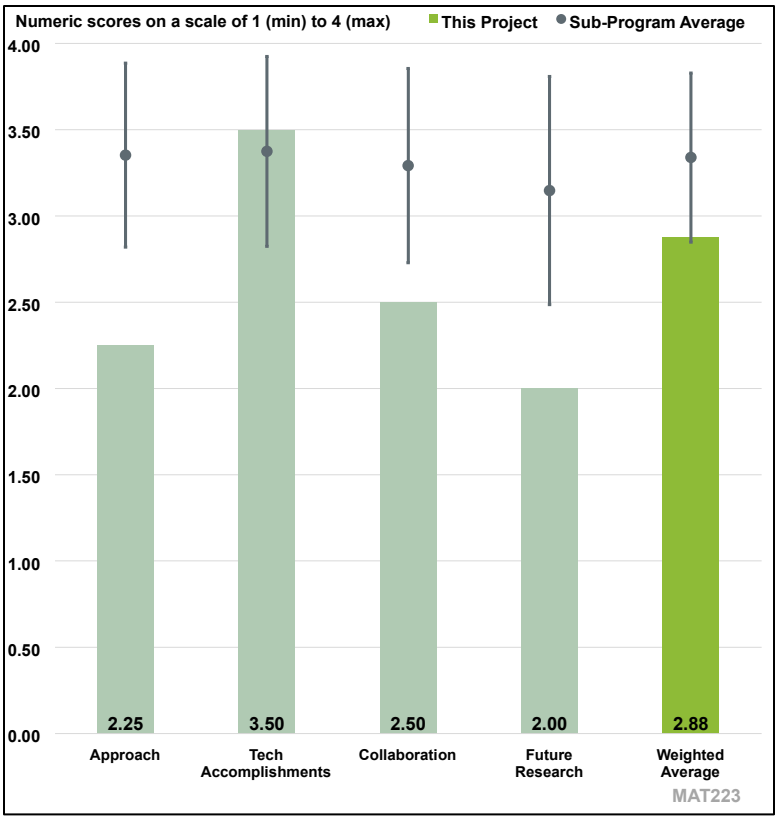

Figure 5-21. Presentation Number: MAT223 Presentation Title: Extending High-Rate Riveting to New Material Pairs Principal Investigator: Kevin Simmons, Pacific Northwest National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer observed the benefit of the team studying both paste and tape type adhesives, because tape adhesives are industrially useful and often not included in studies. Polyphthalamide resin is well known for both its high performance, particularly at elevated temperatures, and for being difficult to bond to. This was a useful inclusion in the study. Studying short-fiber glass-filled composites would have been interesting because they are much more commonly used in automotive applications. The high-rate friction rivet process appears analogous to existing commercial friction rivet products such as EJOWELD CFF® friction welding. The reviewer was unclear on the advantage of trying to deliver this technology versus using those commercial products.

Reviewer 2

The reviewer elaborated the reason for the low score is purely driven by a lack of clarity in the problem being addressed by these two new processes. There are a multitude of commercial solutions on the market for joining of dissimilar materials. There is no mention of these nor of the gap that the project attempts to fill. This is so critical to understanding the potential for technology transfer and allocation of scant R&D resources.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer said the fundamental understanding of the effects of plasma on substrates and joint performance is significant. The reviewer was glad to see this being transferred to a Lightweight Materials Consortium (LightMAT) project.

Reviewer 2

The reviewer remarked that the plasma treatment process and adhesive fillers look plausible for production. The high velocity (HiVe) joining performance looks sufficient for industrialization pending a solution to questions related to the sound level produced and related safety/health implications. How effectively the electromagnetic actuator mitigates noise will be critical in determining whether this process can be industrialized.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer said the teams appear to have worked largely in parallel while remaining mutually relevant and compatible. Pairing computational analysis with physical process development is nice to see and allows for a more comprehensive solution to be delivered.

Reviewer 2

The reviewer felt that the project should have focused on the clinch and HiVe processes and that the thermoplastic adhesive composition work is out of place in this project. Reversible joining is important, but this reviewer felt that this overall project scope is too broad. Friction riveting is a process having been previously investigated and the reviewer felt dilutes this project's scope.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer said joining CF reinforced polymer (CFRP) is of no practical use, because the material has been largely abandoned by high-volume manufacturers. Extending the adhesive and HiVe studies to short-fiber injection-molded materials is more likely to be useful. Further development of high-rate friction riveting should more clearly demonstrate advantages versus existing commercially available friction rivet products. The reviewer suggested that high-speed in-situ radiography could be interesting if it leads to a more thorough understanding of the process phases and enables more detailed process simulation.

Reviewer 2

The reviewer agreed that the items listed in Future Work themselves are appropriate topics. However, the trend is further dilution of effort. Part of the problem is that the technology gap which these processes target is not identified. Once the gap is identified, some of these topics may be eliminated and others may increase in priority. Furthermore, there are several focus areas which should be identified as stand-alone one-pager projects with their own problem/hypothesis/plan.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer remarked this technology supports the concept of the right material in the right form in the right application which ultimately supports mass savings.

Reviewer 2

The reviewer commented this project is relevant to the VTO Materials subprogram and will help enable high-performance materials to be joined in an efficient and robust manner.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer said correct technical and equipment resources appear to be available for this project.

Reviewer 2

The reviewer believed that the project scope is too broad and, as such, the current allocation of resources is insufficient. The reviewer believes it is better to have smaller, more focused projects which clearly move a technology towards a higher TRL rather that have disparate bits and pieces at various TRLs.

Presentation Number: MAT224
Presentation Title: Solid State Joining of Multi-Material Autobody Parts Toward Industry Readiness
Principal Investigator: Piyush Upadhyay, Pacific Northwest National Laboratory

Presenter

Piyush Upadhyay, PNNL

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

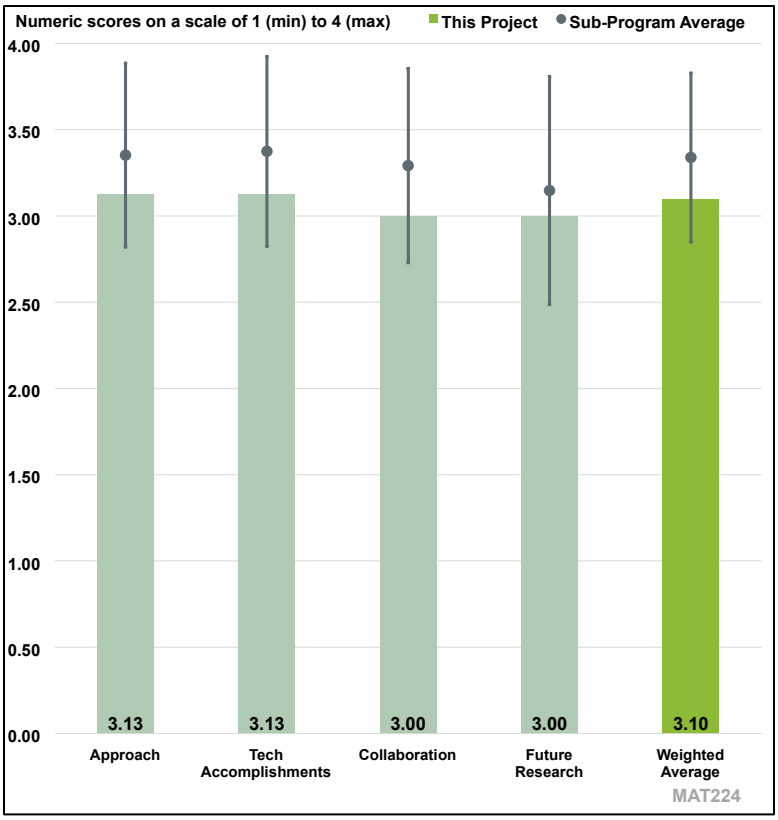

Figure 5-22. Presentation Number: MAT224 Presentation Title: Solid State Joining of Multi-Material Autobody Parts Toward Industry Readiness Principal Investigator: Piyush Upadhyay, Pacific Northwest National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer said the presenters address the barrier of a fast and reliable joining technology for dissimilar metals. The team tries to overcome the barrier to implement friction stir based linear and spot joining methods for assembly of multi-material components. Timely progress has been made to develop control parameters, fixture, and robotic design. While an OEM is involved, the reviewer was unclear if the technology is near adoption.

Reviewer 2

The reviewer said joining dissimilar grades of Al, such as wrought and cast or different strength levels of wrought, is relevant to modern automotive design. This type of joint is common, particularly in battery structures. The knowledge base and best practices for friction stir joining are still under development and in a position to benefit from research work.

Reviewer 3

The reviewer said the project utilizes a well-designed approach that includes both experimental work on friction-stir lap welding, modeling work on FSW joint strength, friction self-piercing rivet (F-SPR) process development, and characterizations for various material combinations.

Reviewer 4

The reviewer observed that the technical barriers listed on Slide 23 is more a laundry list of items to be completed for implementation of the technology rather that explicit technological barriers which need to be overcome.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer said targets (e.g., lap strength) were demonstrated for some dissimilar material pairs of interest (e.g., Aural 2 – high-strength Al). Production speeds were increased in many cases.

Reviewer 2

The reviewer remarked that in recent work, the project team at PNNL (developing friction stir linear welding [FSLW] for three sheet stack-up Al joints) and ORNL (developing F-SPR for two and three sheet stack-ups) appears to have focused on further refining the joining technology, assessing tool life, ensuring quality assurance for high-volume manufacturing, and developing welding strategies for eventual demonstration in stamping.

Reviewer 3

The reviewer believed that satisfactory progress on the process development, modeling, and tool wear has been made to facilitate the technology transfer to other stack-up combinations.

Reviewer 4

The reviewer remarked that the joint configurations that were demonstrated are comparable to joints that have entered production recently. The joining speeds and results are comparable to current production, so the future development will be very relevant in determining the value of this research. The self-reacting robot unit will be an improvement over existing volume production equipment.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer said two national laboratories and multiple industries participate in this collaboration.

Reviewer 2

The reviewer said that the project work seems to be well-coordinated between PNNL and ORNL, with clear-cut research roles for each.

Reviewer 3

The reviewer commented each national laboratory is focused on a separate process and it appears there is very little cross-laboratory collaboration although Honda is clearly working well with both national laboratories.

Reviewer 4

The reviewer remarked that the choice to separate the work between linear joining and point joining was logical and appears well executed for both.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer remarked that the PIs appear to have a systematic plan going forward for FSLW and F-SPR development on wrought and castings in dissimilar configurations; demonstrating FSLW and F-SPR demonstration on stamping; and assembling, testing, and making FSLW runs in captive fixturing.

Reviewer 2

The reviewer said the projects ends in FY 2024.

Reviewer 3

The reviewer commented that the FSLW combinations proposed are already in production for battery structures in Europe. Duplicating work that is already being launched will put the laboratories at a timing disadvantage. Contacting a current linear FSW supplier, such as KUKA or TRA-C Industrie, as an additional industrial partner might be beneficial to identify the technical challenges that the team has not already solved. The reviewer said the F-SPR process appears functionally identical to the EJOWELD® REF process that is commercially available from the EJOT Group. Reviewing that process in some detail would be advisable before attempting more development to avoid duplication of effort.

Reviewer 4

The reviewer said the future work is clearly defined but again reads more like a list of to-do items rather than specific research challenges. For example, rather than a demonstration on stamping, why not focus on the F-SPR on stamped wrinkles which is the actual challenge. Or another topic of the size of the rivet head which impedes the assembly of the weather strip on the door surround flange.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer remarked dissimilar metals joining is important for achieving lightweighting goals of VTO's Materials subprogram.

Reviewer 2

The reviewer said the ability to join dissimilar materials with specific properties is critical for lightweight multi-material design, which in turn closely fits in with DOE-VTO objectives for better-performing, more energy-efficient EVs having only relatively benign environmental impact.

Reviewer 3

The reviewer stated that this technology supports the concept of the right material in the right form in the right application which ultimately supports mass savings.

Reviewer 4

The reviewer pointed out this work is relevant to both the VTO Batteries and VTO Materials subprograms with their related objectives.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer said resources are sufficient.

Reviewer 2

The personnel and equipment appear well matched to the project and appropriate for future development work.

Reviewer 3

The reviewer remarked the project has continued at a steady spending rate of approximately $583,000 per year and all indications are that this amount is sufficient to meet project needs.

Reviewer 4

The reviewer believed that the resources are sufficient for the project team to demonstrate a robotic application of the FSLW at a MRL of 4. However, if the team wishes to achieve a higher MRL, then additional work and detail would be required.

Presentation Number: MAT225
Presentation Title: Surface Modifications for Improved Joining and Corrosion Resistance
Principal Investigator: Yong Chae Lim, Oak Ridge National Laboratory

Presenter

Yong Chae Lim, Oak Ridge National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 67% of reviewers felt that the resources were sufficient, 33% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

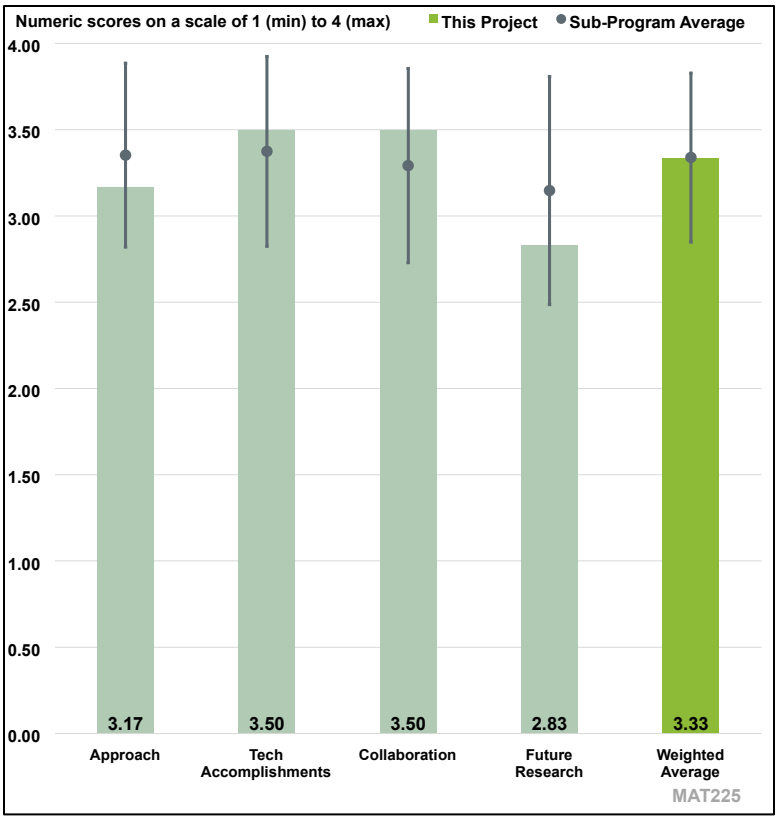

Figure 5-23. Presentation Number: MAT225 Presentation Title: Surface Modifications for Improved Joining and Corrosion Resistance Principal Investigator: Yong Chae Lim, Oak Ridge National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer said the project is reasonably designed and technical barriers are being addressed effectively.

Reviewer 2

The reviewer commented that the work on joint strength after corrosion/environmental aging is very relevant to modern vehicle structures. Corrosion mitigation of Mg joints is helpful going forward because there has been increasing interest in Mg for sustainable mass reduction. Joining CFRP remains a low priority pending a more environmentally sustainable and cost-effective way to produce such composites.

Reviewer 3

The reviewer remarked that the technical barriers are addressed but, unfortunately, through an opportunistic approach via development of two new joining methods. In this reviewer's opinion, this approach dilutes the focus of this project specifically on the effect of surface modification for corrosion resistance.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer remarked experimental work which was originally scoped has been mostly completed and a significant body of knowledge captured.

Reviewer 2

The reviewer said the project is on track with satisfactory progress as planned.

Reviewer 3

The reviewer said plasma treatment looks promising with respect to Al-to-Al joints with steel fasteners. An alumina forming alloy rivet looks interesting, but an austenitic steel is likely too soft to make a viable rivet. Current rivets are martensitic steel with a hardness of around 450 Vickers Hardness. The reviewer said development of a harder alloy may be necessary.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer said the role of each contributing partner is listed; however, it would be helpful if the contributions from PNNL and ORNL are more clearly described.

Reviewer 2

The reviewer really liked the various groups the forming the team for this project. If not for that, the broad scope of the work would have prevented the team from making noteworthy progress.

Reviewer 3

The reviewer said the regular meeting schedule and clearly defined roles show that collaboration was a priority on this project and not a documentation afterthought.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer commented that the future research objectives are clearly defined but unclear on what the mitigation solutions are for potential barriers.

Reviewer 2

The proposed future work is clearly defined, and a logical extension of the work done to-date.

Reviewer 3

The reviewer remarked that the items listed as future research are individually of interest, but it is not clear to this reviewer what technology gap is being targeted since many of the items are titled “optimization.” Optimization is an engineering exercise and does not address a research issue. In some instances, the baseline is untreated Al but on Slide 9, the baseline is anodized Al. The reviewer stated that in cases of dissimilar materials, the industry standard is to use anodized Al which should be the baseline. Furthermore, understanding the relative performance of this baseline versus open air plasma coating and silane plasma coating would be of interest.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer affirmed that this project supports the VTO Materials subprogram objectives.

Reviewer 2

The reviewer remarked that this technology supports the concept of the right material in the right form in the right application which ultimately supports mass savings.

Reviewer 3

The reviewer commented that the project is relevant to the VTO Materials subprogram and could facilitate effective use of light metals in vehicles.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer felt that the resources are sufficient with support from various laboratories and industries.

Reviewer 2

The reviewer observed that the resources are well organized and appear sufficient for the tasks.

Reviewer 3

The reviewer believed that the project scope is too broad and, as such, the current allocation of resources is insufficient. The reviewer felt that it is better to have smaller, more focused projects which clearly move a technology towards a higher TRL rather than having disparate bits and pieces at various TRLs.

Presentation Number: MAT226
Presentation Title: Machine Learning for Joint Quality and Control
Principal Investigator: Keerti Kappagantula, Pacific Northwest National Laboratory

Presenter

Keerti Kappagantula, PNNL

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

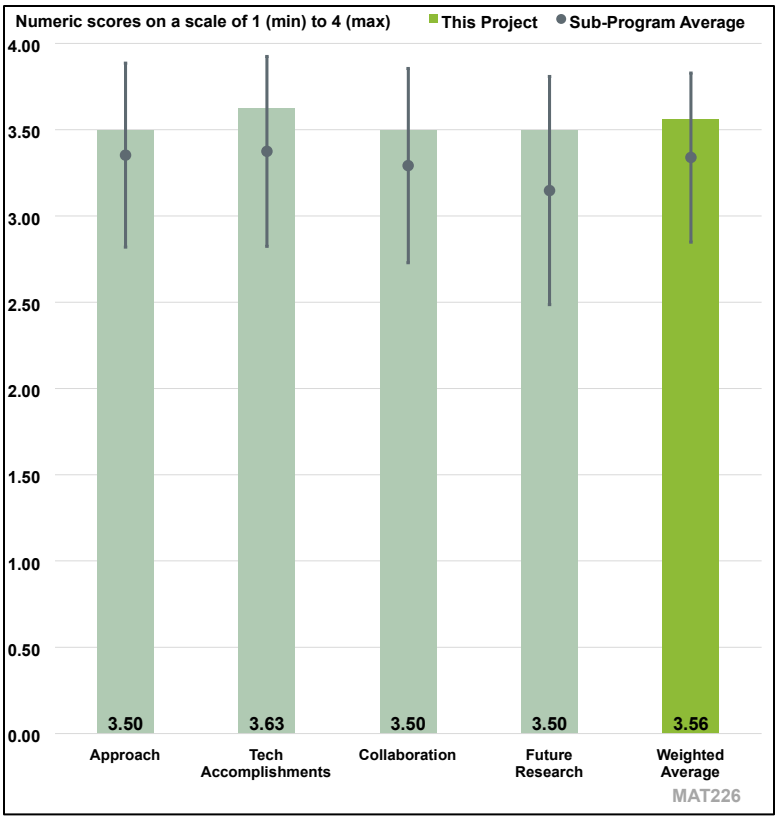

Figure 5-24. Presentation Number: MAT226 Presentation Title: Machine Learning for Joint Quality and Control Principal Investigator: Keerti Kappagantula, Pacific Northwest National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer remarked that this project mostly addressed the technical barriers for controlling the weld quality through a data-driven ML approach.

Reviewer 2

The reviewer said the approach for performing the work is good and should lead to most, if not all, of the project goals being met. The project seems to be well designed and seems to have largely proceeded according to plan.

Reviewer 3

The reviewer detailed that the project is evaluating joints manufactured by the resistance spot welding of dissimilar materials. New steel-steel data (greater than 130 gigabytes) provided by General Motors (GM) is being used to develop and apply an AI/ML-based model framework to analyze post-processed joint data. This data set should be beneficial to help understand the risks in a production environment. The approach is excellent, well designed, and logical. Both PNNL's and ORNL's timelines are reasonable to accomplish the milestones. The reviewer said ML is an effective approach to understand the relationship between resistance spot welding parameters and weld attributes.

Reviewer 4

The reviewer remarked that the process development time is a topic that is relevant and not often considered in projects. This project is well-focused on the barrier defined. Modern ultra-high strength steel and third generation advanced high strength steel have very high carbon equivalent and resistivity compared to older materials. There is a clear need to optimize weld parameters on challenging material combinations, such as mild steel to ultra-high strength steel.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer said the project has been sharply focused on addressing the technical barrier during this review period and worked closely with the industry partner to identify the needs.

Reviewer 2

The reviewer said PNNL and ORNL have each completed two milestones with the remainder of the milestones under the current period of performance either on track or ahead of schedule. The ML model is currently showing over 98% accuracy in predicting the achievement of a nugget with desired size metrics, which is impressive, and promising for use in a production environment.

Reviewer 3

The reviewer commented the methodology shows very high predictive accuracy for nugget size, which is consistent with the project's stated goal.

Reviewer 4

The reviewer remarked technical progress made so far is satisfactory and seems to be consistent with the overall project plan. The PIs have made progress in designing the ML framework with what seems like substantial amounts of data from GM, their industry partner. Implementing the framework on the production floor is not part of the scope of this project. The reviewer recommended the PIs should take time to discuss the graphs and tables presented in more detail in the future. This reviewer had to figure out what some of the graphs and tables were saying, as very little in terms of a full explanation of the data was presented by the PIs.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer pointed out PNNL focused on identification of weld sensitivity to parameters and ORNL focused weld quality prediction. Both collaborated closely with GM for application of the ML models.

Reviewer 2

The reviewer said the interfaces in this collaboration were well described by the PIs in this project. The specific contribution of each team member was well articulated.

Reviewer 3

The reviewer detailed the project team consists of two national laboratories (PNNL and ORNL) and one industry partner (GM) and is a stellar example of both inter-lab and industry partner collaboration. The team appears to be leveraging the large GM dataset well to achieve the project's stated goals.

Reviewer 4

The reviewer remarked while the approaches between the two teams are different, they show comparable degrees of success and avoid unnecessary duplication of effort.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer said the proposed future work seems logical and appropriate to achieve the project's goals. This work should assist the team in overcoming the remaining barriers.

Reviewer 2

The reviewer said the project clearly defined the future work for each laboratory and it is highly likely to achieve their targets.

Reviewer 3

The reviewer had no issues with proposed work.

Reviewer 4

The reviewer said future work is appropriate as proposed. A higher value might be achieved by optimizing to minimize weld energy and/or maximizing weld strength and toughness on challenging alloys. That would deliver a benefit to the vehicle itself beyond the considerations of development time and efforts.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer said the project supports the Materials objective.

Reviewer 2

The reviewer said this project contributes to solving joining of materials (especially dissimilar) employed in lightweighting of vehicles.

Reviewer 3

The reviewer remarked joining of dissimilar materials enables vehicle lightweighting and therefore reduction in GHG emissions. This project directly supports and aligns well with DOE objectives to improve energy efficiency.

Reviewer 4

The reviewer commented this project is relevant to the Materials subprogram, particularly with the increasing use of advanced high strength steel with rich chemistries and relatively high resistance and carbon equivalent.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer said resources are sufficient for the project to achieve the stated milestones.

Reviewer 2

The reviewer remarked that the funding level seems to be adequate. There is no indication that the PIs are running out of funds to complete the proposed work.

Reviewer 3

The reviewer said the project is progressing well and the team has been able to complete milestones. The budget and resources allocated to the project appear to be sufficient to successfully complete future research goals.

Reviewer 4

The reviewer remarked that the resources appear be in accord with the demands of the project.

Presentation Number: MAT231
Presentation Title: Light Metals Core Program Introduction
Principal Investigator: Glenn Grant, Pacific Northwest National Laboratory

Presenter

Glenn Grant, Pacific Northwest National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

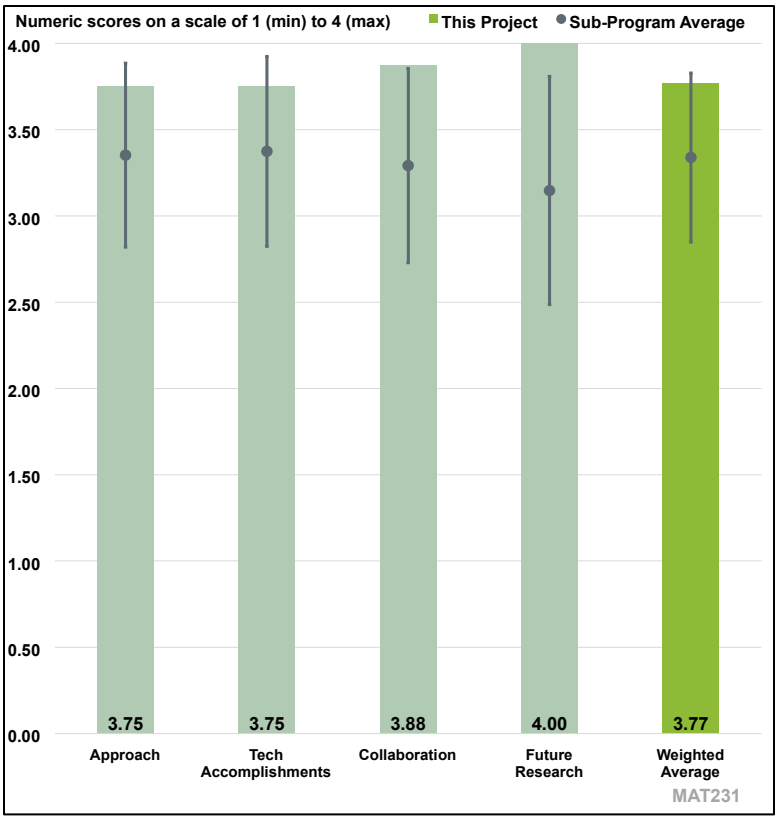

Figure 5-25. Presentation Number: MAT231 Presentation Title: Light Metals Core Program Introduction Principal Investigator: Glenn Grant, Pacific Northwest National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer observed that this was an introductory presentation to the entire first phase of the Light Metals Core Program (LMCP). While there are some takeaways from the effort, e.g., “uni-alloy” concepts, the overall theme of local modification of properties to achieve vehicle lightweighting had mixed results.

Reviewer 2

The reviewer pointed out the program’s goal is to create lightweight alloy materials. The program is transitioning from Phase 1 to Phase 2 and looking to improve metal alloys. The program is still in preliminary stages of Phase 2 and is well designed.

Reviewer 3

The reviewer said the approach was very organized and well thought out to identify key research areas to focus on that will enable lower cost light metals use. The reviewer liked how five different thrusts were identified and said they make sense in order to drive project alignment to deliver on the overall program objectives.

Reviewer 4

The reviewer had no comments.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer said good accomplishments were noted but there was no example of technology that the entire industry is looking to adopt.

Reviewer 2

The reviewer commented that the program is still in its preliminary stages and is building on the work done in Phase 1. No specific accomplishments from Phase 2 were highlighted.

Reviewer 3

The reviewer said progress was made during the LMCP 1.0 phase and the plan to build upon that progress was clearly articulated for the LMCP 2.0 phase.

Reviewer 4

The reviewer had no comments.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer said collaboration between national laboratories was excellent and well-highlighted.

Reviewer 2

The reviewer said the project is a collaboration between PNNL, ORNL, and Argonne National Laboratory (ANL). No industrial partners are identified at the current time but will be identified for guidance in the future.

Reviewer 3

The reviewer remarked the collaboration framework was clearly articulated between PNNL, ORNL and ANL, identifying both leads at each organization and key capabilities being leveraged.

Reviewer 4

The reviewer had no comments.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer noted the project has ended but some aspects are being pursued in LMCP 2.0 phase, which were highlighted in the poster session.

Reviewer 2

The reviewer remarked that the project has just started, and the team has identified the tasks and approach for execution of the project.

Reviewer 3

The reviewer believed that the appropriate areas for development have been defined, and with this focus progress will be made to achieve the defined targets.

Reviewer 4

The reviewer had no comments.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer said the project supports the lightweighting objectives of the DOE VTO's Materials subprogram with 25% glider weight reduction at less than $5/kg saved.

Reviewer 2

The reviewer observed that the project's focus is on improving the properties and manufacturability of lightweight metals for vehicles. This meets the VTO Materials subprogram objectives and can lead to several benefits for vehicles including reducing battery size, utilization of sustainable materials, and reduction of GHG emissions in the glider platform.

Reviewer 3

The reviewer noted that the project has defined key areas to focus on to develop cost-effective materials and manufacturing processes to enable the use of lighter metals in a cost-effective manner.

Reviewer 4

The reviewer had no comments.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer said resources were sufficient.

Reviewer 2

The reviewer remarked that the team has all the resources required to conduct the project.

Reviewer 3

The reviewer believed the resources to be sufficient and that the project is continuing with scientists who have been engaged with LMCP 1.0 to LMCP 2.0, which is good that the experience is being built upon.

Reviewer 4

The reviewer had no comments.

Presentation Number: MAT235
Presentation Title: Light Metals Core Program - Thrust 4 - Residual Stress Effects
Principal Investigator: Ayoub Soulami, Pacific Northwest National Laboratory

Presenter

Ayoub Soulami, Pacific Northwest National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

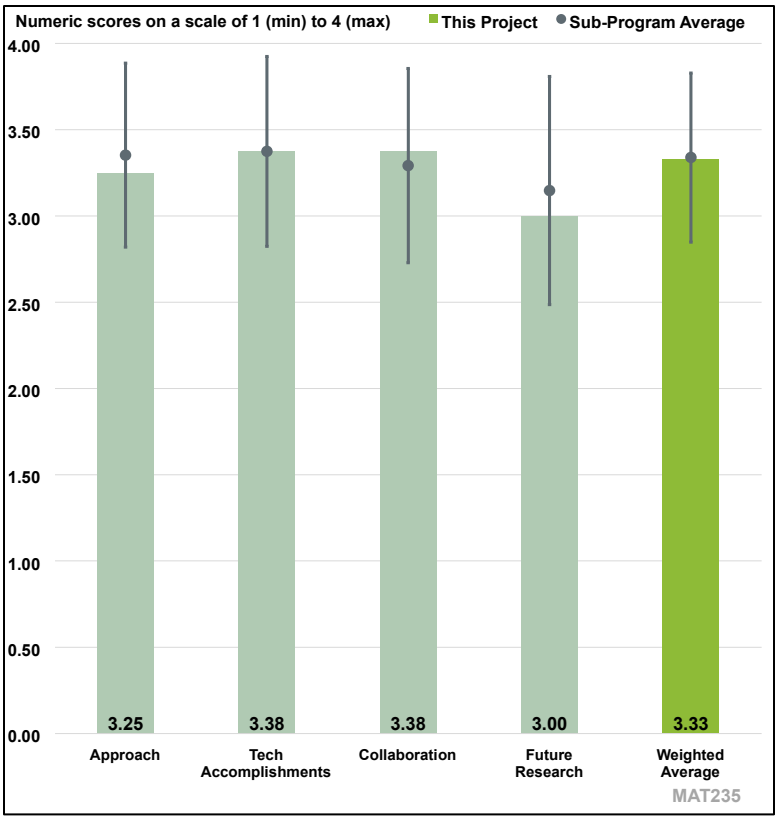

Figure 5-26. Presentation Number: MAT235 Presentation Title: Light Metals Core Program - Thrust 4 - Residual Stress Effects Principal Investigator: Ayoub Soulami, Pacific Northwest National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer said the project team is developing an integrated suite of computational models and an experimental framework to address challenges associated with residual stresses. A few useful projects supporting the LMCP have been implemented.

Reviewer 2

The reviewer remarked that this work validated the residual stress simulation approach using a few dissimilar materials and processes, which can be used as a cost-effective tool for process optimization and stress relief.

Reviewer 3

The reviewer commented that the project has been well designed to explore residual stress prediction and characterization for FSP as well as for peening operations.

Reviewer 4

The reviewer remarked that a broad scope of work applying sound approaches was effectively described.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer said the overall performance of the team has been excellent with several useful examples of residual stress measurements, modeling, and validation.

Reviewer 2

The reviewer commented most of the simulated results agree reasonably well with the experimental measurements except for case of bending-unbending. Stress distribution associated with a wide variety of process was revealed for Mg and Al alloys.

Reviewer 3

The reviewer remarked that this work has shown residual stress may be directionally predicted; however, it is not clear what level of accuracy is required for engineering application.

Reviewer 4

The reviewer said the broadly presented scope of work indicated good technical progress on multiple projects.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer noted that the muti-laboratory collaboration was a highlighted aspect that appeared to have been accomplished.

Reviewer 2

The reviewer remarked that the collaboration and coordination with multiple tasks was clearly described.

Reviewer 3

The reviewer observed that good collaboration was demonstrated between PNNL and ORNL, however, the role of ANL in this project was not very clear. The reviewer noted that the PI only listed the team at PNNL on the project title slide.

Reviewer 4

The reviewer said the collaboration plan was good, but the projects seemed to largely support other PNNL efforts in the LMCP.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer affirmed that the PI clearly defined the scope of future work, which will aim to predict part performance considering heterogeneity in microstructure and residual stress profiles. Clarification on how the component life will be predicted and what are the technical barriers to overcome would be beneficial since the established database only serves for stress evolution analysis.

Reviewer 2

The reviewer remarked that the proposal to extend to component validation seems to be an appropriate and applicable next step.

Reviewer 3
The reviewer said the project has ended.

Reviewer 4
The reviewer said the project has ended.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1
The reviewer affirmed that the project supports multiple overall VTO Materials subprogram objectives.

Reviewer 2
The reviewer said residual stress measurement and control is important for several lightweighting projects.

Reviewer 3
The reviewer remarked that this project aims to establish an integrated suite of computational models for acceleration of product development cycle time for enhanced part performance through a stress evolution analysis.

Reviewer 4
The reviewer said that, though aspects are generally applicable to many engineering problems, this particular project is relevant for automotive materials and manufacturing.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1
The reviewer said resources are sufficient.

Reviewer 2
The reviewer remarked that this project has been completed and achieved the listed milestones.

Reviewer 3
The reviewer remarked that the resources applied are sufficient for the target objective.

Reviewer 4
The reviewer commented that there are sufficient resources.

Presentation Number: MAT236
Presentation Title: Advanced Characterization and Computational Methods
Principal Investigator: Thomas Watkins, Oak Ridge National Laboratory

Presenter

Thomas Watkins, Oak Ridge National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

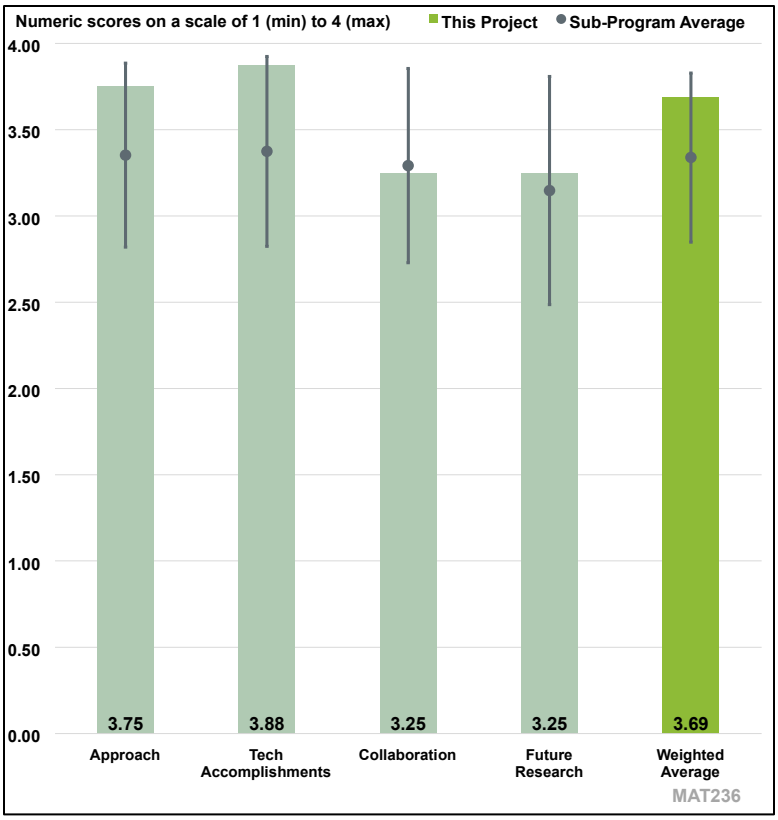

Figure 5-27. Presentation Number: MAT236 Presentation Title: Advanced Characterization and Computational Methods Principal Investigator: Thomas Watkins, Oak Ridge National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer stated that the overall objective of Thrust 4 by combining advanced characterization and computational tools supports the PMCP goals for accelerating development of new materials used in powertrain applications. The reviewer affirmed combining funds and resources from all the national laboratories and awarding proposals from the main tasks based on their needs is a logical and well-designed approach. Materials data collection for models and performance validation is important especially for conductivity, lightweighting, and magnetic applications which are critical technical barriers addressed in Thrust 4. Some FY 2023 tasks seemed to focus on high-temperature applications, which may not be significant technical barriers for EV powertrains.

Reviewer 2

The reviewer commented that the team of national laboratories are applying advanced materials characterization and computational tools to accelerate the development of the next generation powertrain materials with superior combinations of properties, manufacturability, and cost to enable the design of future advanced EVs. The establishment of a database of material properties accelerates the development of the materials needed to support the improvements required to

successfully deploy EVs. The process to select these projects includes a review of the proposed project by the laboratory leaders, then either rejection, suggested revisions, or acceptance. This approach is a fair way to get tasks integrated into the project as these laboratory leaders are the most knowledgeable about the status of the database and where new capabilities are needed.

Reviewer 3

The reviewer observed that the slides did not mention specific TRLs that they planned to address, but the project titles cover a decent range of TRL levels. The project is well designed, and the timeline is reasonably planned.

Reviewer 4

The reviewer remarked that the main technical barrier to be addressed was reducing the weight of the integrated traction drive and that new powertrain materials are needed to address current technology applications for electric powertrains in light-duty, medium-duty, and heavy-duty vehicles.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer expressed that Thrust 4 delivered impactful, interesting, and novel results in both characterization and computational needs. Thrust 4 contribution to the publications was impressive. Aided by Thrust 4, the PMCP tasks published a sizable number of papers in high impact factor journals. The reviewer especially commends the achievements in round-robin testing efforts and high-throughput alloy design efforts. These are two excellent examples of accelerated materials discovery and performance testing.

Reviewer 2

The reviewer verified that multiple activities were completed over five years under this project. These research tasks are expanding the database of material characteristics needed to support the development of more efficient electric propulsion systems. Sixteen FY 2023 tasks were completed to help expand the understanding of advanced materials and their properties. Most work is being performed to understand and improve the electrical and thermal properties of materials. The materials with the most promise appear to be Al-Ni alloys and carbon nano-tube coatings. The national laboratories leveraged their impressive capabilities to perform the testing needed to understand these materials. Success is difficult to assess for these types of projects; however, the Impact factor assessment appears to be an effective metric. There were 77% (24 of 31) of the peer-reviewed journal publications assessed to have an impact factor of greater than 5.

Reviewer 3

The reviewer affirmed that the technical progress showed a well-planned and well-executed project.

Reviewer 4

The reviewer verified that the technical progress was completed on track because the project inputs have led to measurable milestones of output in the last five years of research and the project is 100% completed.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer observed that FY 2023 efforts seem to be focused on mostly ORNL projects and collaborations. In addition, collaboration with the LCA task is lacking. The reviewer suggests that interlaboratory collaboration should be prioritized.

Reviewer 2

The reviewer stated that the three national laboratories participating as program partners - ORNL (program lead), PNNL, and ANL - are working together and effectively using their unique tools to support the development of next generation EV powertrain materials. The NREL is supporting these projects by offering use of their High-Performance Computing User Facility. This arrangement appears to be an effective way to perform the work using facilities that are best suited to complete the proposed subtask activities.

Reviewer 3

The reviewer commented the team includes ORNL, ANL, and PNNL. The reviewer verified some projects showed highly integrated efforts.

Reviewer 4

The reviewer remarked interactions and collaboration existed for the project research studies involving multiple nationally recognized laboratories including PNNL, ANL, ORNL, and NREL. The reviewer also confirmed collaboration between and across laboratories was sufficient for the completion needs of the project based on the numerous specialized technology resources available to be shared.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer articulated a new phase of the PMCP was launched for FY 2024 with Thrust 4 maintaining its structure and approach from Phase 1. Thrust 4 will likely deliver high-impact research in this new program; however, a LCA task seems to be missing in Thrust 4. In the researcher’s opinion, assessing the efficiency and emissions impact of new materials and component technologies is critical. Thrust 4 efforts can help with this aspect. Also, more details on the objectives and targets of the new program could have been provided.

Reviewer 2

The reviewer stated that research was concluded in September 2023 on efforts to improve electrical and magnetic measurements for materials used in EVs under this project. These critically important material properties were assessed for use in a variety of applications in EVs. Some important property characteristics were discovered by accident. Challenges remain regarding the high demand and limited access for some science tools. Challenges also remain surrounding the integration of characterization data with advanced analytics.

The reviewer suggested that a database of materials, which is needed to cost-effectively help improve the materials being used in EVs, could be developed by carefully assessing and characterizing these materials with unique properties. Although this project has concluded, a new project using a similar approach was launched in February 2024 and now aligns with the PMCP 2.0

phase. Many of the previously completed projects have been selected to continue based on encouraging results. Five tasks are underway in three research areas: Advanced Characterization of Materials (ORNL, PNNL, ANL), Electrical and Magnetic Properties Measurements (ORNL), and Computational Materials (ORNL).

Reviewer 3

The reviewer remarked that the proposed future research includes experimental and simulation efforts by three national laboratories: Task 4A1-24 Advanced Characterization of Materials, ORNL; Task 4A2-24 Electrical and Magnetic Properties Measurements, ORNL; Task 4A3-24 Advanced Characterization of Materials, PNNL; Task 4A4-24 Advanced Characterization of Materials, ANL, and Task 4B1-24 Computational Materials, ORNL. The project clearly defines the purpose of future work, which is advanced characterization, and the future work is likely to achieve defined targets.

Reviewer 4

The reviewer commented that the project has proposed future research program tasks planned to be started that is subject to change based on funding levels available. The likelihood of planned future research work achieving defined target was not clearly confirmed.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer affirmed that the PMCP Thrust 4 supports the VTO Materials subprogram objectives of developing higher efficiency powertrains for EVs. With unique characterization and computational capabilities, Thrust 4 provides significant assistance in materials discovery and materials property testing for powertrain-relevant applications and components. Quick assessment of new materials can accelerate their transition to the application, resulting in efficiency improvements in EV powertrains, lightweighting, and lesser demand for critical materials.

Reviewer 2

The reviewer expressed that the project is directly relevant to the VTO Materials subprogram objectives.

Reviewer 3

The reviewer observed the project directly links to the VTO Analysis, Energy Efficient Mobility Systems, and Materials subprograms and is considered to support the overall VTO objectives.

Reviewer 4

The reviewer stated the project is very relevant to the overall VTO Materials subprogram objectives because the project's research studies resulted in the development of a low-melting point element assisted nucleation mechanism proposed in the task, "Lightweight Materials for Improved on Electrical Properties", as well as the development of a better successful predictor for identifying "dirty" alloys developed from the round-robin test plan results in the thermodynamic study for computer coupling of phase diagrams and thermochemistry proposed in the task, "Design of Sustainable Lightweight Die Cast Structural Alloys for EVs".

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer remarked that the total funding of Thrust 4 is sufficient and recommends awarding fewer proposals with higher budgets to provide more funds for characterization and computational

efforts that can benefit multiple development tasks. The reviewer also suggested allocating more funds for the LCA of various materials and technologies developed in the program.

Reviewer 2

The reviewer commented these subprojects complement the activities being performed outside of this Thrust 4 project. This approach is a cost-effective method to expand the ICME database and modeling which will keep the data and tools updated and accurate.

Reviewer 3

The reviewer expressed that the three national laboratories provided sufficient and powerful resources for the project to achieve the stated milestones in a timely fashion.

Reviewer 4

The reviewer articulated that the resources were sufficient to achieve the stated milestones in a timely manner for the multiple industry and national laboratory partners collaborating on the project.

Presentation Number: MAT237
Presentation Title: Materials Lubricants and Cooling for Heavy Duty Electric Vehicles
Principal Investigator: Jun Qu, Oak Ridge National Laboratory

Presenter

Jun Qu, Oak Ridge National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

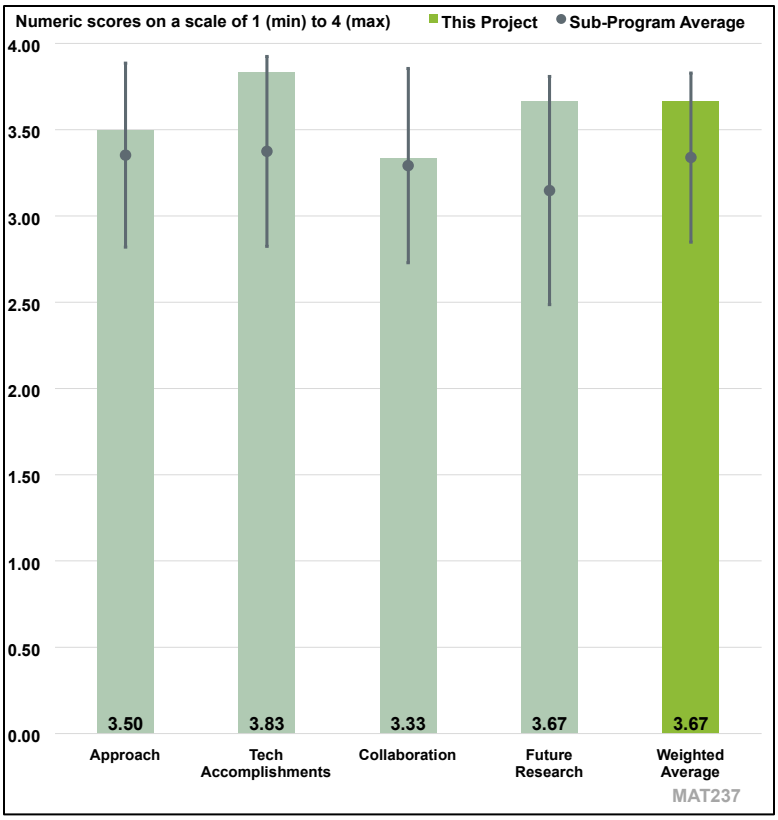

Figure 5-28. Presentation Number: MAT237 Presentation Title: Materials Lubricants and Cooling for Heavy Duty Electric Vehicles Principal Investigator: Jun Qu, Oak Ridge National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer said that the project has completed, and the research addressed significant concerns with thermal dissipation and frictional losses.

Reviewer 2

The reviewer acknowledged that the approach is innovative because it involved adding modified CNTs to EV lubricants to enhance heat transfer and coating CNTs onto powertrain components to enhance thermal and frictional properties. This approach took advantage of the unique properties of CNTs for high thermal conductivity and low surface friction.

Reviewer 3

The reviewer mentioned that new propulsion materials are needed to address current technology gaps of increased heat dissipation from electric motors (e-motors) and reduced parasitic losses in the EV powertrains of heavy-duty vehicles. This recently completed project is performing some very exciting research that can have a significant impact when commercialized for real-world applications. The reviewer commented that the research plan is well developed and has successfully demonstrated that both super lubricity and heat transfer efficiency can be accomplished. By integrating CNTs, this approach provides a pathway for achieving both characteristics.

Through the research presented, the reviewer believes that a process to organically modify the CNTs has been established and a pathway was established for using polar CNTs and non-polar CNTs in lubricating oil with a significant improvement on viscosity. Notably, CNTs were assessed as an approach to improve thermal impedance reduction using a CNT coating as part of a thermal interface material. This project, which completed in FY 2023, also leveraged existing knowledge from an ICME database as a cost-effective approach to determine a possible solution to address EV cooling and parasitic friction challenges.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer said that the project has completed.

Reviewer 2

The reviewer acknowledged that the team successfully demonstrated the effect of CNTs on the thermal conductivity of EV fluids and the strong protection from wear in unidirectional sliding.

Reviewer 3

The reviewer noted that this two-year project obtained remarkable results related to efficient heat dissipation and lubricity improvements. CNTs can improve thermal and lubricity properties in lubrication fluids and will also provide an emergency coating to ensure that if lubricant is lost, low-friction operation can continue for an extended period. The reviewer noted that up to 18% improved thermal conductivity was observed by adding CNTs into EV fluids. Organic modification increased viscosity properties more than new CNTs and good compatibility was confirmed between the super lubricity CNT coating and EV lubricants.

Regarding the PMCP 1.0 phase coatings efforts, the reviewer expressed that the CNT coating showed robust super lubricity behavior under various loads and temperatures and in various EV lubricants which attracted global attention in broad fields of science and technology. Preliminary results also showed increased heating and cooling rates for the potential application of the CNT coating on a heat exchanger, which was also demonstrated with the PMCP 1.0 phase preliminary investigation of the thermophysical and tribological impacts of CNT coatings.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

This reviewer noted that the collaboration was between the ORNL resources and Valvoline.

Reviewer 2

The reviewer observed that there was good collaboration between the ORNL resources and Valvoline, an industrial partner through a CRADA.

Reviewer 3

The reviewer stated the alignment of the project team with ORNL as lead can leverage their unique capabilities from other related projects under Thrust 4 of the PMCP 1.0 phase to maximize the investment made by the DOE. ORNL is also establishing the mechanisms needed to commercialize this technology as they develop CRADAs with industry partners. The CRADA between Valvoline and ORNL will permit the successful transition to a commercialized product. These arrangements are critical to bringing this technology to the commercial marketplace.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer is interested in seeing where the planned aging behavior will be affected, especially when used as an additive (versus a coating). There will be some degradation due to shear that will affect CNT dimensions and numbers and may have an impact on viscosity and elastohydrodynamic boundary lubrication as well as the additives needed to maintain dispersion. questions how the cost of the additives compares with currently available coatings/additives and state-of-the-art materials. What is the electrical property benchmark for other additives currently being investigated?

Reviewer 2

The reviewer observed this project has ended but the team will start a new project aiming at further developing the CNT/fluid for lubrication and thermal management.

Reviewer 3

The reviewer stated that the scope of work assessing these technologies was completed under the PMCP 1.0 phase; however, there are several significant steps that are still needed to develop a commercial product with this technology. Challenges that should be investigated include developing a fundamental understanding of (1) CNTs networking visualization/confirmation by liquid-cell transmission electron microscopy and atomic force microscopy and (2) effects of the size and morphology of the CNTs. Also, a better understanding of long-term dispersion of CNTs in EV fluids as well as their compatibility with EV fluids and thermal pastes is needed.

In addition, the effect of aging on the behavior of CNT-containing lubricants and thermal pastes is not well understood and should be investigated. With the potential thermophysical and tribological properties of CNT coatings, investigating the coating growth of CNTs on heat exchanger materials like Al and Cu alloys should be addressed and studied.

The reviewer pointed out that continuation of this research under the PMCP 2.0 phase should be based on the encouraging results from PMCP 1.0 phase for both the CNTs and the ionic liquids technologies.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer asserted that improving thermal and friction efficiencies in e-motors will increase over efficiencies of EVs.

Reviewer 2

The reviewer highlighted the technology being developed will improve EV thermal management and prolong component service life. This objective and resulting improvements directly support the VTO Electrification subprogram.

Reviewer 3

The reviewer found this project is directly relevant to the VTO Materials subprogram objectives.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer observed that the laboratory and industry partners have excellent resources to complete this effort.

Reviewer 2

The reviewer found the team was given a sufficient budget of $240,000 per year on lubricant additives and $230,000 per year on CNT coatings for improving thermal management and lubricity.

Reviewer 3

The reviewer believed this innovative approach to lubrication and cooling has significant commercial applicability in EV space and throughout industry. The use of CRADAs should be encouraged to allow industry to invest in this promising research. DOE should also identify other possible applications of this exciting and innovative research.

Presentation Number: MAT241
Presentation Title: Advanced Processing and Additive Manufacturing for EV Propulsion Advanced Ceramics and Processing for Wireless Charging Systems
Principal Investigator: Beth Armstrong, Oak Ridge National Laboratory

Presenter

Beth Armstrong, Oak Ridge National Laboratory

Reviewer Sample Size

A total of two reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

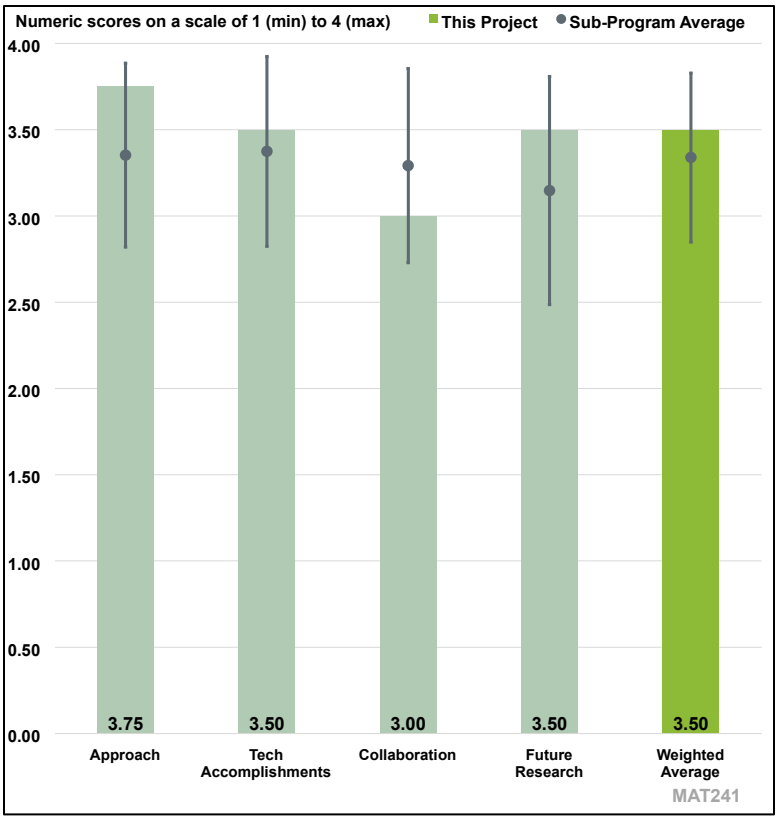

Figure 5-29. Presentation Number: MAT241 Presentation Title: Advanced Processing and Additive Manufacturing for EV Propulsion Advanced Ceramics and Processing for Wireless Charging Systems Principal Investigator: Beth Armstrong, Oak Ridge National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer acknowledged that dynamic charging is an important research area that is being addressed by this effort.

Reviewer 2

The reviewer remarked that ORNL researchers are developing tunable and lighter weight advanced ceramic materials. They are also developing new processing methods for fabrication of wireless charging systems for EV applications. The reviewer noted this project was completed using a six-stage process: (1) determine properties of interest, (2) benchmark existing materials, (3) develop new materials, (4) optimize ferrite fabrication methods, (5) characterize materials, and (6) fabricate lightweight architectures using advanced processing techniques. This two-year project was started under the PMCP 1.0 and was completed in September 2023 and is considered reasonably planned. A project refocused on magnetic field control and alignment was started under the PMCP 2.0 phase in February 2024.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer highlighted that this project has successfully completed FY 2023 efforts and is on track to meet a FY 2024 milestone.

Reviewer 2

The reviewer observed that the team has successfully completed a baselining of common commercial materials, and an assessment of composite and porous architectures is possible. A nonmagnetic cementitious space leads to the applicability of a lighter weight porous structure. Dopant nickel ferrite materials meet the Curie temperature requirements to permit induced magnetism. A baseline was established with a 50/50 composition of nickel zinc, and the content of nickel was changed to adjust magnetic properties. To achieve this, three approaches can be used: (1) intrinsic (modify chemistry/doping), (2) extrinsic (change particle size/porosity/grain size/sintering aids), and (3) external (adjust magnetic dipoles).

The reviewer made the following observations:

- Additives were investigated to adjust properties for constructing complex parts.
- A more fundamental understanding of nickel dopant materials is needed since large grains are needed for optimum magnetic behavior.
- A processing method to achieve larger grains is needed since sintered microstructure is highly dependent on the starting particle size.
- The balance of sinterability and mechanical properties is critical.
- Doping creates complex spinel solid solutions and researchers have investigated the detailed defect chemistries of doped ferrites with computational thermodynamics.

Slip casting/printable AM formulations and bulk casting were initiated in this project and magnetic field enhancements were successfully demonstrated through the addition of ferrites. The reviewer stated that all milestones for this project have been completed and a final paper is being peer reviewed for journal publication.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer remarked that work appeared to be primarily conducted at ORNL.

Reviewer 2

The reviewer observed that the project team led by ORNL can leverage their extensive in-house capabilities that are required to advance the material development work. Using the National Transportation Research Center and the Manufacturing Demonstration Facility along with Raman microscopy and electron probe microanalysis, these facilities and tools provide the needed capabilities to assess the development of these materials.

The reviewer remarked that ORNL should be investigating potential university collaborators with magnetic characterization equipment availability for ceramics at high hertz testing ranges. The addition of the industry partner, Steward Advanced Materials (a commercial powder vendor

providing virgin material), provided the team with a new capability to assess actions needed to bring macro scale material production to the commercial marketplace. The reviewer pointed out that leveraging other national laboratory capabilities should also be considered. In addition, when the time is right, connecting with an industry partner who would be interested in commercializing the material into a wireless charging solution could be executed with a CRADA.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer mentioned that a new task has been initiated: “Ferrite Ceramics for Magnetic Field Control and Enhancement” for the evaluation of processing to reduce weight and meet field and magnetic shielding needs, and software by CompuTherm called CALculation of PHAse Diagrams (CALPHAD) is being used for modeling efforts to guide the development of future ferrite material compositions.

Reviewer 2

The reviewer expressed that existing models are inadequate for the chemistry prediction capability that is needed to predict magnetic properties; however, the needed research aligned with the PMCP 2.0 phase has begun. Researchers are evaluating different processes (composition, colloidal processing techniques for casting and AM fabrication/sintering, use of field) to reduce weight and meet field and magnetic shielding needs. CALPHAD model enhancements will guide the development of future ferrite material compositions. The reviewer pointed out that research is still needed to evaluate intermediate and large-scale magnetic properties. A complete understanding of these magnetic properties is needed to develop a ferrite ceramic material for wireless charging systems.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer noted that this project supports technologies to enable dynamic charging which is a focus of the VTO Electrification subprogram.

Reviewer 2

The reviewer asserted that this project is directly relevant to the VTO Materials subprogram objectives and is focused on the development of materials needed for increased EV deployment.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer acknowledged that the laboratory and their industry partner have the resources to complete the project.

Reviewer 2

The reviewer observed that the resources appear to be sufficient to achieve the stated goals of the project, which is continuing under the guidance of the PMCP 2.0 phase.

Presentation Number: MAT242
Presentation Title: Advanced Processing and Additive Manufacturing for EV Propulsion Novel Ultra High Conductivity Composites for EVs
Principal Investigator: Tolga Aytug, Oak Ridge National Laboratory

Presenter

Tolga Aytug, Oak Ridge National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

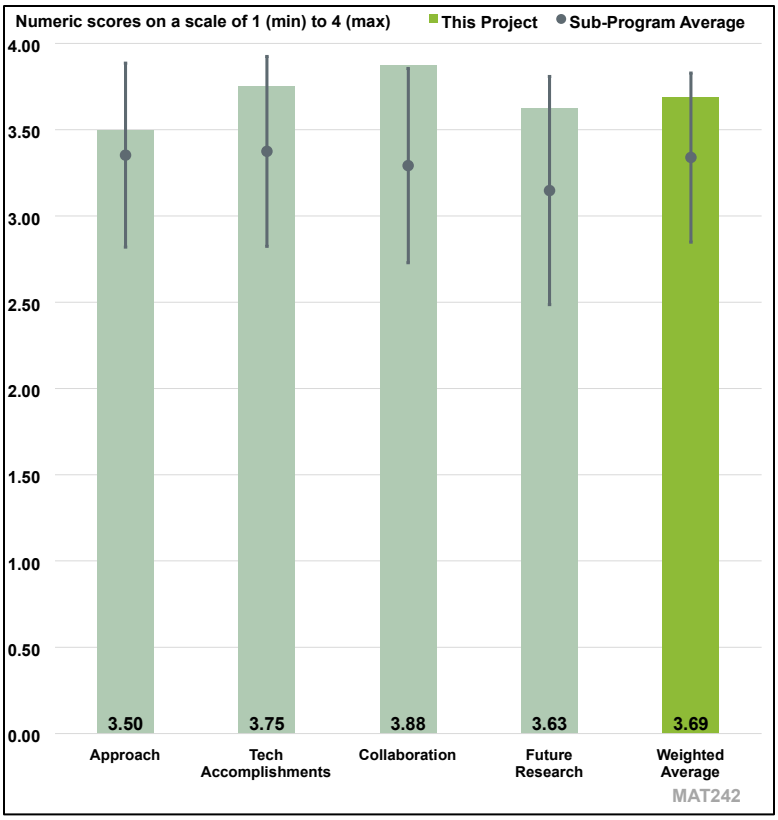

Figure 5-30. Presentation Number: MAT242 Presentation Title: Advanced Processing and Additive Manufacturing for EV Propulsion Novel Ultra High Conductivity Composites for EVs Principal Investigator: Tolga Aytug, Oak Ridge National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer praised the project since a considerable amount of decent work was done on this research, however, an economic evaluation was not performed. What is the cost target? What is the justifiable cost increase that would be economically acceptable based on the increased efficiency? This is the major barrier to deployment of this technology and should be addressed. The reviewer observed that even if the technology is not economically viable, the presentation should include a statement of how much the cost will need to be reduced for commercial adaptation since the efficiency gains available was defined. Is that number possible? If so, what advancements are necessary to achieve it?

Reviewer 2

The reviewer noted that this project addressed important technical barriers for the reduction in volume and weight of EV components by improving electrical conductivity of Cu windings. As highlighted in the U.S. DRIVE Roadmap, ultra conductive Cu is a key enabler. Embedding CNTs into the Cu matrix by reel-to-reel processing is a novel and reasonable approach. The reviewer

concluded that this process successfully increases conductivity of Cu due to significant advantages and properties of CNTs. The only limitation of the overall project approach is the thickness of Cu tapes produced by the process and its production volume output.

Reviewer 3

The reviewer remarked that this research on novel, ultra-high conductivity materials for EVs is being performed to provide means for reductions in volume and weight of EV components. Improvements in efficiency are limited by electrical conductivity of Cu windings and this research provides the materials to meet the DOE 2025 performance targets for power density, size, and reliability goals. Both efficiency and component volume and weight are currently limited by the electrical conductivity of Cu windings. U.S. DRIVE Roadmap aligns with this need and highlights CNT-based Cu materials such as ultra-conductive Cu as a key enabler.

Reviewer 4

The reviewer acknowledged that the barriers to production of Cu with CNT layers were clearly surmounted, and a reel-to-reel method was devised. This is the first step towards making the technology commercial. However, the reviewer expressed that additional work might be needed to reduce the process costs, which were not addressed in this project, while at the same time achieving a more significant increase in performance.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer commented that technical advancements of the powertrain components in both weight and efficiency were presented and demonstrated. These were significant in size to make a discernable difference to the end user.

Reviewer 2

The reviewer praised that, over its course, this project delivered outstanding results, especially a decrease in resistivity values and an increase in ampacity that is significant. These results are also confirmed by the computational study and by third-party testing by the project collaborators. The reviewer also noted that the study on doped CNTs is another highlight. In FY 2023, the researchers focused on scale-up efforts and showed continuous operation of their process. Electrical performance of the continuous reels was shown to be like stationary processing. The reviewer stated that the project reached all milestones and targets.

Reviewer 3

The reviewer pointed out that ultra-high conductive materials are needed since the market for Cu is growing significantly, and weight savings can be achieved if less material is used. Ultra conductive Cu (UCC) with CNTs embedded in a Cu matrix material is one example. Excellent interfacial adhesion was achieved between the Cu and CNT layers and Cu successfully infiltrated the CNT layer, which is very important for improved conductivity.

The reviewer noted that the project demonstrated a double layer matrix from a single layer and provided the validation that more layers can be added because the research continued to achieve a dual-sided UCC. However, improvements in resistivity did not scale linearly with additional layers. Also, improvement in the dual-sided CNT layers was lower than the double-layer CNT coated samples due to non-uniformity of Cu film.

Additionally, the reviewer asserted that cross junctions (e.g., CNT-CNT) can help to significantly increase the electronic charge density near the Fermi level. Nitrogen doping (e.g., pyrrolic-nitrogen) results in a 30-fold increase in the conductivity of semiconducting CNTs compared to graphitic doped CNTs. The reviewer affirmed that a scale up to an all-continuous reel-to-reel process was established and UCCs from this process have similar microstructural evolution and electrical performance as stationary processed UCCs.

Reviewer 4

The reviewer noted that, although no detailed project plan was provided in this presentation, the investigators completed all project milestones and demonstrated that the proposed combination of CNT with Cu could improve the conductive properties above those of pure Cu. This could enable somewhat more efficient use of our limited Cu resources.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer stated that, from the presentation, the team at Southwire and ORNL clearly worked well together and shared data and learnings to optimize the composites.

Reviewer 2

The reviewer praised the collaboration efforts of this project that were outstanding. The project team collaborated closely with suppliers and end users and the fact that the end users verified the property improvements is very important. The project also leveraged PMCP Thrust 4 capabilities and demonstrated fruitful collaboration with the advanced computational work.

Reviewer 3

The reviewer highlighted that the alignment of the project team with ORNL allowed them to leverage their unique capabilities from other related projects under PMCP Thrust 4 to maximize the investment made by DOE. ORNL is using the Oak Ridge Leadership Computing Facility, specifically the Compute and Data Environment for Science data analytics research facility, and the Summit supercomputer to achieve the research goals. More importantly, ORNL is also preparing to move this project from laboratory research to commercial production. ORNL has partners with some leading organizations: Southwire, Chasm Advanced Materials, and General Graphene. The reviewer recommended that, with GM now collaborating on metallurgical joining of the UCC tape composites, a formal arrangement with the partners and GM in the form of a CRADA should be considered.

Reviewer 4

The reviewer commented that all the contributions by the partners combined to complete the project successfully.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer observed that the ability to continue optimization of the materials and further refine the characterization were proposed. These are areas where more work would create value. The ability to refine the theoretical models and validate them with the experimental data will be important in this space as well.

Reviewer 2
The reviewer found that the project reached its objectives, and the proposed future work is reasonable for the scale-up of their process. The reviewer contended that the scale-up efforts should also include a techno-economic analysis and a feasibility study. Thousands of tons of Cu wires are used in transportation applications, and it is important to demonstrate that this process can achieve such high demands and volumes.

Reviewer 3
The reviewer pointed out that to move this technology to the market, the researchers are proposing to optimize the complex parameter space and detail characterization efforts to enable scale-up of UCC fabrication. The optimization of the CNT dispersion formulation and annealing protocols on long-length UCC prototypes is also needed. ORNL is also proposing to investigate the effect of CNT-types (single-wall opposed to double-wall) on the electrical properties as well as activities to assemble and evaluate the influence of multilayer UCC composites with additional Cu/CNT stacks. The reviewer suggested that a comparison between recycled Cu versus virgin Cu should be completed to determine if there are any differences in UCC performance.

Reviewer 4
The reviewer noted that no additional work is planned because this project has been completed. Of course, refinements to the techniques and economic evaluations would be required before transitioning to commercialization.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1
The reviewer mentioned that the current largest barrier to widespread EV adoption in the United States is range anxiety. Heat is the major source of losses of efficiency in battery powered vehicles, and this technology can significantly reduce that loss. The increased resistance as a function of temperature makes this issue even more of a challenge. The reviewer remarked that this is a very needed technology.

Reviewer 2
The reviewer asserted that this project is highly relevant to the objectives of the VTO Materials and Electrification subprograms. Ultra-high conductivity Cu wires and windings can result in significant reduction in EV motor weights and volumes and wiring harnesses within the vehicles. This will also decrease the Cu demand by the electrification of the transportation sector. However, the correlation between the conductivity/ampacity increases to motor volume and weight savings should be quantified. Also, a correlation between the conductivity increases and reduction in Cu losses will be useful.

Reviewer 3
The reviewer asserted that this project is directly relevant to the VTO Materials subprogram objectives. Improvement in electrical conductivity over baseline Cu can reduce the weight of EVs. The reviewer noted that a 30% electrical conductivity performance can reduce the weight of e-motors by 14-20%.

Reviewer 4
The reviewer pointed out that one of the significant factors involved in the deployment of EVs in large numbers is the availability of the critical materials needed to manufacture the vehicles and their

batteries. Although most discussions center on cathode materials, the suppliers of Cu for electrical systems, including batteries, are also expected to be constrained. Therefore, any technology that can serve to reduce the material requirements without reducing functionality is clearly supportive of overall VTO objectives.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer believed that the project was sufficiently completed within budget and delivered a large amount of quality data on well-developed samples. This is a great area of opportunity and was technically well explored by the team.

Reviewer 2

The reviewer observed that this project is 100% complete and achieved all milestones and targets with the allocated resources.

Reviewer 3

The reviewer commented that the resources appear to be sufficient to achieve the stated goals of the project. However, additional resources could accelerate UCC material to the commercial market. This should be considered because the demand for Cu is significantly increasing, and alternative ultra-conducting material is needed.

Reviewer 4

The reviewer observed that the project was completed within its budget.

Presentation Number: MAT243
Presentation Title: Manufacturing Demonstration of a Large-scale Multi-material Passenger Vehicle Sub-system
Principal Investigator: Srikanth Pilla, Clemson University

Presenter

Srikanth Pilla, Clemson University

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 33% of reviewers felt that the resources were sufficient, 33% of reviewers felt that the resources were insufficient, 33% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

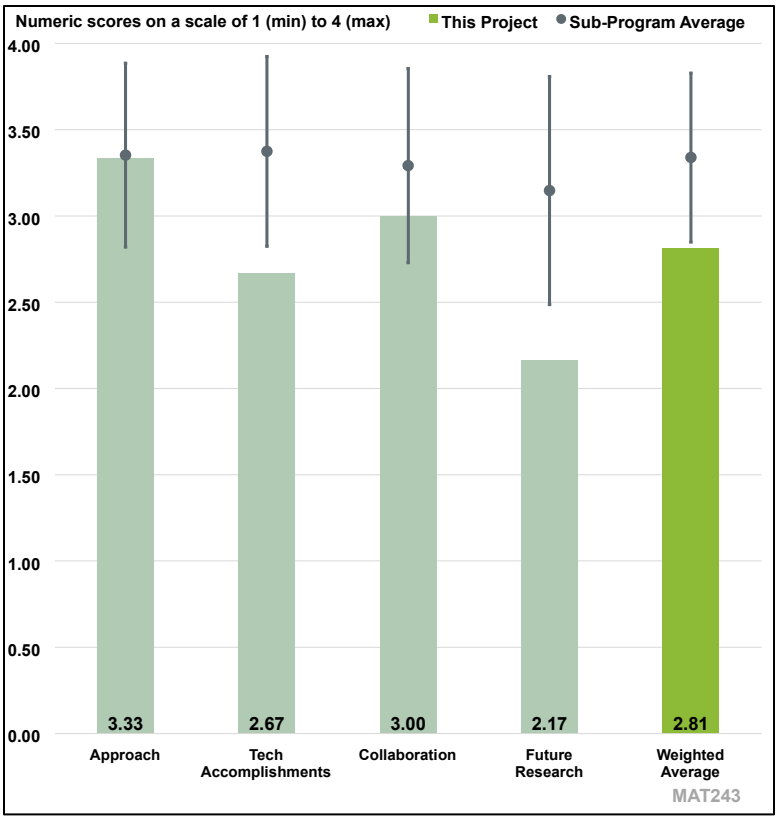

Figure 5-31. Presentation Number: MAT243 Presentation Title: Manufacturing Demonstration of a Large-scale Multi-material Passenger Vehicle Sub-system Principal Investigator: Srikanth Pilla, Clemson University

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer praised that Slide 3 did an excellent job providing the various barriers and the technology readiness level associated with each. This should be used as an example for other projects.

Reviewer 2

The reviewer remarked that the overall approaches chosen for the proposed research make logical sense and the project and timeline is reasonably designed. The reviewer was unclear about how the accuracy of the prediction model can be improved to provide a better match to the experimental observations such as the discrepancy on Slide 9. The experimental results presented on Slide 10 demonstrated large variation ranges as well, which is more than “2% error range” claimed between the experimental and calculation results.

Reviewer 3

The reviewer praised the approach as good but is concerned that the Go/No-Go milestones for cost, corrosion, and CF transition joints have not been achieved. Continuation of this project should be reevaluated based on Go/No-Go status. The reviewer does not recommend this project to continue.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer commented that the project is making reasonable progress into Phase 3 on design optimization using outcomes from Phases 1 and 2 for conceptualization and refinement.

Reviewer 2

The reviewer observed that the team listed the project as 45% complete despite being 2.5 years in progress with 1.5 years remaining. This indicates a risk of completing the project on time, however, overall progress is being made in all research areas.

Reviewer 3

The reviewer asserted that sufficient technical progress has not been made to continue this project. Cost, corrosion, and end-of-life recycling have not been achieved for the Go/No-Go requirements. The deficient performance of the recycled CF is a key factor. The reviewer believes the assumption that paint and e-coat are “the same” and, as such, the processes have been excluded is an incorrect assumption. The choice of the cumulative energy demand method versus GHG emissions is convenient and misleading.

Manufacturing and assembly costs are not included in the cost calculation. A three-minute cycle time does not result in low-coat high-volume manufacturing. End-of-life requirements and disassembly and repair have not been considered. Axial crush performance of composite material is not being considered.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer noted that the descriptions on Slide 12 regarding how the partners have been actively contributing to each aspect of this project were clear.

Reviewer 2

The reviewer believes that having a project on ultrasonic AM within the Joining Core Program would be a good collaboration aspect for this project. There are many unanswered questions around the multi-material transition joint that are not highlighted given the breadth of the overall project.

Reviewer 3

The reviewer observed that the collaboration between the OEM and the project team needs to be increased to achieve the desired project goal, to realize the project objective, and to avoid “another report in the file”. The assumption of utilizing existing OEM facilities and recycled materials is the key to success of the project appears not to be addressed.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer remarked that the cost modeling is reasonably planned with mitigation strategies reasonably identified. The design refinement that relies on the performance prediction models established in previous budget period may experience issues in inaccuracy, which is not sufficiently described.

Reviewer 2

The reviewer noted that the items listed as “Future Work” seem more like a laundry list of items to be done to complete the project rather than critical roadblocks which lack solutions and if not solved will keep the project from moving forward. At the minimum, there should be an aspect of the risk level associated with these items.

Reviewer 3

The reviewer does not recommend that the project proceed because the Go/No-Go milestones were not met. Without positive Go/No-Go results, further effort is not warranted.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer commented that this project supports the objectives for the VTO Energy Efficient Mobility Systems and Materials subprograms.

Reviewer 2

The reviewer noted that the project goal meets the VTO Materials subprogram objective. Until the Go/No Go milestones are met, demonstration projects are premature.

Reviewer 3

The reviewer remarked that this technology supports the concept of the right material in the right form in the right application which ultimately supports mass savings.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer affirmed that the project execution clearly demonstrates sufficient resources available for achieving the stated milestones.

Reviewer 2

The reviewer pointed out that the level of resources is insufficient to bring forward all aspects of the project to the same TRL. Unfortunately, if this is the case and even if they can produce a prototype, there is still significant work remaining and that jeopardizes the likelihood for technology transfer to industry.

Reviewer 3

The reviewer asserted that the focus of resources needs to be directed to achieve the Go/No-Go milestone decision. Further investment of resources is not recommended.

Presentation Number: MAT244
Presentation Title: Lightweight Metals Core Program P1A - Sheet Materials with Local Property Variation
Principal Investigator: Scott Whalen, Pacific Northwest National Laboratory

Presenter

Glenn Grant, Pacific Northwest National Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

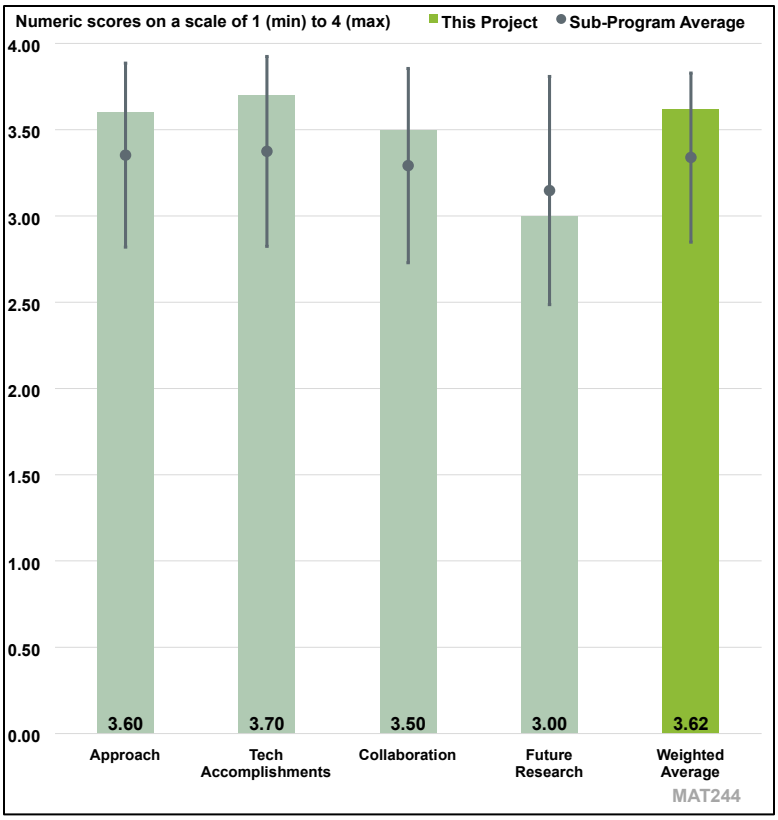

Figure 5-32. Presentation Number: MAT244 Presentation Title: Lightweight Metals Core Program P1A - Sheet Materials with Local Property Variation Principal Investigator: Scott Whalen, Pacific Northwest National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer observed that the technologies under development offer significant potential for weight reduction through tailored wall thickness of Al extrusions. Experimental investigations confirm ability to achieve target thickness and properties, and the project has completed all milestones per the original project plan.

Reviewer 2

The reviewer pointed out that the project aims to utilize Shear Assisted Processing and Extrusion (ShAPE™) processing to extrude Al with mechanical properties customized within different regions. The reviewer believes that tailored properties and variable wall thicknesses can be achieved through the clever strategies that were implemented. The technology, however, remains far from being implemented in an automotive production environment since there are few ShAPE™ machines in use.

Reviewer 3
The reviewer observed that the team has a clear plan and approach to the project and to address technical barriers with the goal to extrude Al with mechanical properties customized within different regions.

Reviewer 4
The reviewer commented that focusing on development of the ShAPE™ process to enable Al articles to have the right property in the right place is a good approach to enabling greater use of lightweight Al in vehicles.

Reviewer 5
The reviewer noted that the project was well-designed to achieve all the technical milestones. The industrial participants provided the necessary materials and guidance on the choice of target part and desired properties. For future programs, the reviewer suggested that the project would be greatly enhanced if the industrial partner provided a cost target for the parts being demonstrated and some analysis should be performed at the end of the project to guide the path forward to achieve those costs, if possible.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1
The reviewer praised the project for being successful in demonstrating potential to both control material properties and local thickness of Al extrusions and for completing all milestones as planned.

Reviewer 2
The reviewer expressed that the project team has made excellent progress in relation to their goals and milestones by meeting all objectives of the project.

Reviewer 3
The reviewer noted that all milestones were completed. The team presented on the ShAPE™ process and their developments for selective property modification during bulk manufacturing, i.e., selectively modified strength and toughness.

Reviewer 4
The reviewer noted that all project milestones were completed in October 2023, and through this work, meaningful development was completed to show that the ShAPE™ process can enable the use of Al in terms of manipulating the properties of the Al-fabricated article to increase its value and potential for use.

Reviewer 5
The reviewer acknowledged that the SHAPE™ process is unique and provides the platform to evaluate continuous processes while simultaneously achieving controlled mechanical properties. The PI made considerable progress and achieved all the goals for the program. Foremost, the team demonstrated that the glider weight could be reduced by changing the wall thickness along the glide because the SHAPE™ process allows the shear imparted on the part to be changed along its length. The reviewer noted that the very nature of this process allows the strength to be changed and increased or decreased where needed. This is a significant accomplishment at scale and demonstrated that the SHAPE™ process also refined the part microstructure, producing high-angle grain boundaries. The significance of this is that there should be some increase in the fatigue resistance of the part. The reviewer recommends that this project should be continued.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer observed that the collaboration was reported to include not only national laboratory participants but key industry stakeholders.

Reviewer 2

The reviewer considered that there was good collaboration by three other industry partners and the lead lab, PNNL.

Reviewer 3

The reviewer noted that the team has members from national laboratories and industry.

Reviewer 4

The reviewer asserted that there was good collaboration by PNNL for input from Ford and materials from Rio Tinto and Wagstaff.

Reviewer 5

The reviewer commented that the team appears adequate to perform the work described. However, the reviewer was unclear on the contributions from the industrial partners until near the end of the presentation .

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer noted that no further research is proposed because all the work has been completed.

Reviewer 2

The reviewer stated that the project has ended.

Reviewer 3

The reviewer commented that the project was completed, however, the team continues developing variable properties using post-consumer scrap metal as the feedstock for a ShAPE™ phase 2.0 effort.

Reviewer 4

The reviewer expressed that the suggested future work to use ShAPE™ to enable the use of post-consumer scrap metal in automotive parts makes sense because the feedstock/metal cost will be further reduced. ShAPE™ can be used to enable the use of a lower quality feedstock to meet automotive part requirements.

Reviewer 5

The reviewer observed that the proposed future work was minimal, with the only objective of evaluating the effect of using the SHAPE™ process with scrap feedstock. High shear processes tend to have high tool wear and cost. The reviewer suggested that, at some point in the future, there needs to be some emphasis on assessing both tool wear and cost. Additionally, this shear process leads to grain refinement and the formation of high-angle grain boundaries, which significantly increase fatigue resistance, so a future consideration should be to evaluate SHAPE™ for parts that need improved fatigue resistance.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer commented that this project is fully aligned with the mission statement of the Vehicle Technologies Office.

Reviewer 2

The reviewer concluded that this project is relevant for local processing goals of the LMCP.

Reviewer 3

The reviewer stated that this project meets the goals of VTO for R&D to increase understanding of novel materials and to engage industry for further development and deployment of technologies to achieve more fuel-efficient light-duty and heavy-duty vehicles.

Reviewer 4

The reviewer said that the research performed enables Al to be used cost effectively in automotive parts which is consistent with the VTO Materials subprogram objective to deliver materials that reduce automotive weight.

Reviewer 5

The reviewer affirmed that this project supports the need for a future generation of materials and processes to reduce vehicle weight while increasing passenger safety. The use of emerging scalable high-shear processes to produce the glider form is novel and appears to be a step in a new direction for automobile manufacturing. The reviewer suggested that at some point, there needs to be an equipment analysis to determine part size versus SHAPE™ machine size, as well as a life cycle cost analysis to determine if SHAPE™ technology is cost-competitive with current manufacturing technologies.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer stated that appropriate resources have been deployed to meet all project objectives.

Reviewer 2

The reviewer said resources were sufficient.

Reviewer 3

The reviewer acknowledged that the project team has all the resources required to conduct the work.

Reviewer 4

The reviewer noted that all work was completed.

Reviewer 5

The reviewer observed that the resources were adequate to achieve the milestones laid out in the program plan.

Presentation Number: MAT245
Presentation Title: Lightweight Metals Core Program P1B - Form-and-Print - AM for Localized Property Enhancement of High-strength Al sheet
Principal Investigator: Alex Plotkowski, Oak Ridge National Laboratory

Presenter

Alex Plotkowski, Oak Ridge National Laboratory

Reviewer Sample Size

A total of two reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

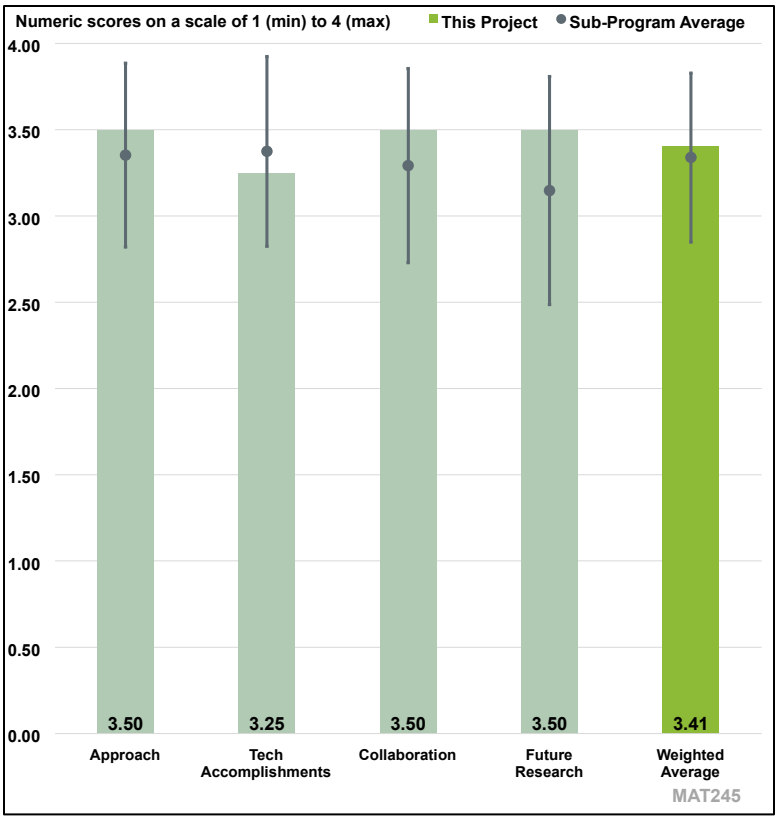

Figure 5-33. Presentation Number: MAT245 Presentation Title: Lightweight Metals Core Program P1B - Form-and-Print - AM for Localized Property Enhancement of High-strength Al sheet Principal Investigator: Alex Plotkowski, Oak Ridge National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer considered that the approach taken was well developed. Evaluation of AM for enabling property/performance enhancements to cost effectively use Al in automobiles is a sensible approach.

Reviewer 2

The reviewer observed that this project appeared to use a tool only because ORNL had one. At the outset, there was no discussion regarding the priority of the most important task to be accomplished —research on material hems, stiffness, or lap joints. The reviewer was unclear about whether the problem could be solved or if there was inadequate funding or something else because the results did not appear to have sufficient detail. Slide 10 seemed like a one-off because dissimilar plug deposition and porosity was discussed. There was no science discussed as to why or how the problem of porosity could be solved. The reviewer remarked that there should be a preference for fewer issues tackled with a deeper understanding of each issue rather than what was presented.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer commented that the project team executed the plan for evaluating fusion joining of hems and dissimilar plug deposition. The reviewer was encouraged to see that fusion joining of hems did not cause melt-through, suggesting this process is likely achievable commercially. Porosity was an issue that was presented during the dissimilar plug deposition work and identified an area for future development. There were unexpected challenges with the Mazak system used, but the reviewer believed that the team did their best to work through them.

Reviewer 2

The reviewer stated that this project had potential but fell short of meeting needs. In the last year of a project, a nice touch would be to review all accomplishments to give a new reviewer a greater perspective of the work. Additionally, the relevance was not properly addressed because the presenter does not answer why AM can produce unique geometries, misconstrues how AM is useful and how AM helps the automotive industry. While the technical accomplishments appear satisfactory, the connection to the why AM is needed makes it hard to determine the impact and relevance of this project.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer observed a good collaboration team with ORNL, PNNL, and external collaborators including Ford for a discussion of application areas, Mazak, and Lincoln Electric for help with the Al deposition equipment, and CompuTherm for CALPHAD support.

Reviewer 2

The reviewer applauded the fact that the project listed a stellar team of participants. The reviewer was unclear about how this project integrates with the other project tasks and subtasks (P1A, P1C1, and P1C2) within Thrust 1 of the LMCP. Also, because the project is completed, more should have been presented about the computational task, which seemed to be an afterthought.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer observed that the proposed future work makes sense, focusing on process optimization to address the porosity issue, reducing cycle time, and understanding long-term performance.

Reviewer 2

The reviewer commented that the project is on target for identifying the issues that need to be addressed should there be a follow-up project.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer determined that the project is relevant to achieving the weight reduction targets set by the VTO.

Reviewer 2

The reviewer stated that, if this project could be set up to operate aerobically at high throughput in the future, the project would be very relevant to the mission of EERE. The key issues that need to be addressed were highlighted (e.g., reducing defects, reducing the impact of oxygen via a cover gas, and optimizing the process to avoid melting through and enable welding of dissimilar materials). While the research is directionally appropriate, the reviewer felt that having one slide indicating that this technology can be scaled and implemented cost-effectively and addressing the development of deeper process science into solving the problem at hand would be very beneficial.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer stated that the resources were sufficient to achieve the current project objectives but more needs to be done going forward to further develop the viability of the AM technology in helping enable AI usage.

Reviewer 2

The reviewer said that this question is irrelevant since the project is not continuing.

Presentation Number: MAT246
Presentation Title: Lightweight Metals Core Program P1C - Local Thermomechanical Processing to Address Challenges to Implementing High Strength Al Sheet
Principal Investigator: Mert Efe, Pacific Northwest National Laboratory

Presenter

Mert Efe, Pacific Northwest National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

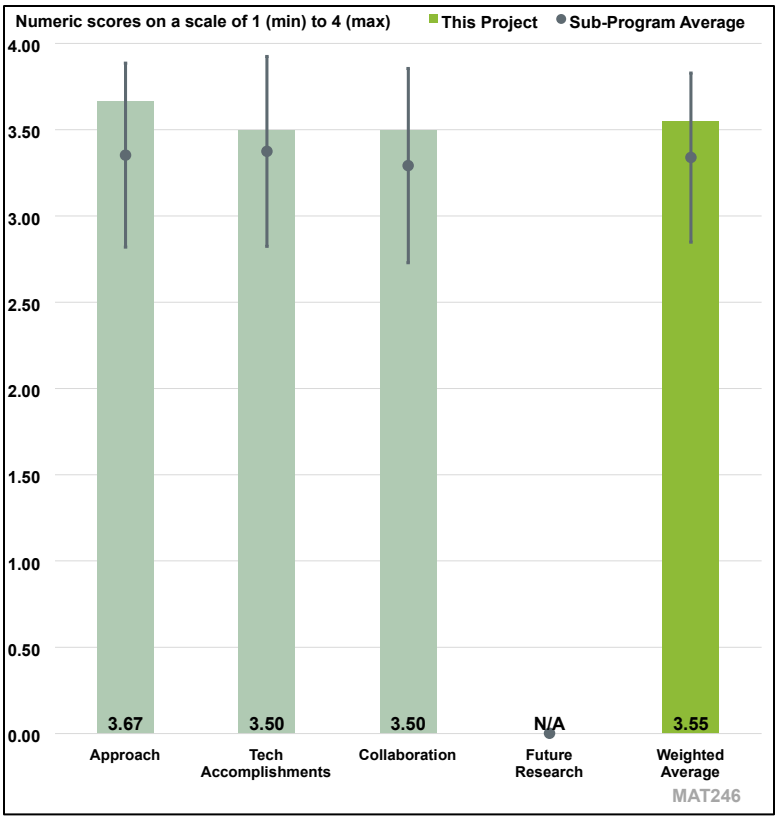

Figure 5-34. Presentation Number: MAT246 Presentation Title: Lightweight Metals Core Program P1C - Local Thermomechanical Processing to Address Challenges to Implementing High Strength Al Sheet Principal Investigator: Mert Efe, Pacific Northwest National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer commented that the objectives are well-defined and the approaches to meet the objectives are scientific. A set of different methods have been investigated to improve the local formability of T6 heat-treated Al sheets which will contribute to weight and cost savings.

Reviewer 2

The reviewer observed that the approach by the research team to performing the work is well thought out and effectively addresses the technical barriers inherent in the project. Methodologies are sound and demonstrate a clear understanding of the current challenges. Furthermore, the timeline is reasonably planned, allowing sufficient time for each phase of the project to be executed meticulously. Overall, the approach used by the research team is adequate to address the technical challenges and achieve the project goals successfully. The reviewer remarked that a more in-depth microstructure characterization could be employed to enhance the results. This would improve the fundamental understanding of the processes and their impact on microstructure, which in turn affects

performance. Such detailed analysis could provide valuable insights that lead to the refinement of process parameters and optimization of overall performance.

Reviewer 3

The reviewer observed that the approach to evaluating the use of three local thermal/mechanical processes (FSP, roller bending/unbending, and laser processing) to enable property improvement of Al sheets is reasonable and that the project was well designed and well planned.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer noted that local process modification by FSP and bending/unbending combined with heating improved formability. The reviewer was unclear about the details of the joint bending/unbending plus local heat treatment results and the abbreviation “IH” on Slides 7, 11, 12, and 13. [Note: IH is abbreviation for induction heating]

Reviewer 2

The reviewer pointed out that the project team has developed four different processes and successfully demonstrated them in various applications. To further enhance understanding and optimizing the process parameters, a study of the correlation between the resulting microstructure and the laser modification process parameters would be beneficial.

Reviewer 3

The reviewer remarked that all technical milestones were completed. The only remaining milestone is the publication of a journal article detailing the research performed with ultrasonic modification on edge properties and microstructure. The inverted VDA test apparatus with digital image correlation development was effective to evaluate the dissimilar materials and to understand performance after FSP processing and showed the performance benefits of FSP. In addition, microstructure evaluations were conducted to understand crack propagation mechanisms in T6-treated samples after FSP that added insight into FSP.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer stated that the project had several informal industry collaborations for supply of materials and testing procedures along with active collaboration with ORNL. This project also led to a LightMAT project with industry.

Reviewer 2

The reviewer noted a good collaboration between PNNL and ORNL, good collaboration for input into test method development from Ford, and good insight/feedback from GM on unique needs.

Reviewer 3

The reviewer observed that, although this is a collaborative project between ORNL and PNNL, the tasks were divided among both national laboratories and performed individually, which has led to a lack of interaction and integration. The project does have some industry collaboration, but the level of engagement and interaction among the partners appears insufficient. The collaboration with the other national laboratory on advanced characterization seems largely symbolic, without unmistakable evidence that it significantly contributes to a better understanding of the developed

modification processes. The resources are heavily focused on process development, and additional investment in microstructure characterization is required. This would not only enhance the collaboration but also provide a more comprehensive understanding of how the processes impact microstructure and performance.

The reviewer pointed out that more active and integrated collaboration between all parties involved, including industry partners and national laboratories, is needed to fully leverage their expertise and resources. This would ensure that all aspects of the project are addressed synergistically, leading to more robust and impactful outcomes.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer believed that this question was not applicable to the project.

Reviewer 2

The reviewer noted that this project ended in FY 2023.

Reviewer 3

The reviewer commented that, although the project is complete, the future work proposed aimed at enabling recycled Al to be used in automotive manufacturing is reasonable reduce cost and increase the commercial viability of this technology.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer acknowledged that this project would enable vehicle lightweighting for improved energy efficiency and cost reduction.

Reviewer 2

The reviewer stated that the project goal is consistent with the VTO Materials subprogram objectives.

Reviewer 3

The reviewer noted that project efforts are consistent with the overall VTO Materials subprogram objectives to reduce glider weight by 25% at a cost of less than $5/kg.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer had no comments because the project has ended.

Reviewer 2

The reviewer believed that the resources are sufficient to achieve the project goals and milestones.

Reviewer 3

The reviewer found that the resources for this project were sufficient.

Presentation Number: MAT247
Presentation Title: Lightweight Metals Core Program P2A - Solid Phase Processing of Al Castings
Principal Investigator: Saumyadeep Jana, Pacific Northwest National Laboratory

Presenter

Saumyadeep Jana, Pacific Northwest National Laboratory

Reviewer Sample Size

A total of two reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

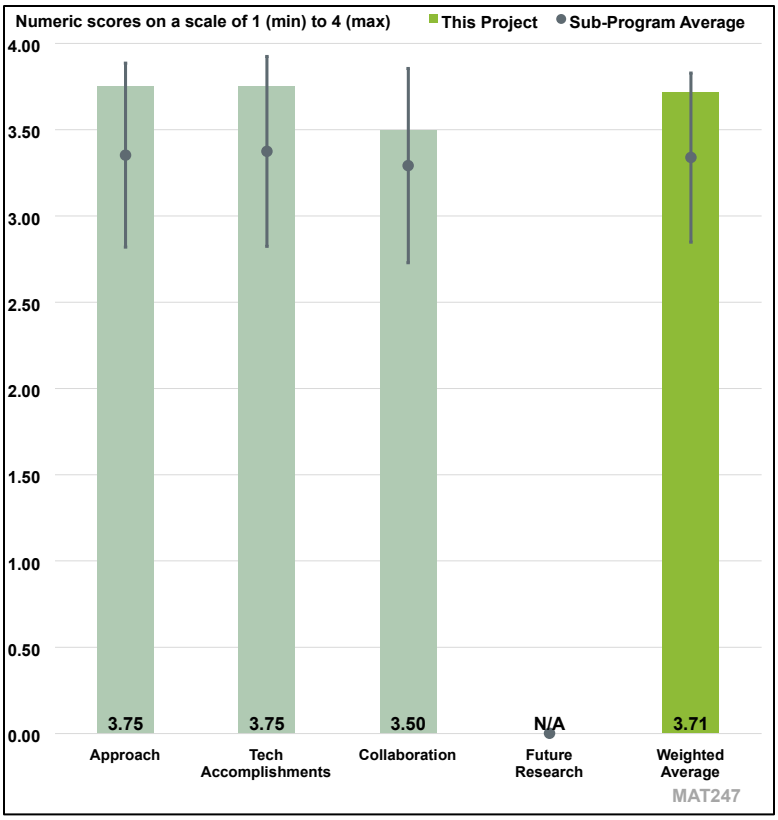

Figure 5-35. Presentation Number: MAT247 Presentation Title: Lightweight Metals Core Program P2A - Solid Phase Processing of Al Castings Principal Investigator: Saumyadeep Jana, Pacific Northwest National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer expressed that the project is well designed and effectively addresses the technical barriers associated with enhancing the local thermo-mechanical properties of high-pressure die-casting (HPDC) alloys through modification of the microstructure and removal of casting defects. The project team aims to achieve improved fatigue and fracture toughness in locally modified HPDC Al-alloys, specifically A380 and Aural-5. Also, the team has successfully developed and demonstrated that both FSP and pulsed ultrasonic processing can effectively modify the local microstructure, thereby enhancing the fatigue and mechanical performance of the parts.

Reviewer 2

The reviewer noted that the project plan addressed the barriers/challenges. The reviewer stated that the approach was reasonable because the plan identified two methods to be developed and validated to overcome the barriers for FSP and power ultrasonic surface processing of HPDC Al alloys.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer provided the following positive feedback. To further strengthen the project, a clear criterion for the maximum size of casting defects that can be effectively removed should be established to be beneficial. This addition would provide a more comprehensive framework for evaluating the success of the defect removal processes and ensure consistent quality improvements. Regarding the design and timeline of the project overall, the reviewer commented that the project is well-conceived, and the timeline is reasonably planned, which allows for systematic execution of each phase. The methodologies employed are robust and show promise in achieving the project goals with the suggested minor improvement for thoroughness.

Reviewer 2

The reviewer remarked that all milestones were completed, and the project showed encouraging results and identified some potential areas to focus on understanding needs for the future.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer noted that the project is primarily a collaboration between PNNL and ORNL with a strong focus on tool and process development. This collaboration has been successful in achieving the initial goals. However, additional microstructure characterization should be planned to better understand the relationship between the microstructure and process parameters. The project team recognizes this need and has mentioned plans to incorporate in the next phase of the project under PMCP 2.0.

The reviewer suggested that the project would benefit from increased input from industry partners to assess the practicality of the developed processes in a real production environment. Such collaboration would ensure that the processes are not only scientifically sound but also feasible and efficient for industrial application. By involving industry partners more deeply, the project could gain valuable insights into potential challenges and opportunities for process optimization in real-world settings. The reviewer affirmed that, while the current collaboration between PNNL and ORNL is effective, expanding the scope to include more comprehensive microstructure characterization and enhanced industry engagement would further strengthen the project's outcomes and applicability.

Reviewer 2

The reviewer stated that the collaboration between PNNL and ORNL was good and support from Ford, GM, and Magna by providing die cast parts for the evaluations was beneficial.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer pointed out that the project ended in FY 2023.

Reviewer 2

The reviewer expressed that this project has completed, but for the LMCP 2.0 phase, the future work should consider using design and modeling to help eliminate die-cast defects. The methods evaluated in this project are helpful to repair or improve defects after the die casting, but an effort to

develop methods through design/process to prevent the defects that would eliminate the need for post die-casting processes and rework would be beneficial.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer agreed that the project supported the overall VTO Materials subprogram objectives.

Reviewer 2

The reviewer pointed out that enabling giga-casting of Al parts supports the 25% weight reduction targets of the VTO Materials subprogram in a cost-effective manner.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer observed that the funding allocation is sufficient to achieve the stated objectives.

Reviewer 2

The reviewer stated that the resources were sufficient.

Presentation Number: MAT248
Presentation Title: Lightweight Metals Core Program P2B - High Intensity Thermal Treatment
Principal Investigator: Aashish Rohatgi, Pacific Northwest National Laboratory

Presenter

Aashish Rohatgi, Pacific Northwest National Laboratory

Reviewer Sample Size

A total of two reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

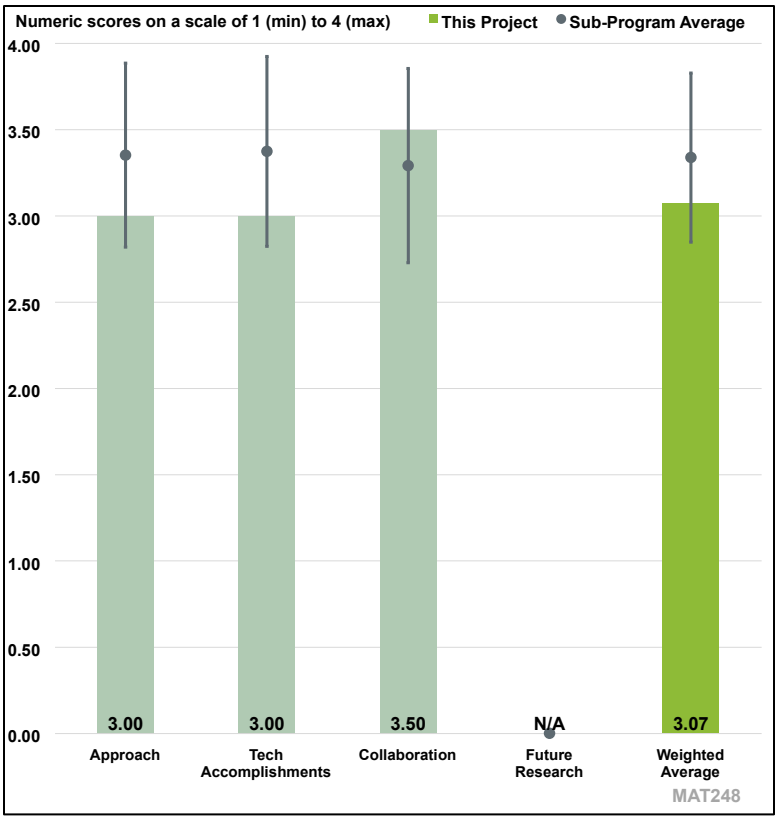

Figure 5-36. Presentation Number: MAT248 Presentation Title: Lightweight Metals Core Program P2B - High Intensity Thermal Treatment Principal Investigator: Aashish Rohatgi, Pacific Northwest National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer stated that the two processes, ultrasonic intensification during solidification and water jet peening, were evaluated to improve properties of castings. Both processes have demonstrated some success in improving properties.

Reviewer 2

The reviewer noted that the approach to evaluate ultrasonic melt treatment, localized heat treatment, and surface processing to improve mechanical properties is rational. However, the reviewer was unclear regarding any constructive interaction between these methods. Otherwise, the scope of the work appears very broad.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer remarked that the progress is satisfactory and a unique in situ grain refinement measurement was reported. Fatigue life improvement was reported after water jet peening, but the interpretation of the improvement was not clear.

Reviewer 2

The reviewer considered that the demonstration of ultrasonic treatment to refine the grain size and, more importantly, and identification of the primary intermetallic aspect ratio are encouraging results towards the development of recycled Al alloys for structural applications. Similarly, water peening was demonstrated to improve the fatigue life of castings.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer commented that there was good collaboration with three separate industries reported in this project led by PNNL.

Reviewer 2

The reviewer concluded that there are multiple examples of great collaboration with other national laboratories (e.g., in situ synchrotron diffraction experiments with ANL) and industry (e.g., laser peening and water peening).

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer noted that the project has ended.

Reviewer 2

The reviewer believed that this question was not applicable.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer stated that the project supports the LMCP program goal for local property enhancement.

Reviewer 2

The reviewer observed that the development of recycled structural Al alloys will advance energy efficient mobility systems via vehicle lightweighting.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer stated that the resources were sufficient.

Reviewer 2

The reviewer noted that the project has been completed.

Presentation Number: MAT249
Presentation Title: Lightweight Metals Core Program P2C - Cast-and-Print - AM for Localized Property Enhancement of Al Castings
Principal Investigator: Alex Plotkowski, Oak Ridge National Laboratory

Presenter

Alex Plotkowski, Oak Ridge National Laboratory

Reviewer Sample Size

A total of two reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

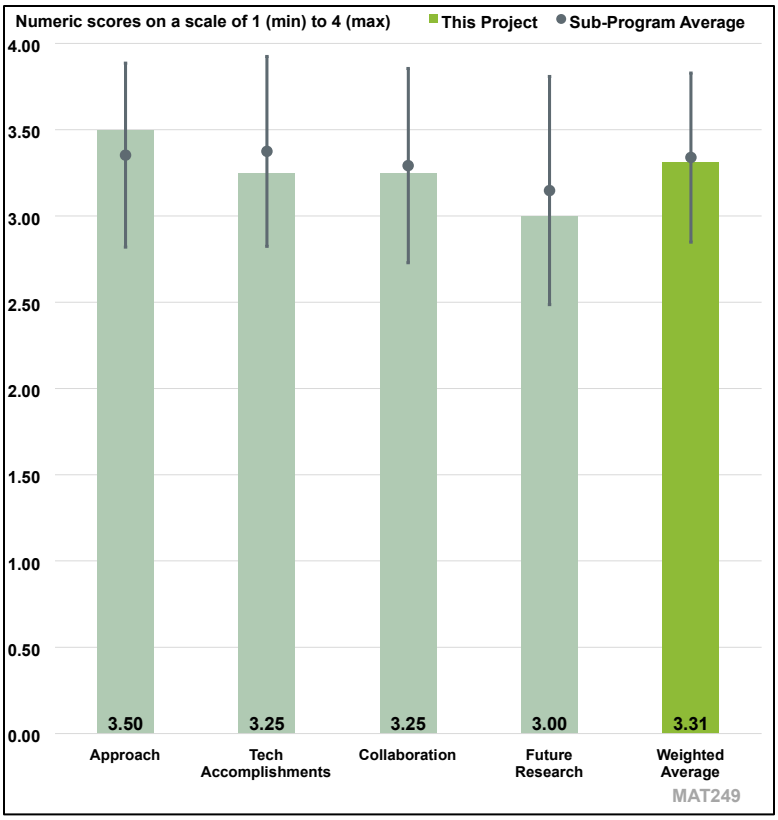

Figure 5-37. Presentation Number: MAT249 Presentation Title: Lightweight Metals Core Program P2C - Cast-and-Print - AM for Localized Property Enhancement of Al Castings Principal Investigator: Alex Plotkowski, Oak Ridge National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer commented that the project is well designed and effectively addresses the technical barriers associated with modifying the microstructure and geometry of Al alloy castings using AM. The selected approach, which combines wire AM with machining, is sound and well-suited to achieving the project's objectives. This hybrid concept enables advanced structural designs for light-weighting and local microstructure modification to improve material properties. The reviewer affirmed that, overall, the design of the project and the execution plan are well conceived, promising successful achievement of the project goals. The strategic planning and sound approach ensure that technical barriers are addressed effectively and future research into mechanisms of defects should further enhance the potential for success.

Reviewer 2

The reviewer stated that the project is well designed for exploring the potential of building AM structures for the purpose of enabling joining of previously layered cast parts.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer observed that, by leveraging AM, the project aims to enhance the mechanical performance of Al alloy castings making them more suitable for advanced applications. The focus on both structural design and microstructure modification demonstrates a comprehensive understanding of the technical challenges involved. The methodology for this project is robust and integrates innovative techniques to overcome potential obstacles.

The reviewer noted that the timeline was reasonably planned and allowed sufficient time for each phase of the project to be executed meticulously. However, to fully realize the goal of developing a defect-free process, additional investigation into defect formation mechanisms is required. Understanding the origins and behavior of defects during the AM process will be crucial in refining the techniques and ensuring consistent quality.

Reviewer 2

The reviewer commented that the project was well executed and demonstrated the basic feasibility of the concept. The reviewer noted that future work may determine if sufficient quality and scalability can be achieved beyond laboratory investigation.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer praised that collaboration within the project team is commendable, with major industry partners covering the automotive and tooling sectors. This collaboration is crucial for the successful outcome of the project to ensure that the developed processes are practical and relevant to real-world applications. The involvement of industry partners brings valuable insights and expertise that enhance the overall quality and applicability of the resulting technology.

Reviewer 2

The reviewer noted that collaboration between the laboratory and industry was highlighted and evident in the way the workplan was developed and executed.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer commented that the project ended in FY 2023.

Reviewer 2

The reviewer observed that the future work presented showed appropriate targets and identified technical barriers for the quality and scalability of this concept.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer asserted that the project supported the overall VTO Materials subprogram objectives.

Reviewer 2

The reviewer stated that this project is relevant to automotive material and manufacturing.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer expressed that the resources ae sufficient to achieve the stated goals.

Reviewer 2

The reviewer said that appropriate resources were applied to achieve the stated objectives.

Presentation Number: MAT250
Presentation Title: Lightweight Metals Core Program P3A - Cast Magnesium Local Corrosion Mitigation
Principal Investigator: Vineet Joshi, Pacific Northwest National Laboratory

Presenter

Vineet Joshi, Pacific Northwest National Laboratory

Reviewer Sample Size

A total of two reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

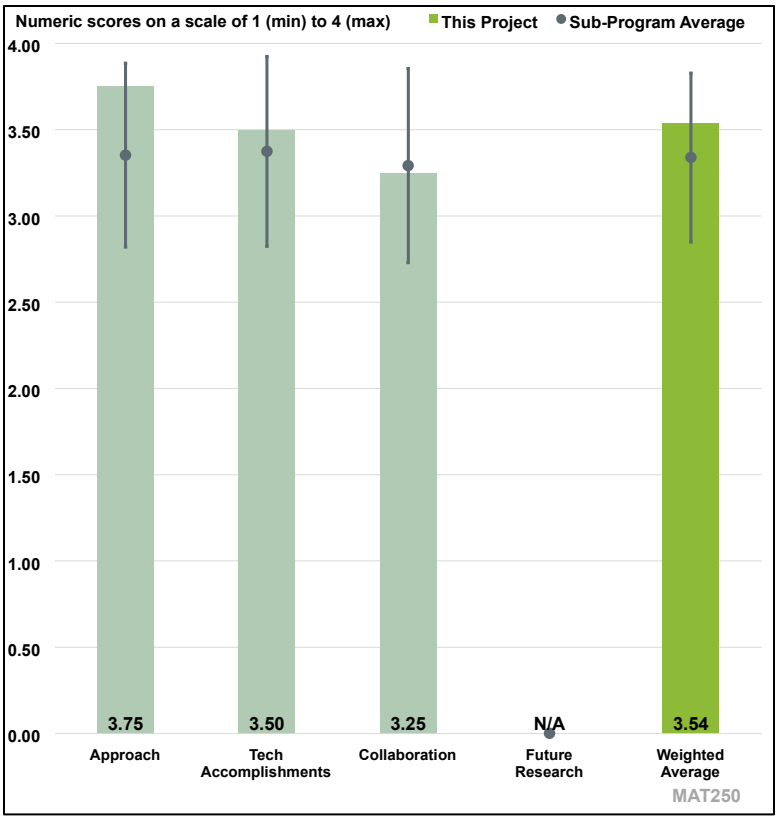

Figure 5-38. Presentation Number: MAT250 Presentation Title: Lightweight Metals Core Program P3A - Cast Magnesium Local Corrosion Mitigation Principal Investigator: Vineet Joshi, Pacific Northwest National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer determined that the project is well designed and effectively addresses the technical barriers associated with enhancing the local properties of Mg alloy castings. The objective of developing low-cost, advanced manufacturing processes to improve corrosion resistance and wear resistance is both ambitious and achievable. The collaboration between PNNL, ORNL, and ANL leverages the unique strengths of each institution, ensuring a comprehensive approach to tackling these challenges.

The methodologies employed, including surface alloying with cold spray, surface plasma treatment, and advanced characterization, are innovative and well-suited to achieving the project's goals. By exploring processing windows beyond what is documented in literature, the project pushes the boundaries of current knowledge and capabilities. Additionally, the integration of ab-initio modeling work provides valuable baseline water stability studies, offering useful insights and comparisons with surface-modified reactive and alloying processes.

The timeline is reasonably planned, allowing sufficient time for each phase of the project to be executed meticulously. Strategic planning and clear milestones for this project ensure that technical barriers are addressed effectively, which leads to the successful development of scalable and cost-effective processing methods.

Reviewer 2

The reviewer acknowledged that this project demonstrated a clear understanding of key barriers (corrosion and wear resistance of Mg) and built a team of industrial and laboratory investigators to address and overcoming the barriers. The processing methods employed were both novel and commercial, indicating that if successful, they could be utilized in a large-scale manufacturing environment. The team used reactive processes to deposit improved coatings and surface alloying. Arguably, cold spray is just a deposition process. In all cases, considerable progress was made toward improving galvanic corrosion and reduction of wear.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer observed that the technical progress made so far has been impressive and aligns well with the project plan. Both surface treatment processes, cold spray (alloying) and plasma (reactive), have demonstrated superior corrosion, wear, and adhesion properties compared to the substrate material. This indicates significant advancement towards the objectives of enhancing local properties of cast Mg for broader implementation in lightweight vehicles. The methodologies utilized, including plasma, lithium salt, thermal carbon dioxide, cold spray, and AM have shown promising results.

The exploration of processing windows beyond what is documented in the literature has yielded innovative solutions and valuable data. The ab-initio modeling work has provided a solid foundation for understanding water stability, offering insightful comparisons with surface-modified reactive and alloying processes. Overall, the reviewer praised the project for making excellent technical progress and meeting or exceeding the planned milestones.

Reviewer 2

The reviewer expressed that Task 3A1 was nicely planned and executed. For both approaches, open-air plasma and lithium-salt assisted, the team made significant improvements in both the corrosion and wear resistance of Mg substrates. Also, the presentation indicated that these coatings work on non-conformal surfaces and the plasma technology is already a commercial process. The microstructures of the plasma coating were homogenous and had a coherent interface with the Mg substrate. The lithium-assisted thermal coating requires continued development to improve its microstructure.

The reviewer observed that Task 3A2 looks promising because cold spray is a low-cost deposition process. The team should consider adding an impact aid to the feed powder that helps adhesion to the surface but does not become part of the coating. This approach may allow improvements in surface finish.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer remarked that the collaboration within the project team is strong because ORNL and PNNL played leading roles in the research and development activities. Industry partners provided

valuable support by supplying materials and offering technical assistance with processing equipment. This industry involvement is crucial for ensuring the practical applicability of the developed processes and aligning them with real-world needs. Contributions by ANL have been valuable, particularly in providing advanced characterization capabilities. Leveraging expertise at ANL in advanced characterization has the potential to maximize this collaboration, especially in residual stress characterization of cold-spray surfaces as well as phase characterization of plasma coating and would provide deeper insights into the effects of surface treatments and help optimize the processes further.

In summary, the current collaboration is highly effective, and with increased involvement from ANL and potentially other external entities, the project could achieve even greater success. This enhanced collaboration would lead to a more comprehensive understanding of the materials and processes, ultimately driving the project towards its ambitious goals.

Reviewer 2

The reviewer affirmed that this project has demonstrated solid collaboration among the team members. The team members meet regularly, use the same materials, and are focused on solving the same issues, albeit using different approaches. One differentiator from other programs in this area is that the external collaborators participate beyond just supplying materials or ideas. They are depositing coatings and broadening the approaches being evaluated as potential commercial solutions. This effort epitomizes the meaning of a team, and the results demonstrate significant accomplishments in the art of coating Mg materials.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer stated that the project ended in FY 2023.

Reviewer 2

The reviewer commented that the program has concluded and no proposed or suggested future work was indicated.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer acknowledged that the project supports the overall VTO Materials subprogram objectives.

Reviewer 2

The reviewer observed that this project is directed at improving corrosion resistance in Mg components for lightweight vehicles. The project is absolutely on target to support VTO Materials subprogram objectives and processing science. For Mg components to gain more traction for use in vehicles, the project focused on improving galvanic corrosion between dissimilar materials which is a key challenge to the deployment of Mg components in vehicles across the United States. The project targeted the key technical challenges and addressed them with focused research targeting novel coating methods to improve corrosion and wear resistance.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer stated that the resources are sufficient to achieve project goals.

Reviewer 2

The reviewer concluded that the resources were adequate to conduct the research described.

Presentation Number: MAT251
Presentation Title: Lightweight Metals Core Program P3B - Thermomechanical Property Modification of Mg Castings
Principal Investigator: Mageshwari Komarasamy, Pacific Northwest National Laboratory

Presenter

Mageshwari Komarasamy, Pacific Northwest National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

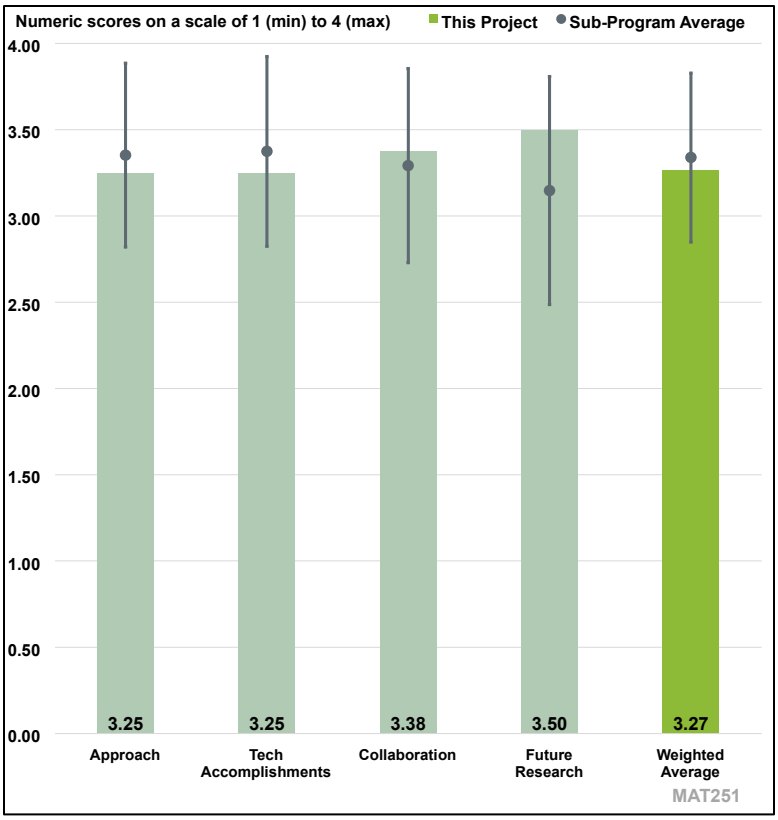

Figure 5-39. Presentation Number: MAT251 Presentation Title: Lightweight Metals Core Program P3B - Thermomechanical Property Modification of Mg Castings Principal Investigator: Mageshwari Komarasamy, Pacific Northwest National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer observed that the primary technical barrier for this project is to demonstrate new cast alloys with strength and ductility necessary to meet the increased demands for specific safety-related components envisioned for future vehicle applications that are currently unavailable. The approach is to evaluate the modifications of AZ91D Mg and AM60B cast alloy properties using local friction processing of high-strength, non-rare earth, cast Mg alloys to increase strength locally via friction stir deposition and friction stir plug processing. This would include processing of curved high-pressure die-cast Mg plates and deposition of high-strength AM experimental alloy on a low-strength AM60B substrate by varying rotation speeds, traverse rates, and changes in the applied force to obtain quality deposits. The approach of using FSP for deposition of dissimilar alloys is considered novel but, if successful, this is an excellent and well-designed approach to meet the project objective within the specified period.

Reviewer 2

The reviewer verified this project was well design to explore friction stir deposition Mg.

Reviewer 3

The reviewer clarified that the barriers for this project are porosity, low strength ductility, and fatigue life limits in HPDC Mg components. The three tasks set out to address the barriers in differing ways. Task 1 evaluated property modification in two alloys, Task 2 addressed increasing the strength in non-rare earth cast Mg, and Task 3 evaluated curved surfaces. Tasks 1 and 2 specifically addressed many of the barriers described and delivered valuable and tangible results that demonstrated that the use of flame spray pyrolysis could deliver an increase in strength, reduce porosity, refine the grain structure, and increase fatigue resistance. The tasks were well-designed and executed. Hopefully, this project may be continued or some part of it picked up by industry for continuation.

Reviewer 4

The reviewer stated that, considering the barriers, the project was well designed and some of the technical barriers were addressed. The practicality of the friction stir approach deserves some scrutiny, due to the necessary rates of production for high-volume automotive manufacturing. The described approaches appear to be much more suitable for lower volume, higher cost margin industries, rather than automotive. It is certainly possible to reduce defects with solid state deformation into the volume of a thin wall casting, but the practicality of friction stirring multiple sites, or even full surface regions, on millions of complex castings seems very unlikely. Surface finishing was also not convincing. The project seemed more focused on using the existing tools rather than the practical manufacturing and materials needs of the automotive sector. But the laboratory scale project was very well planned and executed.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer remarked the FSP samples were reported to exhibit significant improvement in fatigue life over as-cast by more than two orders of magnitude. Methods such as overlapping double passes and varying tool design reduced the porosity fraction to <1%–3% that of AM60B Mg cast alloy by greater than two orders of magnitude. Samples that had <0.01% porosity in the gage section were reported to exhibit fatigue run off. After FSP, the porosity was reduced from ~2% in the base material to ~0.04% and ~0.1% in the 45^{o} and 65^{o} curved surfaces, respectively. The deposition of a stronger material onto a weaker substrate was successfully demonstrated and the deposit thickness was uniform at lower rotation rates compared to higher rotation rate. There was no measurable variation in quality or densification from top to bottom of the deposited material and no major difference in microstructure across the width and height of the deposited material. Microscale particles with an average diameter of 1.20 µm and few particles above 3 µm were identified and an increase in particle size was observed with increase in tool rotation rate which may contribute to the strength of the deposited material being 2.6 times that of AM60B in the as-cast and friction stir processed conditions. These are considered outstanding technical accomplishments for improving the properties of cast Mg alloys.

Reviewer 2

The reviewer commented this project demonstrated the laboratory scale feasibility of the concept and highlighted some the property advantage for friction processed Mg over that of cast Mg.

Reviewer 3

The reviewer expressed that this project demonstrated noteworthy progress on Task 2, friction surface layer deposition. By controlling the FSP rate, the researcher was able to refine the

microstructure and substantially reduce porosity while refining the grain structure, which led to increased fatigue resistance. The reviewer praised the researcher for this significant achievement. The project team also demonstrated the ability to deposit stronger alloys onto a weaker substrate alloy, producing a layered composite, increasing its overall strength. This project team delivered significant valuable research advancing Mg processing science.

Reviewer 4

The reviewer affirmed that the project team described the technical progress adequately. Defects were mitigated by friction stirring to reduce porosity and improve mechanical properties. Deposition of a stronger material was a bit less convincing. Processing of curved plates was a helpful demonstration, but deformation of the part due to the necessary pressure of the friction stir tool was a concern and the proposed mitigation was machining which added a second manufacturing step to the additional friction stir step.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer stated that the collaboration consisted of three national laboratories (PNNL, ORNL, and ANL), a materials supplier (Meridian) and an industrial Canadian metals and materials research center (CANMET Materials). There was no involvement by academia, but the level of research did not necessarily require academic involvement since an industrial research center was one of the partners. The research team appeared to be well coordinated and involved in the research to make significant contributions to the project objective.

Reviewer 2

The reviewer remarked that national laboratory and industry collaboration appears to have been effective.

Reviewer 3

The reviewer commented that the tasks and team appeared cohesive, and the work appeared well coordinated. The reviewer questioned whether a linkage to an automotive OEM is missing. Their presence would indicate that there is interest in expanding the use of Mg in vehicle technology.

Reviewer 4

The reviewer affirmed that several internal and external collaborations were described, including Meridian (supplier), CANMET Materials, and two other national laboratories.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer verified that this project ended in FY 2023 and no future research was proposed by the presenter.

Reviewer 2

The reviewer questioned what future research would be possible on this topic based on the presentation content.

Reviewer 3

The reviewer stated there is no proposed future research as this project has ended.

Reviewer 4

The reviewer stated that the response to the proposed future research is not applicable.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer remarked this project is directly relevant to the VTO Materials subprogram goal of producing higher performance Mg alloys with properties meeting or exceeding strength and ductility requirements of lightweight alloys for use in lightweighting vehicles.

Reviewer 2

The reviewer commented this is relevant research for exploration into automotive materials and manufacturing.

Reviewer 3

The reviewer expressed that this project is directed at improving Mg components for lightweighting vehicles. It is absolutely on target to support VTO Materials subprogram objectives and processing science. For Mg components to gain more use in vehicles, stiffness (ductility) and fatigue resistance need to be improved. The project targeted the key technical challenges and addressed them with focused research targeting novel processing methods to drive the improvements. The use of FSP is a unique approach to improving the microstructure and properties of Mg casting and has clearly shown promise in reducing porosity and increasing fatigue resistance. The use of FSP for surface layer deposition is also novel and shows potential for a viable novel approach to improving materials properties locally as needed by design specifications.

Reviewer 4

The reviewer affirmed that the project has some relevance, but primarily for low-volume, higher cost margin automotive applications for lightweight castings.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer articulated that the funding of $300,000 over three years is considered sufficient to support the level of research required for this project although there were three national laboratories, and two industries involved in a collaborative effort.

Reviewer 2

The reviewer observed the resources applied were appropriate for the targeted objectives.

Reviewer 3

The reviewer verified this project is 100% complete. The researcher and project team accomplished a significant amount of work and delivered valuable science with the available funds.

Reviewer 4

The reviewer stated the resources were sufficient.

Presentation Number: MAT252
Presentation Title: Lightweight Metals Core Program - Thrust 4 - Materials Lifecycle
Principal Investigator: Jeff Spangenberger, Argonne National Laboratory

Presenter

Jeff Spangenberger, Argonne National Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

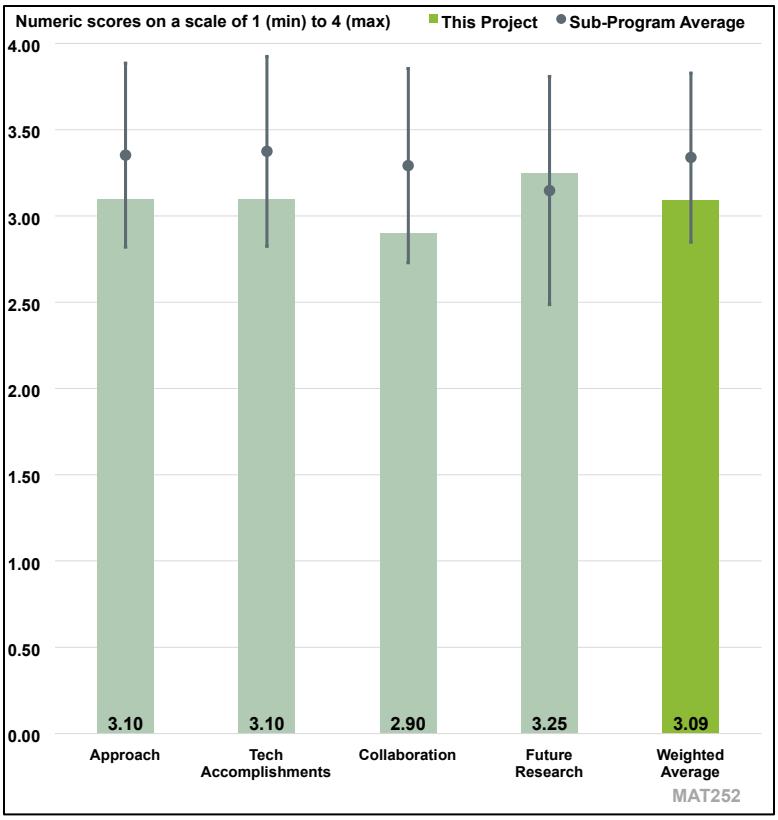

Figure 5-40. Presentation Number: MAT252 Presentation Title: Lightweight Metals Core Program - Thrust 4 - Materials Lifecycle Principal Investigator: Jeff Spangenberger, Argonne National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer remarked that the team has made satisfactory progress in materials LCA and has developed several tools for such analysis that is important for industry and other stakeholders.

Reviewer 2

The reviewer noted that the PI addressed the technical barrier most sufficiently in evaluating the complex technical challenges associated with Al recycling .

Reviewer 3

The reviewer found difficulty in fully evaluating the approach without more detail on the model developed and the assumptions and data that were input to the model. The project, as designed, provided insights into the life cycle benefits, and identified opportunities for improving and expanding recycling of Al. Additional research on scrap metal properties and processing by industry, as well as the impacts of Al and Mg aging on recyclability, is needed to inform further development of the model.

Reviewer 4
The reviewer observed that this project has performed well and is timely in exploring the major challenges in recycling of lightweight materials by tying together cost and impact of material sustainability for material selection.

Reviewer 5
The reviewer criticized that this project seems to offer little that is novel or relevant, although it showed more results this year than in previous years. The presentation did not address the stated objective of “identifying opportunities to improve wrought-to-wrought Al recycling” nor were practical insights on how to reduce costs provided.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1
The reviewer stated that this project analyzed the lifecycle of GHG emissions reduction through two LMCP technologies: (a) local thermomechanical processing and (2) HPDC. Good actionable conclusions were made for both technologies in terms of improving their GHG footprint.

Reviewer 2
The reviewer commented that the PI has delivered milestones 1 through 4 successfully and is progressing to deliver Milestone 5.

Reviewer 3
The reviewer observed that the project has completed all milestones except releasing the Ever LightMat model. The presenter stated that although the original plan was to release the standalone model, the plan has been changed to release the model after an interactive framework between the Ever LightMat model and the Greenhouse gases, Regulated Emissions, and Energy use in Technologies (GREET) is established which seems reasonable.

Reviewer 4
The reviewer stated that this project made very good progress regarding the level of deliverables.

Reviewer 5
The reviewer pointed out that the Ever LightMAT model is the first clear output that this project has provided over the three-year period of performance. However, the approach used, and the value of results were not clearly described. As one example, one conclusion wat that using local thermomechanical processing on vehicle closure panels can lead to a net life cycle reduction of 13kg of carbon dioxide per vehicle. Yet, nothing in the inputs to the model described on Slide 5 relate to processing except cycle time. Thus, the reviewer is unclear on how these conclusions about a specific process were reached. Based on the little information that was provided in the presentation, one would suspect that any process that enabled recycling would deliver a very similar result.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1
The reviewer pointed out that this project is led by ANL who reported collaborations with ORNL and PNNL and that there was an excellent effort by the project team to engage industry stakeholders.

Reviewer 2
The reviewer commented that the PI collaborated with various groups from different industry stakeholders and other national laboratories, however, the partners seemed to mainly serve as providers of information for this project.

Reviewer 3
The reviewer asserted that the project team has achieved strong collaboration with the other LMCP partners, but more collaboration with OEMs of automobiles and trucks will ensure that recycling considerations are fully understood. Industry stakeholders that were consulted were not specified in the presentation or in the question-and-answer period. The reviewer suggested that examples of how the TEA and the LCA are guiding LMCP research efforts would be good to see in future presentations, i.e., how the LMCP research is reducing the number of alloys in the recycling mix.

Reviewer 4
The reviewer stated that a strong national laboratory collaboration effort was evident.

Reviewer 5
The reviewer was unclear about what process information was collected from a small sample of the program tasks offered as an outcome for the program, or even what process information was collected. Slide 10 claims to collect process information from the entire LMCP team but it was never made clear what outcome or value was produced by such collaborations. For example, the Ever LightMAT model framework for “Component Manufacturing” described on Slide 5 does not have any processing input, other than cycle time. This seems extremely odd for a model that was designed to support a program based around multiple processing approaches to enable lightweight and recycled materials.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1
The reviewer stated that the project has ended.

Reviewer 2
The reviewer commented that the proposed future research is clearly defined, and the project is highly likely to achieve the goals presented.

Reviewer 3
The reviewer pointed out that the end date is shown as December 2023, but the presenter indicated that establishment of an interactive framework between Ever LightMat and GREET is underway or will soon be underway. The reviewer was unclear about whether the remaining work is being conducted as part of this project or a follow-on project. The proposed future research will add significant value in guiding the research of the LMCP. In addition to continuing conversations with industry, new conversations with additional industry stakeholders (especially domestic and international OEMs for automobiles and trucks) should be initiated.

Reviewer 4
The reviewer encouraged continuing development of the framework linking the Ever LightMat model and the GREET model.

Reviewer 5
The reviewer remarked that the value of the approach adopted by this former project was never clear as noted in the comments by this reviewer in Question 3 above which give some examples of a few obvious gaps.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1
The reviewer stated that this project supports the lightweighting mission of the LMCP 1.0 phase.

Reviewer 2
The reviewer affirmed that this project supports the VTO Materials subprogram objectives.

Reviewer 3
The reviewer observed that the TEA and the LCA of the lightweighting materials and recycling needs provide insights that can help guide material R&D projects to achieve cost and performance goals while considering the end-of-life requirements for automotive materials, components, and products. Understanding the barriers to recycling is critical to developing sustainable materials and products.

Reviewer 4
The reviewer noted that this project is directly applicable to materials.

Reviewer 5
The reviewer found that this project is relevant, but the approach did not deliver outcomes that were clearly relevant to the overall program goals of local processing.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1
The reviewer stated that the project resources are sufficient.

Reviewer 2
The reviewer contended that the resources for this project seem to be sufficient for the project to achieve the stated milestones since the project mainly expands from Al to a wider range of lightweight materials and from light-duty to medium-duty and heavy-duty vehicles.

Reviewer 3
The reviewer observed that the project received $150,000 in FY 2021 through FY 2023, and $25,000 in FY 2024 which seems appropriate for the research that was conducted. The reviewer was unclear if the proposed future work will be completed under a separate project or if FY 2024 funding has been added to the project to pursue the proposed future work.

Reviewer 4
The reviewer commented that the resources applied were sufficient for the target objectives.

Reviewer 5
The reviewer concluded that the resources were more than adequate for what was produced.

Presentation Number: MAT254
Presentation Title: Conductive Lightweight Hybrid Polymer Composites from Recycled Carbon Fibers
Principal Investigator: Yinghua Jin, Rocky Tech Ltd.

Presenter

Yinghua Jin, Rocky Tech Ltd.

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

0% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 0% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

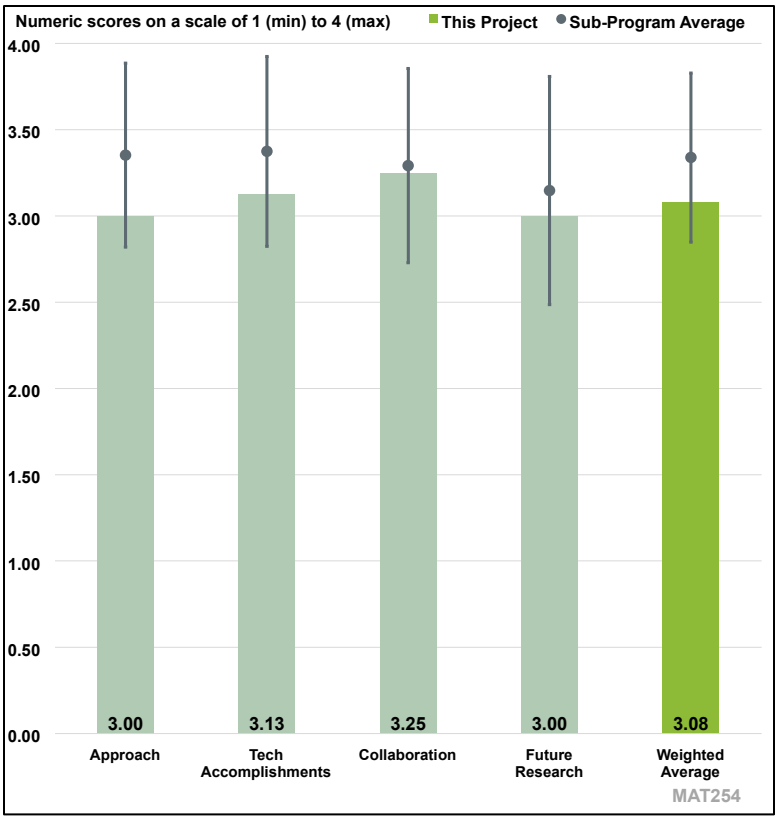

Figure 5-41. Presentation Number: MAT254 Presentation Title: Conductive Lightweight Hybrid Polymer Composites from Recycled Carbon Fibers Principal Investigator: Yinghua Jin, Rocky Tech Ltd.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer commented that the project results appear satisfactory.

Reviewer 2

The reviewer commented that the effects of fabrication conditions, fiber types, and variance in vitrimer on mechanical properties of the composites have been addressed. The reviewer also remarked that the project is designed well, and the timeline is reasonably planned.

Reviewer 3

The reviewer praised the collaboration in this project highlighting the partnership with an excellent chemistry department for vitrimer formulation. The reviewer commented on the use of computational techniques and structural variation to search for ideal structural intermediates.

Reviewer 4

The reviewer noted that the research approach involved synthesis of non-isocyanate-based polyurethanes with adaptable covalent networks (vitrimer) that are filled with milled recycled carbon fibers (rCF). Milling of rCF enhances electrical conductivity by increasing percolation potential. However, the milling step adds cost.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer noted the project progress is as described.

Reviewer 2

The reviewer questioned the optimal ratio of nano-fillers to micro-fillers and inquired whether using only micro-fillers, is better than using hybrid fillers. The reviewer remarked that the contribution of nano-fillers needs to be more clearly addressed.

Reviewer 3

The reviewer commented that the chemical formulation work can be time consuming but noted the company has identified some clear opportunities in this space.

Reviewer 4

The reviewer acknowledged that the vitrimer composition with enhanced ductility was synthesized but questioned why milling of rCF is desired for the composite application if the impregnation of CF fabric will be targeted. The reviewer also noted that the milled fibers must have compatible functionality for bonding with the matrix and sought clarification on sure how those functionalities are created. The reviewer added that project will end in August 2024.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer noted the team’s collaboration with the appropriate university laboratory.

Reviewer 2

The reviewer commented that the roles of the company and the university are clearly presented noting the university’s contributions included surface modifications of fillers, mechanical, and thermal characterizations. The reviewer affirmed that no national laboratory participated in the project based on the presentation.

Reviewer 3

The reviewer affirmed that the primary project partners are the company and University of Colorado at Boulder which is assisting with formulation and characterization.

Reviewer 4

The reviewer praised the excellent teamwork and collaboration between RockyTech and the Chemistry and Mechanical Engineering Departments at University of Colorado at Boulder.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

Slide 12: The reviewer commented that the presenter highlighted three research approaches in the slides but questioned which approach was better in terms of consistency. On Slide 16 regarding reproducibility, the reviewer commented that the open circuit voltage appears high and questioned how it could be reduced.

Reviewer 2
The reviewer questioned whether the coating of rCF-reinforced vitrimer is applied to the fabric or the composite lamina. The reviewer also noted that a comparison of the mechanical properties between the two cases should be addressed.

Reviewer 3
The reviewer commented that the scale up process for vitrimers, their rCF composite manufacturing, and consistent demonstration of their properties are shown as potential future work. However, the reviewer noted the project is ending this year.

Reviewer 4
The reviewer believed that this question was not applicable.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1
The reviewer commented “none” as a response to the relevance of the project supporting the overall VTO subprogram objectives.

Reviewer 2
The reviewer commented that the research supports the repurposing and reusing of the materials to re-manufacture the composites with enhanced properties.

Reviewer 3
The reviewer commented that the new recyclable formulations presented are composites of the future, highlighting this is a key area of research for matrix formulation.

Reviewer 4
The reviewer commented that the project supports the VTO Materials subprogram objectives.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1
The reviewer stated that the project resources are sufficient.

Reviewer 2
The reviewer commented that based on the presentation, the project resources are sufficient. There are sufficient tools to prepare the hybrid fillers, vitrimer and composite fabrications, and characterizations.

Reviewer 3
The reviewer commented that the project resources seem appropriate and are correctly allocated between the recipient and sub-awardees.

Reviewer 4
The reviewer noted that the resources were adequate for this project.

Presentation Number: MAT257
Presentation Title: Changing the Design Rules of Rubber to Create Lighter Weight More Fuel-Efficient Tires
Principal Investigator: Kurt Swogger, Molecular Rebar Design, LLC.

Presenter

Kurt Swogger, Molecular Rebars LLC

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

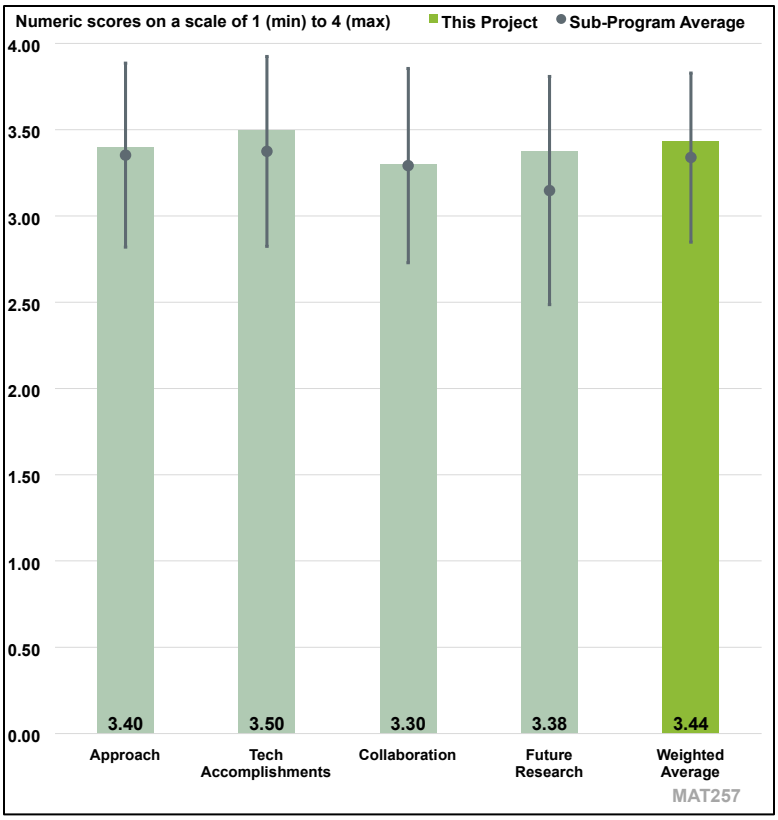

Figure 5-42. Presentation Number: MAT257 Presentation Title: Changing the Design Rules of Rubber to Create Lighter Weight More Fuel-Efficient Tires Principal Investigator: Kurt Swogger, Molecular Rebar Design, LLC

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer commented that the research approach addresses the stated technical barriers.

Reviewer 2

The reviewer exclaimed the design of the project and timeline were “Great!”

Reviewer 3

The reviewer observed that the approach to modifying rubber using the Molecular Rebar Design, LLC (MRD) CNT materials coupled with silane is described; however, the approach to optimizing is not described. Criteria and methods for determining success in the screening and iteration is not described and the reviewer is not clear about what “success” looks like. The approach includes producing “enough” high-quality silane-molecular rebar to supply Goodyear to build prototype tires. Again, no benchmarks are identified, and no specific quantity of material (or number of tires) is prescribed. The overall project would be strengthened by identifying critical parameters being optimized and specifying the amount of material to be supplied.

Reviewer 4
The reviewer commented that this project was very hard to evaluate because specific details and technical content were limited in both presentation and documentation. Overall, the project appears to have generated interesting results, indicating a relevant project approach.

Reviewer 5
The reviewer commented that the work seems impactful, and the properties of the tires clearly seem to be a leap forward from existing technology while maintaining a cost advantage.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1
The reviewer commented that the project accomplishments appear to meet all objectives.

Reviewer 2
The reviewer exclaimed that the technical progress was " Good!"

Reviewer 3
The reviewer commented that the technical accomplishments of the project are well described which includes methods to determine the "optimal" blend of silane-molecular rebar to silica loadings based upon matching hardness and matching modulus of incumbent silica loaded tires. The reviewer praised the further optimization described for tread improvement noting significant improvements in abrasion, rolling resistance, and tread weight while maintaining wet grip of the tire.

The reviewer noted that the technical approach toward scaling primary batch material appears to be complete setting the stage for commercial scaling, which is critical for transitioning the technology to production. And while current manufacturing rates are modest, this approach appears to be a major step toward commercialization. The reviewer concluded that the (9.5kg/day) rate will support the project goal of building 30 "good" test tires.

Reviewer 4
The reviewer commented that, based on the limited information provided, the project has demonstrated relevant progress.

Reviewer 5
The reviewer commented that scale up potential with rubber and tire partners is evident. While the intellectual property may be hard to defend over the long term, the project is an excellent achievement with clearly benchmarked results.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1
The reviewer noted that the research team partnered with industry collaborators who actively contributed to the effort.

Reviewer 2
The reviewer commented that the team has collaborated with one of the largest producers of commercial automotive tires in the world which is critical for transitioning the improvement to tires for EVs. The reviewer praised the team and its collaborative partners highlighting a commitment by Goodyear to use the MRD material to mold up to 50 tires to support his effort. The reviewer was not

entirely clear about the role of other identified collaborators, specifically Arlanxeo. The organization's role in the approach or technical accomplishments is not described. The reviewer assumed that their role will be more important for potential Phase III (i.e., commercialization) efforts to expand the implementation of silane-molecular rebar in tire manufacturing.

Reviewer 3

The reviewer commented that team claimed a healthy collaboration with Good Year but needs further clarification on the impact of this collaboration.

Reviewer 4

The reviewer acknowledged the coordination between the research team and tire manufacturer; however, the reviewer noted no additional collaborators were mentioned.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer commented that future work will address remaining challenges to development and demonstration of the technology.

Reviewer 2

The reviewer said in progress.

Reviewer 3

The reviewer commented that MRD has demonstrated a useful method of improving tires to address the challenges of accelerated wear and generation of micro-particles from EVs. Their proposed future research lacks details but expresses the clear need to continue to improve and optimize the formulation of tire rubber including exploring a variety of coupling agents and specific chemical species, both of which are helpful.

The reviewer suggests that scaling the technology to demonstrate the economic impact on tire manufacturing would be an important and necessary path forward while noting that MRD provides limited details regarding the methods and approach for scaling aside from suggesting collaboration with pilot production units operated by other synthetic polymer manufacturers.

The reviewer further remarked that this work will be most likely receive private funding, so the proposed plans are perfectly acceptable to remain private and out of public view.

Reviewer 4

The reviewer commented that the team indicates additional testing and scale-up, both of which seem important and necessary.

Reviewer 5

The reviewer commented that the project has ended and is poised for impactful new products.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer noted that the project addressed the VTO Materials subprogram objectives.

Reviewer 2

The reviewer had no comments.

Reviewer 3
The reviewer stated that the work presented is clearly relevant to the VTO goals to expand opportunities for electrification of transportation markets, as well as improving energy efficiency. Insight to the impact of CNTs on material properties of rubber and synthetic rubber materials is relevant to the VTO Materials subprogram objectives. The reviewer noted the work is interesting and useful for commercialization.

Reviewer 4
The reviewer commented that the project has relevance within the DOE program if it can prove the scaled-up advances proposed.

Reviewer 5
The reviewer commented that the project shows a clear benefit to downstream value cycles for tires and noted this is a larger issue for EVs than for traditional vehicles.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1
The reviewer commented that the project resources are adequate for the work.

Reviewer 2
The reviewer had no comments.

Reviewer 3
The reviewer commented that although work conducted under the SBIR program is clearly constrained in terms of funding levels, MRD has demonstrated that Phase II funding is sufficient to show a meaningful impact on EV tires. The reviewer commended MRD's use of SBIR Phase II funding to address and achieve the goals outlined at the start of this project for improving abrasion resistance of the tire rubber while deriving added benefits of lower rolling resistance and tire weight. The added mass and increased torque delivered directly to the tires would clearly lead one to expect accelerated tire wear. The reviewer concluded that the project results should position MRD for successful Phase III commercialization efforts.

Reviewer 4
The reviewer commented that the project cannot be evaluated for resources due to the limited information provided.

Reviewer 5
The reviewer commented that the project appears to be on time and within budget, noting the budget has been well utilized for an industrial entity.

Presentation Number: MAT265
Presentation Title: Low-Cost Multifunctional Composites from Recycled Materials for Lighter and Smarter Vehicles
Principal Investigator: Xiaodong Li, University of Virginia

Presenter

Xiaodong Li, University of Virginia

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 80% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 20% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

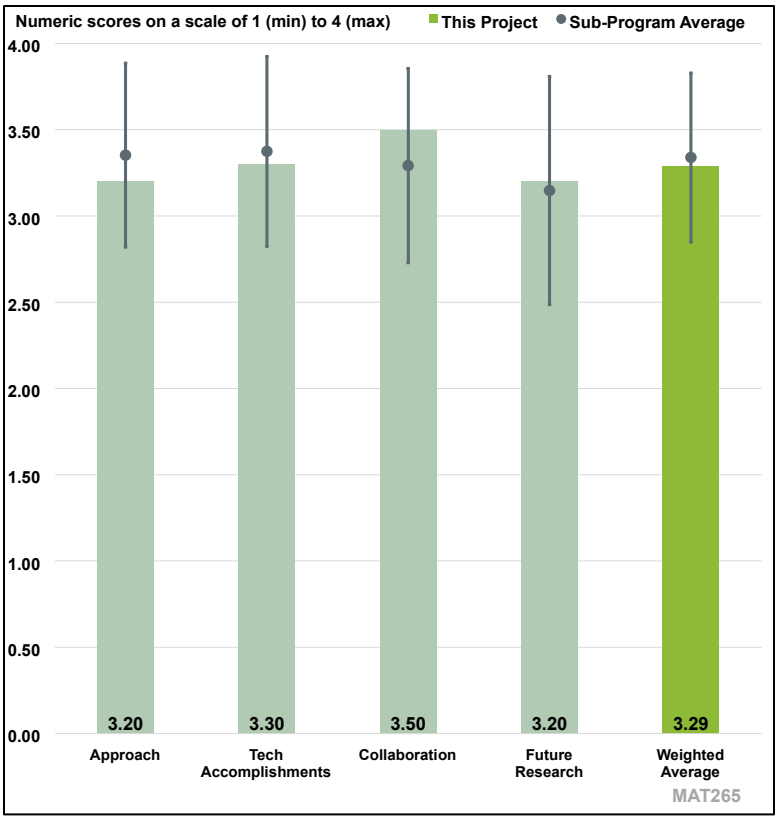

Figure 5-43. Presentation Number: MAT265 Presentation Title: Low-Cost Multifunctional Composites from Recycled Materials for Lighter and Smarter Vehicles Principal Investigator: Xiaodong Li, University of Virginia

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer commented that the technical barriers addressed, the project design, and the timeline were “Okay” as a response.

Reviewer 2

The reviewer commented that the approach to performing the work appears to be fine, but the value of the targeted outcomes is not clear. No background was provided on the demonstration article or how the technology supports the DOE mission since the baseline junction box appears to not have been optimized for weight or performance. Therefore, the reviewer is not clear about how the comparative results will show significant technological advances or overcome significant barriers.

The reviewer further remarks that the plans and practicality of the SHM approach towards implementation should be described and presented much more convincingly beyond stating that more cameras and digital image correlation techniques will ultimately be employed to resolve the health of the structure.

Reviewer 3
The reviewer commented that the general approach of this project, led by the University of Virginia, is good. Due to significant industry involvement, the team can achieve scalable technologies quickly. Focusing on recovering graphene from graphite anodes is important because battery recycling and obtaining graphene are important, rather than reusing it as graphite, and provides an interesting avenue. Also, utilizing recycled CFs from Sonoco Recycling is a good approach, however, the reviewer was not clear about what kind of recycled CF are being used, their properties (strength, length etc.), and what loadings are being targeted.

The reviewer further commented that focusing on EMI shielding and the use of recovered graphene are very good. As questioned during the AMR, the target mechanical properties seem too low and may not satisfy most of the applications for the vehicle parts. The reviewer suggests that the team revisit and clearly define the targeted mechanical properties for each of their targeted parts and seek industry input to define baseline targets. The reviewer concluded that the strategy to try various resins was not clear and it would be beneficial to define which parts of the vehicle they are targeting and why they are looking into certain resins.

Reviewer 4
The reviewer acknowledged that this work targets utilizing recycled materials to produce lightweight composites for EV applications. The technical barriers are well identified, and the tasks are well designed to address those barriers. The reviewer further remarked that the teaming arrangement is well structured for the proposed work and the timeline also appears reasonable.

Reviewer 5
The reviewer stated that the research approach involves manufacturing multifunctional materials from both thermoset and thermoplastic matrices reinforced with recycled CFs and reclaimed graphene from waste lithium-ion batteries. The reviewer further remarked that the scope of the work is too broad and expressed uncertainty about how graphene will be isolated from lithium-ion batteries and made solvent free after separation of lithium ions. The reviewer concluded that, nonetheless, this is a new project with much more to learn.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1
Regarding Slide 11, the reviewer commented that recycled PP shows the highest tensile strength, while the modulus shows a different value influenced by the rCF (e.g., an increase in rCF results in an increase in modulus), which needs clarification. The reviewer further remarked that the purity of graphene from recycled electrodes depends on the separation process, which needs addressed.

Reviewer 2
The reviewer acknowledged that, at the time of the review submission, the project had only been executing for six months. Some of the material performance targets have been achieved, but it was not clear that they represented major advances over existing systems or how they were critical to meeting project goals. The reviewer was unclear about how success would be determined and how effort would be allocated against competing structural systems such as reinforced recycled PP (likely expected to be lower cost) and reinforced Nylon 6 which should have little trouble achieving performance targets. The reviewer stated that while EMI suppression technology is relatively well known, it is not clear that utilizing very small amounts of recycled materials will have a significant impact. The reviewer concluded that correlation of strain with resistivity changes may be useful for

real time monitoring but plans to exploit those observations and development strategies were scarce.

Reviewer 3
The reviewer commented that considering this is a new project, timely progress was made. Targets are clearly defined; however, the team should carefully tailor their directions toward satisfying the targets needed for commercial deployment .

Reviewer 4
The reviewer commented that considerable progress has been made on all relevant tasks for this project given the short performance period. The initial test results of the composites made from recycled materials indicate more room for further improvement. Impurity in recycled materials was mentioned as a key challenge, however, there seems no specific plan for addressing impurities. The reviewer further remarked that the digital image correlation work does not appear well designed and may not provide any benefits towards addressing the key challenges of the project.

Reviewer 5
The reviewer commented that although this is a new project, some of the data presented raised concerns. For example, the recycled polymer matrix reinforced with recycled CFs shows enhanced modulus (as expected) but surprisingly lower strength than neat resin even after a 7 wt.% fiber loading. The reviewer concluded that some degree of fiber matrix incompatibility exists and expressed hope that future research will address this.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1
The reviewer stated that they did not observe any effort from the collaborators.

Reviewer 2
The reviewer commented that there are several key partners, and apparently, they are working together well although interaction plans and details were relatively sparse.

Reviewer 3
The reviewer praised the project which consists of an effective team of collaborators from various institutes but highlighted that one potential challenge may be communication.

Reviewer 4
The reviewer praised the excellent teaming arrangement for the project. The team is comprised of an EV manufacturer, a composite manufacturer, a battery recycler, a plastic recycler, and research institutes. The reviewer also acknowledged the significant contributions from industry as the plastic matrix and recollected graphite materials were provided by industry.

Reviewer 5
The reviewer acknowledged that this is a new project and remarked that it is a multi-team effort with significant potential for collaborative research and opportunities to gain experience from each other.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1
The reviewer referenced prior comments.

Reviewer 2
The reviewer commented that the requirements and plans for refinement of the material and properties need more details, especially if the targeted performance has not been met. The reviewer found the future work plans for EMI and SHM to be sparse.

Reviewer 3
The reviewer remarked that the directions for future work are good; however, the future milestones are not SMART. The reviewer recommended that the team use measurable values as targets that will relate to practical requirements. Once these are defined, the project will have a clearer focus.

Reviewer 4
The reviewer commented that the proposed future research appears reasonable but added an established commercialization or marketing plan would be beneficial. The reviewer also stated that while TEA work is proposed, including a LCA would be even better. .

Reviewer 5
The reviewer commented that the challenges and barriers to be addressed were presented and suggested that the polymer-fiber interface design should be prioritized.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1
The reviewer commented, “None”, as a response to the question.

Reviewer 2
The reviewer commented that the project appears to support the general objectives of vehicle weight reduction and focuses on use of recycled materials (PP, CF, and graphite) to enhance manufacturing sustainability. The reviewer explained that the SHM to support alternative approaches for repair and replacement issues along with EMI protection to replace the natural protection from steels could be enabling for the use of composite materials. Elaborating that the introduction of those alternative materials requires novel approaches to mitigate material deficiencies compared to traditional metallic structures.

Reviewer 3
The reviewer commented that the concept of this project is highly relevant to the future direction of lightweight materials with a focus on addressing circularity and sustainability. The reviewer praised the investigation into EMI shielding as being good.

Reviewer 4
The reviewer commented that this work strongly supports the lightweighting objective of the office.

Reviewer 5
The reviewer commented that the project is relevant and supports the lightweighting goals and sustainability objectives of the VTO Materials subprogram.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1
The reviewer commented that the project appears to be very well funded for the proposed achievements. The reviewer elaborated that there will always be more to be done considering the work to date demonstrated that defined key structural properties were meeting project needs and

presumably will meet weight reduction goals, which are most important to the DOE mission, which have already been achieved in less than nine months. The reviewer concluded that the evidence supporting the work plan to achieve the project goals and project resources were insufficient.

Reviewer 2
The reviewer had no comments regarding resources.

Reviewer 3
The reviewer commented that the project resources appear sufficient to achieve the stated milestones in a timely fashion.

Reviewer 4
The reviewer commented that the project resources are sufficient to execute the work. However, the reviewer noted that the team is trying to accomplish too much, and tasks need prioritized.

Presentation Number: MAT266
Presentation Title: Development and Manufacturing of Multifunctional Energy Storage Composites (MESC) for Automotive Vehicles
Principal Investigator: Amrita Kumar, Acellent Technologies Inc.

Presenter

Amrita Kumar, Acellent Technologies Inc.

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 33% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 33% of reviewers did not indicate an answer.

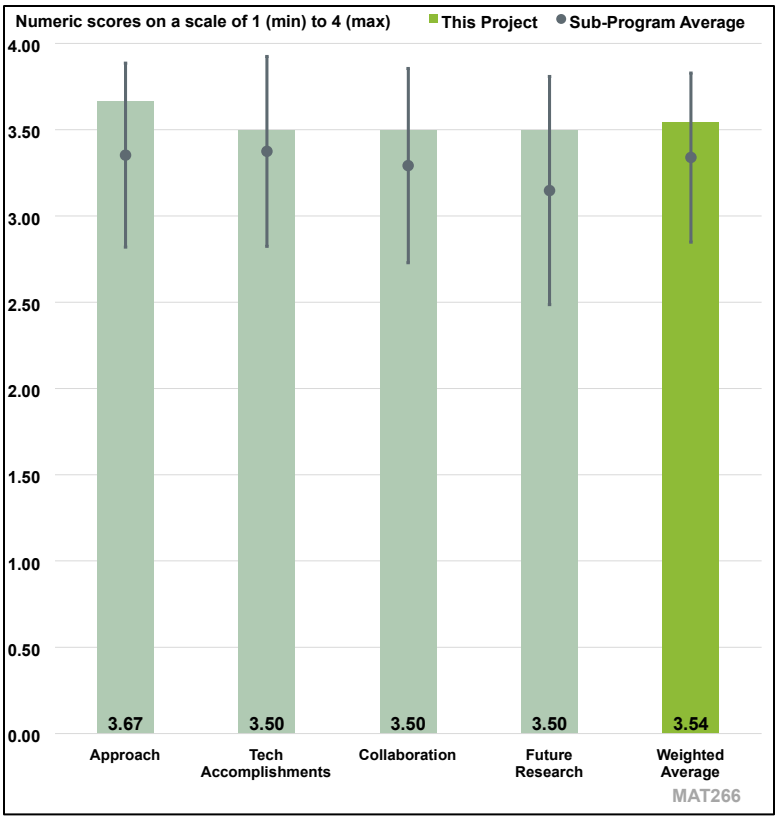

Figure 5-44. Presentation Number: MAT266 Presentation Title: Development and Manufacturing of Multifunctional Energy Storage Composites (MESC) for Automotive Vehicles Principal Investigator: Amrita Kumar, Acellent Technologies Inc.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer remarked that the project approach is expected to address technical barriers.

Reviewer 2

The reviewer commented that the project is well-designed, and the timeline is reasonably planned. The reviewer noted that both the Multifunctional Energy Storage Composites (MESC) structures and the monitoring system have been developed and the preliminary mock-ups have been demonstrated.

Reviewer 3

The reviewer stated that the project is a very important area of research for the VTO Materials subprogram and further explained that structural composites with cellular architecture are being designed for a vehicle battery pack assembly. The reviewer clarified that the composites are capable of monitoring battery health and concluded that the project plans for the budget periods have distinct approaches to materials design and manufacturing goals.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer commented that the project has shown considerable progress toward the objectives.

Reviewer 2

The reviewer commented on the interlocking rivets buy enquired about the design criteria, such as spacing and quantity, and sought clarification on whether numerical modeling or mathematical analysis was part of the design approach.

Reviewer 3

The team investigated design parameters including battery capacity (kilowatt-hours), discharge rate, charge rate, thermal characteristics and both static and dynamic loading (identify battery type and mass), and identified composite enclosure design parameters. The team also established contacts with multiple battery suppliers.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer commented that the industry collaborators were actively contributing to the work.

Reviewer 2

The reviewer commented that the role of the collaborator, TPIC, was working on structures, composites design and manufacturing, and MESC integration was clear but noted that no universities or national laboratories participated.

Reviewer 3

The reviewer remarked that Acellent and TPIC formed an excellent team and noted that the collaboration and work plans with TPIC have been established.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer commented that the proposed work is expected to contribute directly to achieving the targets.

Reviewer 2

The reviewer commented that while the project defined the future work in the early slides, future research was not clearly defined on the Proposed Future Work slide. The reviewer also noted that the Budget Periods 2 and 3 on the slide for proposed future work appear more like achievements than proposed future work.

Reviewer 3

The reviewer commented that the project identified clear tasks for each budget period. The reviewer explained that, in Budget Period 2, experiments with system components will be conducted and numerical simulations established. Commercial design tools will also be developed to guide the fabrication process for the final prototypes. The reviewer noted that sensors will be designed for incorporation into the battery enclosures and prepared for preliminary component testing. Budget

Period 3 will conduct prototype production and estimate mass production cost. The reviewer concluded that the community benefits plan had training opportunities identified.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer commented that the project is relevant to the VTO Materials subprogram objectives.

Reviewer 2

The reviewer stated that the MESC is very relevant to multi-functional composites and energy storage for automotive vehicles.

Reviewer 3

The reviewer commented that this program is very timely and well aligned with the VTO Materials subprogram objectives and added that safe battery enclosures for EVs are needed.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer commented that the resources appear adequate for the large amount of design and prototyping work required.

Reviewer 2

The reviewer remarked that the resources are sufficient for the project and there are sufficient tools to develop the MESC structures and monitoring system.

Reviewer 3

The reviewer found that the resources are appropriate for this project and added that the costs will be appropriately shared by both entities.

Presentation Number: MAT267
Presentation Title: Multiscale Bioinspired Enhancement of Natural-Fiber Composites for Green Vehicles
Principal Investigator: Lorenzo Mencattelli, Helicoid Industries Inc.

Presenter

Paul Myslinski, Helicoid Industries Inc.

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

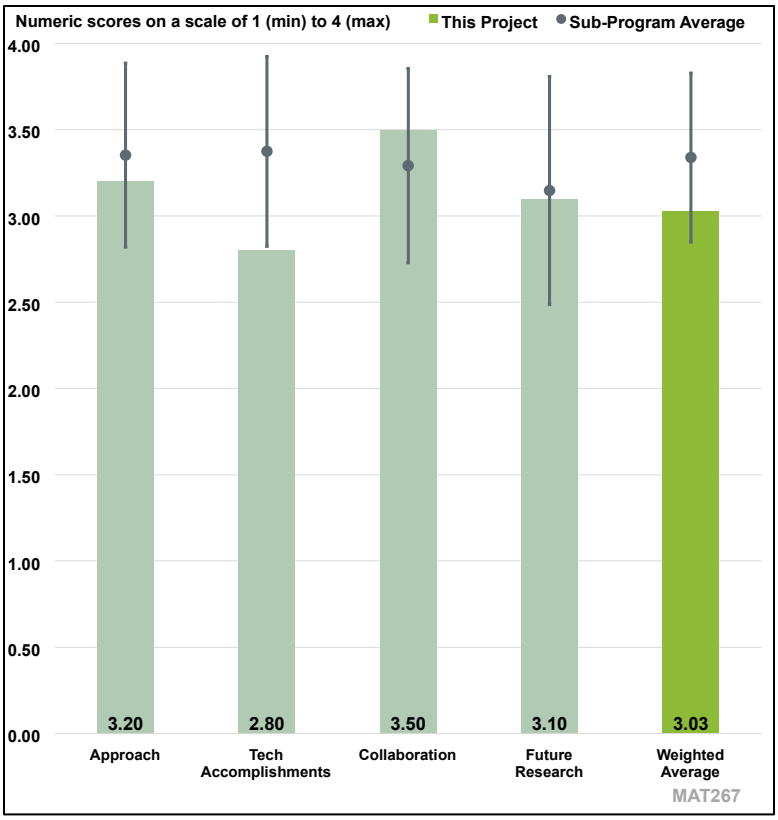

Figure 5-45. Presentation Number: MAT267 Presentation Title: Multiscale Bioinspired Enhancement of Natural-Fiber Composites for Green Vehicles Principal Investigator: Lorenzo Mencattelli, Helicoid Industries Inc.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer commented that the project approach is well designed to address the technical barriers.

Reviewer 2

The reviewer commented that additional work may be needed. For example, investigating the compatibility between the hydrophobic polymer and hydrophilic flax fiber to better address the hygroscopic performances of the natural fiber product, such as dimensional stability, water absorption.

Reviewer 3

The reviewer acknowledged that this work builds off their Phase I project where they developed “helicoid” bio based flax fiber tapes to make flax fiber and polylactic acid composites. In Phase II, the company aims to develop an optimized process for their flax fiber and other thermoset systems. The work has a clear workplan and research approach. The reviewer noted that it would be worthwhile to understand how the research progresses from the materials development phase to the final product

beyond just mechanical modeling to get the properties correct. The reviewer enquired about what additives and other materials will be added to accomplish their goals.

Reviewer 4

The reviewer remarked that this is an interesting project with a relevant approach elaborating that the team performed several materials analyses addressing some of the potential barriers. For example, as indicated in the battery use cases, the team needs to show more evidence for managing fire resistance.

Reviewer 5

The reviewer noted that the company has worked on government projects before and seems to be well organized; however, not much progress was shown to date because the project is in the early stage of the performance period.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer commented that technical progress is in the right direction because there was a considerable amount of sound experimental results from the experiments conducted, but the project is still in a very early phase.

Reviewer 2

The reviewer remarked that more effective methods should be considered for functionalization of the fiber because many other methods can be found in the literature.

Reviewer 3

The reviewer commented that the project has demonstrated reasonable progress towards the goals and has a clear project plan. Despite this, the reviewer found difficulty in determining what materials the project team is using as a baseline. The reviewer explained the project utilizes a wide degree of experimental techniques that makes their data clear to understand and concluded that the team compares materials in the project to polylactic acid materials, which have been the main thrust of their work.

Reviewer 4

The reviewer stated that the team presented several results, but the results showed limited impact on the developmental approach.

Reviewer 5

The reviewer commented that the mechanical properties were not on target, but the project team outlined a likely approach to address the technical issues in subsequent work.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer noted the involvement of a strong partner in the collaboration.

Reviewer 2

The reviewer stated that further engagement with the collaborator at Michigan State University is needed.

Reviewer 3
The reviewer acknowledged the project partners at Michigan State University and TPIC as well as their fabric supplies. The reviewer noted the team has identified problems with the fabrics and have iterated properties to make them better.

Reviewer 4
The reviewer commented that the team seems to have good relationships with companies who provide relevant material systems and collaborates well with the Michigan State University research units

Reviewer 5
The reviewer commented that the collaboration team is small and well-integrated. The reviewer also remarked that the funding distribution appears reasonable and well structured.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1
The reviewer commented that the planned work is consistent with objectives.

Reviewer 2
The reviewer referenced prior comments.

Reviewer 3
The reviewer noted that the project team mentioned early on that they experienced delays in some of their commercialization milestones and “go-to-market” discussions. The team is aiming to make three full-scale materials for battery enclosures; however, the reviewer is not clear whether their materials have the properties to perform in an enclosure or not.

Reviewer 4
The reviewer commented that the team indicated a shift towards increased activity with thermoset materials instead of thermoplastics, which can limit the risk of thermal degradation due to lower processing temperatures. This shift could provide greater potential for elaboration on the fiber-matrix interaction.

Reviewer 5
The reviewer commented that the future research objectives were mostly centered around solving the challenges with the fiber mats in terms of controlling the structure to achieve the mechanical property targets.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1
The reviewer commented that the project supports the VTO Materials subprogram objectives.

Reviewer 2
The reviewer commented, “None,” as a response to the question.

Reviewer 3
The reviewer commented that this work attempts to find an alternative fiber for composites which is always an admirable and worthwhile activity.

Reviewer 4

The reviewer stated that this is an interesting project and well-suited for VTO funding; however, the project must show an impact with relevant use cases.

Reviewer 5

The reviewer commented that this project addresses the core needs of composite materials for glider components.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer observed that the project resources are sufficient.

Reviewer 2

The reviewer commented, “None,” as a response to the question.

Reviewer 3

The reviewer affirmed that there are no reasons to believe the project funding is excessive or insufficient.

Reviewer 4

The reviewer observed that there is no indication that resources limit the project.

Reviewer 5

The reviewer stated that the project resources are proportional to the deliverables.

Presentation Number: MAT268
Presentation Title: Upcycling of Polymer Composites for Vehicle Decarbonization
Principal Investigator: Roger Crane, Composites Automation LLC

Presenter

Roger Crane, Composites Automation LLC

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 80% of reviewers felt that the resources were sufficient, 20% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

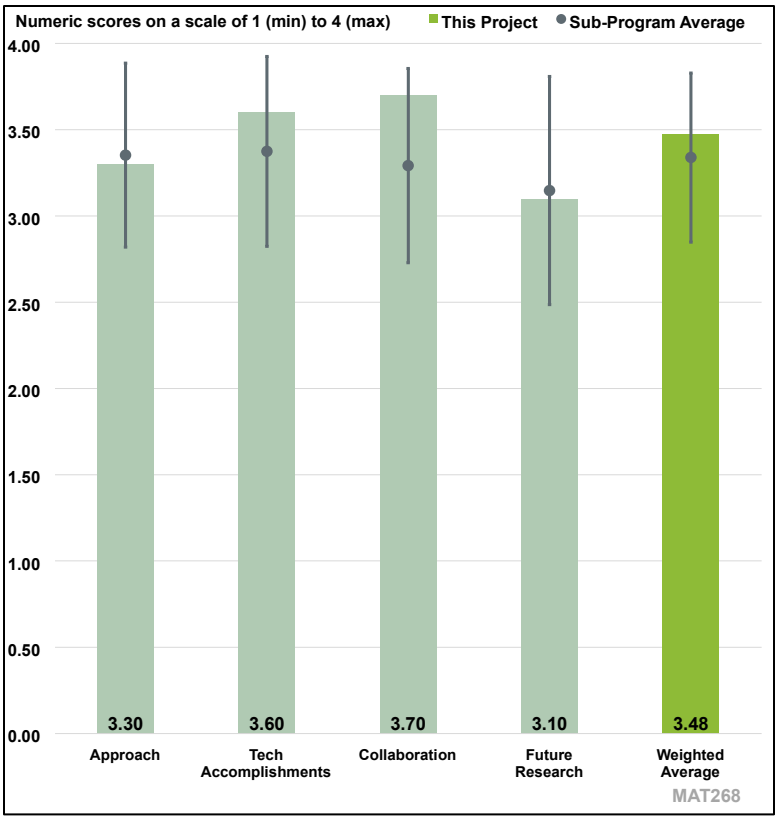

Figure 5-46. Presentation Number: MAT268 Presentation Title: Upcycling of Polymer Composites for Vehicle Decarbonization Principal Investigator: Roger Crane, Composites Automation LLC

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer remarked that since they have Tailorable universal Feedstock for Forming (TuFF) technology, the major objective was to apply this technology to rCFs. The team has focused on commercial sources of rCFs, which is good; however, that comes with various challenges, elaborating that several sources exhibited various issues (residual resin, fiber length etc.). They seem to be pleased with some of the recent results and some identified sources and, if everything works well, this is fine. The reviewer stated implementing a quick screening process prior to the TuFF process (maybe prior to fiber alignment, just remove ill-dispersed or aggregated fibers) needs to be considered to ensure quality control is established. The reviewer concluded that fully relying on fiber quality from those commercial providers is a risk.

Reviewer 2

The reviewer commented that the project is intended to recycle CFs for automotive applications, and various efforts were performed to address technical barriers.

Reviewer 3

The reviewer stated that the project team clearly explains why their work is needed and how they aim to address the technical barriers. The approach and results are logically arranged.

Reviewer 4

The reviewer praised the team's excellent alignment of the reuse and cost reduction of CF through recycling CF in a discontinuous form making high volume processing seem highly likely.

Reviewer 5

The reviewer commented that this project aims to address the technical barriers of weight reduction using CF composite materials, sustainability, and cost reduction using rCF, as well as net shape manufacturing of composites meeting automotive rate, performance, and cost targets. The reviewer concluded that the project is well-designed, and the timeline is reasonably planned.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer noted that the team identified various issues of rCF quality, which impacts the TuFF process. They achieved a good mechanical property with more recent rCF batches which showed promising results. The process will need to be further fine-tuned, but accomplishments have been sufficiently.

Reviewer 2

The reviewer commented that the project accomplished various achievements and obtained noteworthy results. However, there are a list of tasks that need to be accomplished during the next period of the project.

Reviewer 3

The reviewer commented that the technical accomplishments are impressive and expressed interest in the TuFF process and how it could be used to identify fibers when the supplier is unsure of the fibers. The reviewer praised the team for overcoming the supply chain issue and maintaining the >90% property retention in most cases.

Reviewer 4

The reviewer commented that the project appears to be meeting all milestones.

Reviewer 5

The reviewer stated that the technical progress demonstrated a well-planned and well-executed project. The main objectives of this project are to evaluate recycled TuFF processing and resultant material mechanical properties using commercially available rCFs, demonstrate recycled TuFF forming processes meeting automotive rate requirements, and investigate transition opportunities with vehicle OEMs. The reviewer feels that the technical details in the presentation are thorough, and the project deliverables are considered successful. The reviewer also notes that this is a one-year project, and, within a few months, the team delivered on the progress as proposed, demonstrating good team management capability.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer commented that the rCF providers are the major collaborators for this project. They may have some communication difficulty, but they have been collaborating well overall. Mutual parties seem to have signed a non-disclosure agreement, and they are trying to co-develop the optimum process.

Reviewer 2
The reviewer noted that the PI is collaborating with various stakeholders from the suppliers and OEM.

Reviewer 3
The reviewer stated that the team is integrated with multiple different CF recyclers and directly using their samples which makes their collaboration excellent.

Reviewer 4
The reviewer commented that the team is highly aligned with key automotive players and their rCF supply chain.

Reviewer 5
The reviewer commented that the team includes Composites Automation LLC, Carbon Conversions, Inc., R&M International, Inc., and Carbon Fiber Recycling, Inc. The collaboration skillsets and coordination have been demonstrated by the successful project deliverables.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1
The reviewer explained that since the rCF quality significantly impacts the dispersion and TuFF process, the major focus is to validate the process by adding a cleaning pyrolysis step, then evaluating fiber dispersion using TuFF coupons. In general, the plan is good. The reviewer is uncertain whether the team is doing the cleaning step by themselves but highlighted that those steps are needed. It is also not clear whether the fiber length issue was solved. Also, there is an attempt to demonstrate processing with snap-cure, which is fine for now. The reviewer recommends that the team consider exploring the other resin system.

Reviewer 2
The reviewer commented that the project is ending very soon; however, the PI proposed future work that needs to be completed within the remaining very short time. The reviewer expressed concern regarding the PI’s ability to accomplish the proposed tasks within the performance period.

Reviewer 3
The reviewer commented that considering the presentation was short and Phase I is ending, there was minimal focus on future research. For future work, the reviewer suggested that the team improve cycle time and evaluate insertion opportunities.

Reviewer 4
The reviewer commented that the TRL of this project appears to be rapidly advancing, and the future work is well aligned to demonstrate the utility of the process. An assessment of cost (could be relative even) and environmental impact would be beneficial to confirming the value of this process for making composites. The reviewer enquired about how much rCF is available for this process and if that would be the limiting factor for using in vehicles.

Reviewer 5
The reviewer explained that the proposed future research includes selecting OEMs for the Phase II component of interest, establishing requirements including structural performance, crash and fire, integration, manufacturing processes, designing, fabricating, testing, and validating recycled TuFF properties established in Phase II, implementing the recycled TuFF supply chain with recycling

partners, and transitioning the process to Tier I or OEM partners. The presenter clearly defined the purpose for future work. With outstanding performance within a few months, the reviewer feels confident that the team will successfully conduct the proposed tasks for their future work.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer remarked that the project is highly relevant. The use of rCF of a specific fiber length to allow high-performance CFRP is a strong and unique technology, which is highly relevant for lightweight materials.

Reviewer 2

The reviewer commented that the project involves recycling of CFs which supports the VTO Materials subprogram objective.

Reviewer 3

The reviewer commented that this work is extremely relevant, especially as we consider more sustainable composites.

Reviewer 4

The reviewer stated that this process is a disruptive technology that could significantly enable the reuse of recycled fibers and inherently discontinuous fiber types.

Reviewer 5

The reviewer noted that the project directly links to the VRO Analysis, Energy Efficient Mobility Systems, and Materials subprograms and is considered to support the overall VTO objectives.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer commented that the team’s resources are sufficient.

Reviewer 2

The reviewer commented that there are sufficient resources and support for this project.

Reviewer 3

The reviewer remarked that the project has had success that is in line with the project budget.

Reviewer 4

The reviewer recommended increasing the team’s budget to incorporate the TEA/LCA of the developed process. The reviewer expressed interest in learning about the potential impact of this technology while noting that the abundance (or lack thereof) of rCF is the limiting factor. The reviewer also suggested addressing the current availability of the rCF.

Reviewer 5

The reviewer commented that the team consisting of Composites Automation LLC, Carbon Conversions, Inc., R&M International, Inc., and Carbon Fiber Recycling, Inc., provides sufficient resources for the project to achieve the stated milestones in a timely fashion.

Presentation Number: MAT269
Presentation Title: Producing Multifunctional Automotive Composites with Sustainable Plant Based Graphene
Principal Investigator: Daniel Mulqueen, Climate Robotics LLC

Presenter

Daniel Mulqueen, Climate Robotics LLC

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 75% of reviewers felt that the resources were sufficient, 25% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

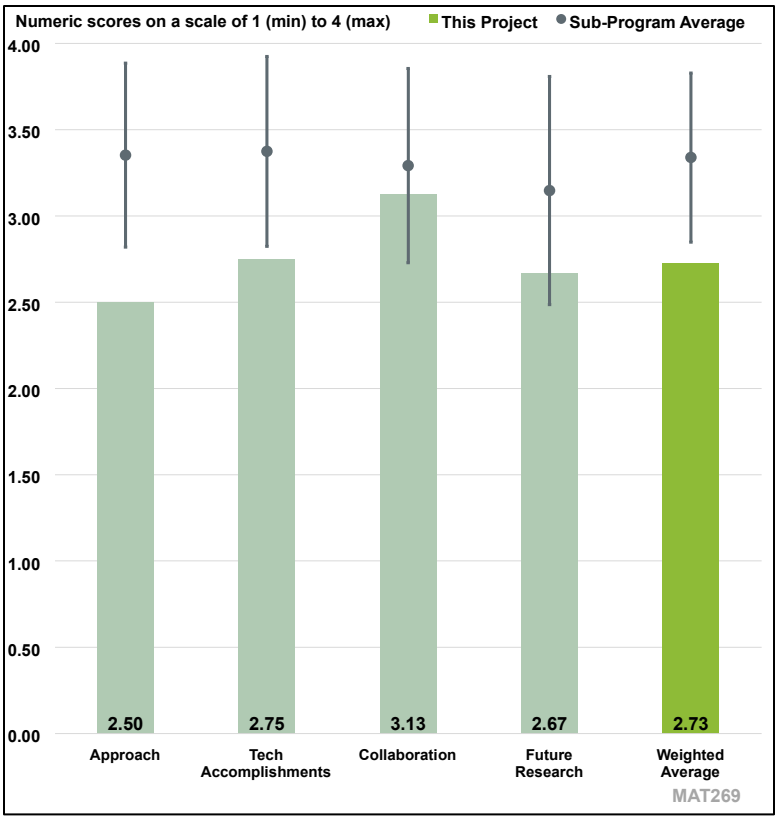

Figure 5-47. Presentation Number: MAT269 Presentation Title: Producing Multifunctional Automotive Composites with Sustainable Plant Based Graphene Principal Investigator: Daniel Mulqueen, Climate Robotics LLC

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer commented that the presentation had clear points about the impact graphene would have on the composite materials for automotive applications, and the technical barriers to using graphene were clearly mentioned. The reviewer noted that the project was well-designed in its approach to creating cheaper and higher quality graphene from a renewable source, and the timeline for achieving the milestones was reasonable. The reviewer explained that main deliverables for the project concentrated on using the graphene in composites, which is very valuable, but it seems like the major barrier to entry for graphene is production cost and quality. However, not much was mentioned about the production of the graphene. The reviewer concluded there should have been more discussion about how this graphene production approach is better than existing methods.

Reviewer 2

The reviewer remarked that the project is well designed to address the main technical barrier. However, the reviewer believed that there appears to be a time constraint, and would like to see more characterization works to be accomplished.

Reviewer 3
The reviewer commented that barriers relevant to VTO subprograms were not clearly articulated enough but the relevance of graphene as a material was.

Reviewer 4
The reviewer remarked that this project was to develop a low-cost, bio-based process to make graphene. There was limited data on the process and the cost or any scaleup issues, and the graphic in the technical backup slides did not include the entire process. The reviewer acknowledged the team tried different conditions of temperature and catalyst loading and fabricated and tested samples to show some properties that seemed to be competitive to existing products.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1
The reviewer remarked that the project has demonstrated timely progress in making composites and quantifying their conductivity, flame resistance, and EMI shielding. Additional evidence to validate the claim of producing high-quality graphene would have been beneficial since the reviewer is not convinced that the composite is of high quality based on the provided data. The reviewer noted that there was a nice reduction in resistance using the graphene; however, the summary slide claims a resistance of one ohm per square surface resistance which appears very different from the resistance shown in the resistance values plot. The reviewer is interested in knowing the plan to achieve one ohm per square surface resistance.

Reviewer 2
The reviewer noted that the project is almost complete and has produced sound achievements. Overall, several tasks were accomplished related to the objective of the project goal.

Reviewer 3
The reviewer commented that it is difficult to judge the technical progress or merit without points of reference for the material produced and the property benchmarks established either from literature or industry. The reviewer is interested in understanding the potential cost savings of using corn compared to what is used commercially and requested that a perspective be provided on the relative cost of different biobased sources for creation of graphene, even if it is very general.

Reviewer 4
The reviewer remarked that there was no discussion on the technical process which was the focus of the project, and the project was difficult to review overall when comparing the objectives to what was reported. The reviewer commented that a key driver was cost reduction yet there was no indication of any cost analysis.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1
The reviewer commented that great collaborations were formed with Johns Manville and Old Dominion Research Foundation and the presentation clearly mentioned the roles of each partner within this project. The reviewer concluded that the project seems well-coordinated and great partners were selected for this project.

Reviewer 2
The reviewer noted that the project PI is Climate Robotics; however, Johns Manville and Old Dominion University are the technical collaborators.

Reviewer 3
The reviewer expressed uncertainty about which project partners contributed to which part of the project.

Reviewer 4
The reviewer commented that the project partners fulfilled their roles within the scheduled time.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1
The reviewer remarked that at the time of the AMR, the project was very close to ending. Proposed future work regarding the approach to scale-up of the production process was discussed. The reviewer thinks the scale-up production of graphene is the most vital part of the future work and suggests confirming that high quality graphene should be produced prior to heavily investing in scale-up.

Reviewer 2
The reviewer commented that the project is completed.

Reviewer 3
The reviewer commented that nine unique conversion trials were run producing various Raman spectra D-band to G-and ratios between 1-1.24 and layers from 4-115. The reviewer acknowledged that the effect of phosphorous appears to be clear, but it is unclear from the other conditions evaluated what is driving these differences. The reviewer concluded that instead of scaling up, future work should also include refining the process parameters that affect conversion as well as gaining a better understanding of the sensitivity of graphene production to corn stover variability.

Reviewer 4
The reviewer stated that a plan should have been outlined to discuss process weaknesses that need to be addressed and further elaborated that there is no mention of cost models to determine competitiveness with current processes and no discussion of quality control or testing final products.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1
The reviewer commented that this project supports the overall VTO Materials subprogram objectives and elaborated that graphene has many benefits to automotive composites. So, if the team can produce high quality graphene at low cost, then there are many applications for this material in the automotive industry in terms of lightweighting and multifunctionality.

Reviewer 2
The reviewer commented that the project is focused on fabrication using graphitization of corn stovers to produce polymer grafted nanoparticles , which support the VTO Materials subprogram objectives.

Reviewer 3

The reviewer remarked that graphene is expensive and using biobased sources appear to have immense potential to reduce the cost of these materials.

Reviewer 4

The reviewer noted that lower-cost, high-quality graphene that generates less carbon dioxide off-gas would help make these materials more competitive and useful for composite design supporting the VTO Materials subprogram, making the project objective very relevant.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer remarked that the project is very close to ending so the funds are sufficient to achieve the remaining tasks.

Reviewer 2

The reviewer commented that the project has sufficient technical, equipment, and financial resources.

Reviewer 3

The reviewer noted that for the scope of work, the resources seem sufficient; however, increasing the budget to continue the work would enable a more thorough analysis of the sensitivity of graphene production on corn stover origin and composition.

Reviewer 4

The reviewer commented that the scope of the future work is very broad and includes process, product, and application development. The reviewer suggested developing a low-cost process that makes a product to match the quality of existing products.

Presentation Number: MAT280
Presentation Title: Materials and Manufacturing Innovation for Sustainable Automotive Composites: Thrust 1 - Innovative Low-Cost Carbon Fiber and Alternative Fiber Technologies
Principal Investigator: Amit Naskar, Oak Ridge National Laboratories

Presenter

Amit Naskar, Oak Ridge National Laboratories

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 75% of reviewers felt that the resources were sufficient, 25% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

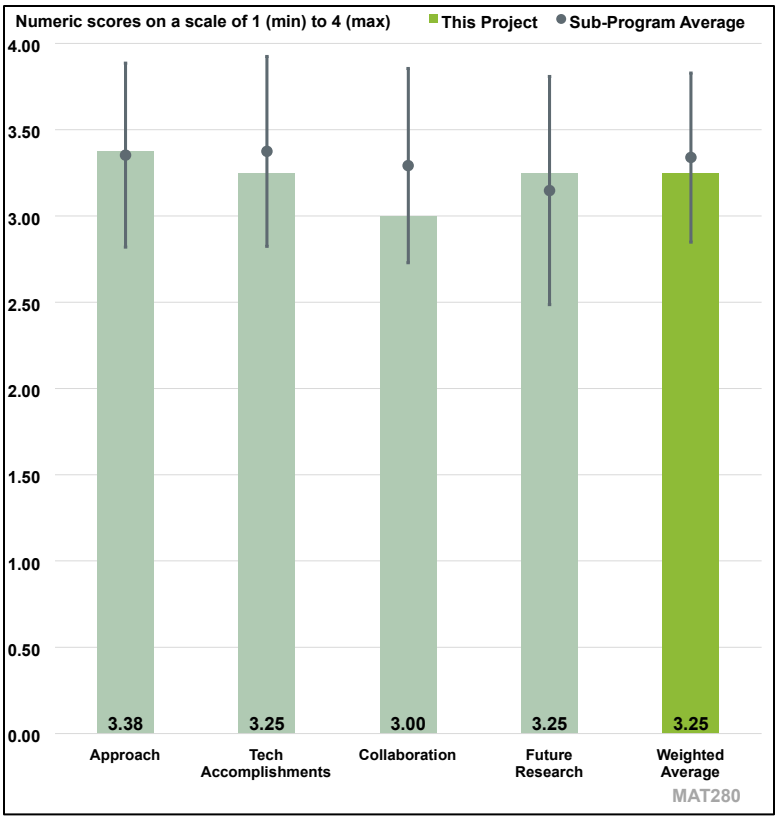

Figure 5-48. Presentation Number: MAT280 Presentation Title: Materials and Manufacturing Innovation for Sustainable Automotive Composites: Thrust 1 - Innovative Low-Cost Carbon Fiber and Alternative Fiber Technologies Principal Investigator: Amit Naskar, Oak Ridge National Laboratories

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer commented that the approach presented by the PIs appears adequate for achieving the project goal and further elaborated that this project is part of a larger effort made consisting of four thrusts, with this project being Thrust 1. Although the PI explained the contribution of this thrust area to the other thrust areas, the reviewer was not clear about the timelines by which the products from Thrust 1 must be delivered to Thrusts 2, 3, and 4. The reviewer expressed concern that the project is still in the early stages and only 15% of the work has been executed.

Reviewer 2

The reviewer remarked that the CCP 2.0 program is an ambitious undertaking. Breaking down the program into four primary thrust areas is well considered and allows for a broad range of activities crossing multiple technology areas. Thrust 1.0 was first reviewed at this AMR. This thrust area is subdivided into multiple projects; each with their own set of objectives, approach, accomplishments, and milestones. Evaluating these within the context of the PeerNet review system is much more challenging.

The reviewer noted that while the intention is to provide candid feedback, this task is made difficult by the breadth and diversity of the projects described under each thrust area. Technical barriers addressed by the presenters were relevant and included driving down the cost of high performance (e.g., 25Msi per 1.8g/cc specific modulus) fibers which is important and necessary to expand applications for fiber reinforced polymers in automotive components. One barrier speaks to supply chain reliability, but another barrier might suggest supply chain variability.

The reviewer further explained that high-performance fibers are highly, and most often, differentiated by supplier. A lack of standards for fiber reinforcement allows supply chain managers to build a broad base of qualified products with localized and global footprints which currently inhibit part manufacturers from making a transition to these materials because the risk of availability from a sole source of supply is too high to accept. The reviewer expressed interest in the DOE chairing an initiative to create relevant standards to qualify fiber suppliers.

Reviewer 3

The reviewer commented that the project aims to develop low-cost CF and alternative fibers from various sources and noted that the project is well designed, and the timeline is reasonable.

Reviewer 4

The reviewer commented that the aim of this project is to support the first pillar of the CCP 2.0 program, which focuses on developing low-cost fibers for composites. The reviewer explained that to achieve this goal, several comprehensive workstreams have been established and these workstreams are dedicated to the development of technology for several types of low-cost fibers including, polyolefins, carbon, UHMWPE, and natural fibers.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer remarked that only 15% of the work has been completed and concluded that there is not much to report from a progress point of view.

Reviewer 2

The reviewer noted that this specific project encompasses six separate projects or tasks. Collectively, the research team is making fine progress on the objectives established for the thrust area. The reviewer explained that it is difficult to assess the progress wholly since each project can stand alone making it difficult to aggregate the accomplishments and evaluate the likely success of the final work product. The reviewer questioned if the objective for I.6.2 is to meet the same physical performance of CF equivalent specific properties of 25Msi per 1.8g/cc). The adoption of natural fibers to support sustainability goals may justify their use in many areas of commercial vehicles, but the fiber performance is unlikely to meet the CF equivalent metric. The reviewer concluded that making this clear would be useful and minimum performance metrics are needed to claim success.

Reviewer 3

The reviewer commented that although the project started only about six months ago, considerable progress has already been made.

Reviewer 4

The reviewer commented that considerable progress has been made on low-cost CFs, polyolefins, and UHMWPE fibers; however, work is still ongoing for natural fibers. The reviewer elaborated that a

critical aspect missing in this task is the development of cost models to understand the expenses associated with producing these fibers using different methods.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer commented that notable collaborators are PNNL and the University of Tennessee, Knoxville while acknowledging that the team has some unnamed industry partners. The reviewer concluded that this team appears to be adequate for executing the work.

Reviewer 2

The reviewer noted that the PI identified the collaborators in Thrust 1.0 and even identified the individual PI's working on each of the six subtasks but provided little detail about the role of each collaborator. The reviewer elaborated that this is less likely a weakness of the program and more a reflection of the challenges related to presenting such a wide range of activities in such a brief time making it difficult to describe each collaborator's role in the project. The reviewer concluded that it is of critical importance to include industrial partners in these efforts that can enable commercial viability and drive the adoption and implementation of these technologies.

Reviewer 3

The reviewer acknowledged that the project will be conducted in collaboration with the University of Tennessee, Knoxville, industry textile manufacturers and preform suppliers, ORNL, and PNNL. The specific industry members providing textile fiber precursors have not been specified. The reviewer noted that the project team previously reported significant delays due to a limited supply of fiber precursors and suggested developing a risk mitigation plan to prevent similar delays.

Reviewer 4

The reviewer praised the collaboration between this group and team members from the national laboratories.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer noted that only 15% of the work has been done and 85% percent remains to be executed. Not much can be said about future work now, except for the promised scope to be executed.

Reviewer 2

The reviewer explained that the future research work involves executing the work as described in the technical approach. However, there are specific future work elements that appear significant. The reviewer praised the CCP 2.0 goal to establish an industrial advisory board and acknowledged that this is highly recommended. The advisory board would have far more impact on project direction than the current AMR process and will be quite valuable. The reviewer noted that connecting with Tier 1 suppliers to facilitate technology transfer is significant. The reviewer suggested including details about costs and a path to scaleup in future work and noted this seems particularly relevant to the expansion of polymeric fibers and the polymer-fiber-reinforced polymers that hold much promise for high-rate production of lightweight materials.

Reviewer 3
The reviewer commented that the future work is well defined, and the targets are achievable.

Reviewer 4
The reviewer suggested that cost models be developed for each fiber system being manufactured in this project and further elaborated that, although the current process is focused on small-scale development, the cost models should be based on large-scale manufacturing. These models will help identify high-cost process steps and help refine the technology development.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1
The reviewer commented that this project contributes to the production of affordable CF material for vehicle light weighting purposes.

Reviewer 2
The reviewer noted that the project's relevance cannot be questioned. Reducing cost, increasing availability, and scaling high performance reinforcements are critical steps toward expanding the use and applications in commercial automotive.

Reviewer 3
The reviewer stated that the project is highly relevant to the VTO Materials subprogram objectives.

Reviewer 4
The reviewer commented that the project is highly relevant as the United States goals to develop domestic technology for fiber production and acknowledged that fibers are currently manufactured outside the United States making the nation critically dependent on supply chain fluctuations and posing future safety risks.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1
The reviewer commented that there is no indication that the allocated funds are insufficient or excessive considering the project is still in the initial stages of executing the work since only 15% of the work has been completed.

Reviewer 2
The reviewer remarked that $5.5 million to fund six projects at ~$300,000 per subtask per year appears low for the ambitious objectives identified. However, the reviewer would not like this statement to discourage the execution of this work. The reviewer suggested enlisting industrial partners where possible to support work such as inking processes as force multipliers for performing the work at the current funding level.

Reviewer 3
The reviewer commented that the project resources are sufficient.

Reviewer 4
The reviewer stated the resources proposed for the project are sufficient.

Presentation Number: MAT281
Presentation Title: Materials and Manufacturing Innovation for Sustainable Automotive Composites: Thrust 2 - Multi-functional Materials and Structures
Principal Investigator: Christopher Bowland, Oak Ridge National Laboratories

Presenter

Christopher Bowland, Oak Ridge National Laboratories

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

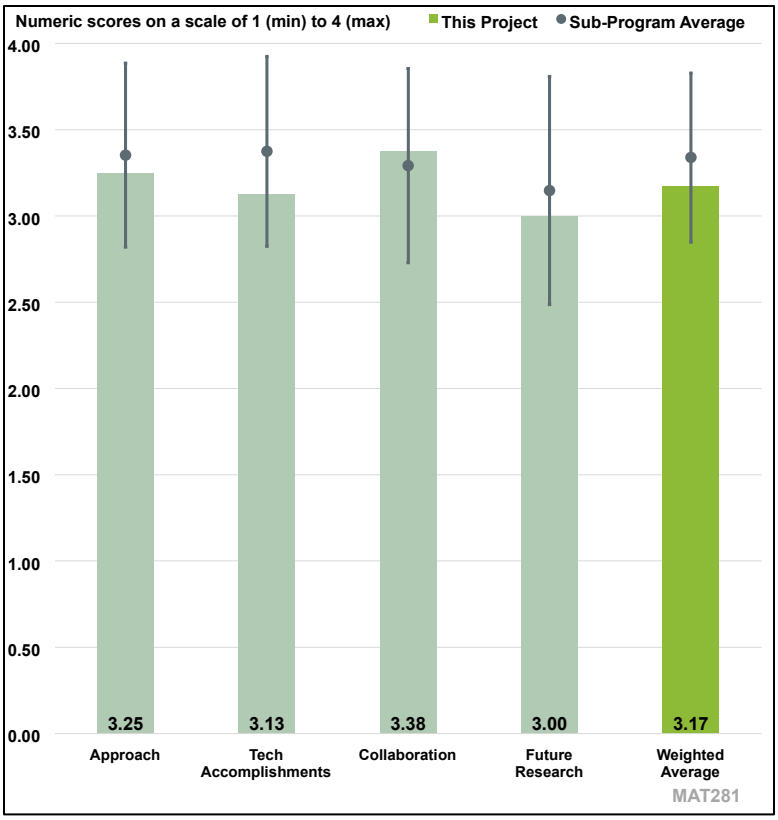

Figure 5-49. Presentation Number: MAT281 Presentation Title: Materials and Manufacturing Innovation for Sustainable Automotive Composites: Thrust 2 - Multi-functional Materials and Structures Principal Investigator: Christopher Bowland, Oak Ridge National Laboratories

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer commented that the primary objectives of the project are to enhance safety through SHM and damage detection or by increasing specific strength properties. This would suggest that the final composite materials developed would be integrated into the primary structure of future automobiles. The reviewer elaborated that there is no consideration for how vehicles are manufactured or the type of loads that are anticipated in service and this could result in a material system that fails to deliver on all appropriate material attributes. For this project to have a meaningful chance of success, the reviewer suggested that a fully defined pathway for how these materials will be implemented in practice, both by the Tier 1 supplier base and at the OEM should be developed.

Reviewer 2

The reviewer remarked that the approach is innovative and well planned because the program is attempting to develop multi-material systems such as NDE, life cycle monitoring, joining, assembling, inspection, painting, and processing of vehicles for improved manufacturing efficiency. The reviewer noted the focus is on six major tasks led by different PIs on the team.

Reviewer 3

The reviewer noted that the goal of each task was not clear in relation to the overall thrust goal because the project has six separate tasks. While it is understandable that there was not enough space to include all the information in the presentation, outlining the overarching goal and each deliverable would have been beneficial. The reviewer added that the topics, which were a mixture of highly exploratory and continuous efforts, were good and recommended soliciting industry feedback about each task to define the deliverable targets that will be impactful to industry. Some of the project task directions seemed to be decided based on researchers' intuition. The reviewer concluded that, for the technology developed in each task, it would be good to define the current state-of-the-art technologies as benchmarks and determine viable targets for each task (with industry feedback) to truly make an impact.

Reviewer 4

The reviewer remarked that the project is Thrust 2 for the CCP 2.0 program titled Multi-functional Materials and Structures and aims to develop technologies in several areas to make multifunctional composites. These areas are defined as (1) self-health monitoring, (2) embedded and over-molded electronics, (3) sensing and energy harvesting, (4) improved thermal management, and (5) improving the fatigue behavior. The reviewer concluded that the approaches developed in each of these areas are excellent.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer commented that the milestones are written without performance improvement targets, therefore, it is difficult to determine if the targeted percentage increase will have a meaningful impact on performance of the resulting parts. The same applies to the Go/No-Go Decision gateway for II.4. The reviewer remarked that the overall objective is to achieve a 30-50% mass saving for a load bearing fiber reinforced component; however, no quantitative metrics are included. The reviewer concluded that it is unclear how this goal will be achieved.

Reviewer 2

The reviewer remarked that the program appears to be on target to complete the major milestones considering the project started recently and only 5% of the work has been completed.

Reviewer 3

The reviewer commented that, considering this is a new project, the progress to date is decent. Although most of milestones are not SMART (not much measurable values), which makes it difficult to assess the progress, the milestones appear to be met. The reviewer also stated that it is difficult to assess the progress of each task.

Reviewer 4

The reviewer attributed great results for the damage characterization of composites and suggested developing a piece of equipment to demonstrate the technology effectively. Not much information was provided for over-molded electronics. The reviewer was curious about the plans for this development. Outlining the next steps and expected outcomes would be beneficial to better understand the direction and goals of this project. The sensing and energy harvesting work has been delayed and it would be desirable to provide more details on the reasons for the delay and the updated timeline for this work. Understanding these aspects would help in adjusting expectations and planning accordingly. Regarding the development of thermal capabilities, CNTs were proposed

as a solution. In the results section, only the improvements in the strength and stiffness of the neat resin with embedded CNTs were provided. While these improvements are noteworthy, the electrical properties of the composite with CNTs are also very interesting and important. The current study focused only on neat resin; however, the composite properties, which combine the resin with reinforcing fibers, would likely provide more relevant and valuable insights. The reviewer wanted to know more about the plans to study the CNTs in the composite material and the proposed manufacturing process for embedding the CNTs in the composite. Understanding the methodology and approach will help in assessing the feasibility and potential impact of this development.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer commented that there appears to be a large network of companies and institutes that are listed as supporting the project; however, how communications are being coordinated across such a large team of contributors is unclear.

Reviewer 2

The reviewer commented that the assembled team consisting of national laboratories, universities, and industry partners is very strong and has the capabilities to complete the work.

Reviewer 3

The reviewer commented that some of the tasks have collaboration, while others do not. The reviewer remarked that having more industrial feedback would be good and acknowledged that once the advisory board is selected, this problem may be solved. Noting for some of the more mature concepts, particularly the continuous ones, the greater industry engagement is recommended so what is practically important and impactful can be properly assessed. .

Reviewer 4

The reviewer praised the excellent collaboration between the project teams.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer commented that the project team could benefit from identifying a potential end use application to establish a more comprehensive list of performance requirements and noted identifying an end-use application would ensure all necessary requirements and constraints are considered not only in service needs but also in part production and vehicle assembly.

Reviewer 2

The reviewer observed that goals have been clearly identified; however, there is ambiguity about how all the six tasks will be integrated and demonstrated in one event or structure. Also, sensing work is very basic and will require much more effort than is currently planned. Testing will be done only at the coupon level which may not be able to encompass all the developments from the six tasks areas. The reviewer suggested that a more complex program structure could be targeted if time and budgets permit.

Reviewer 3

The reviewer commented that the future tasks that were listed are reasonable; however, the purpose of each future work is unclear. This comment is related to clearly defining the end goal. Since the

end goal is not well defined, future work sounds more like incremental development, which may or may not be impactful for vehicle technology.

Reviewer 4

The reviewer suggested developing a piece of equipment to demonstrate the technology effectively. The reviewer further asked for the plans for the over-molded electronic circuit board development. CNTs were proposed for the development of thermal capabilities; however, only the improvements in the strength and stiffness of the neat resin with embedded CNTs were provided in the results section. While these improvements are noteworthy, the reviewer noted that the electrical properties of the composite with CNTs are also very interesting and important. The current study focused only on neat resin; however, the composite properties, which combine the resin with reinforcing fibers, would likely provide more relevant and valuable insights. The reviewer asked for the plans to study the CNTs in the composite material and the proposed manufacturing process for embedding the CNTs in the composite. Understanding the methodology and approach will help in assessing the feasibility and potential impact of this development.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer commented that the proposed research is aligned with the VTO mission statement.

Reviewer 2

The reviewer commented that the program directly targets multi-functional structures for vehicles that is a goal of VTO Materials subprogram.

Reviewer 3

The reviewer remarked that the project is relevant to lightweight materials; however, the targets and expected impacts should be more clearly defined.

Reviewer 4

The reviewer commented that the project is very relevant to support the VTO objectives.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer stated that adequate resources appear to be deployed to complete the proposed work plan.

Reviewer 2

The reviewer remarked that the team comprised of national laboratories, a university, and industry who are well versed in the program areas.

Reviewer 3

The reviewer commented that the resources are sufficient.

Reviewer 4

The reviewer commented that the project has sufficient resources to complete the project tasks in a timely manner.

Presentation Number: MAT282
Presentation Title: Materials and Manufacturing Innovation for Sustainable Automotive Composites: Thrust 3 - Circularity and Sustainability of Polymer Composites
Principal Investigator: Kevin Simmons, Pacific Northwest National Laboratory

Presenter

Kevin Simmons, Pacific Northwest National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

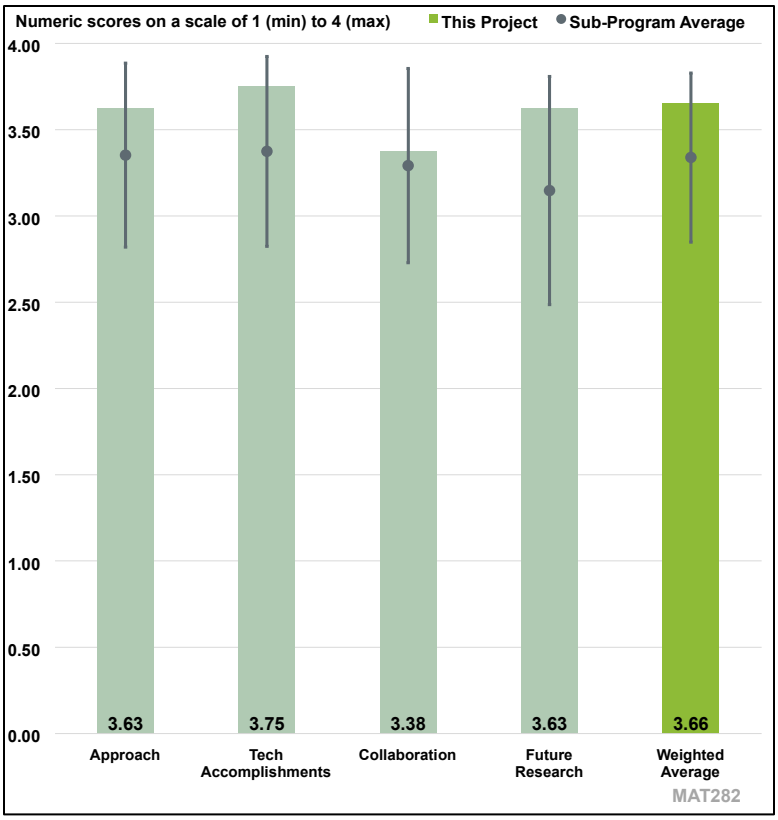

Figure 5-50. Presentation Number: MAT282 Presentation Title: Materials and Manufacturing Innovation for Sustainable Automotive Composites: Thrust 3 - Circularity and Sustainability of Polymer Composites Principal Investigator: Kevin Simmons, Pacific Northwest National Laboratory

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer stated that the project design and timeline are “Good!” as a response.

Reviewer 2

The reviewer concluded that the general target and topic of Thrust 3 is very important, which targets to address circularity and sustainability of polymer composites; however, because of lack of space and time for the presentation, various details were unclear. Each task should clearly define the target performance as a deliverable, especially as measurable SMART values. Showing milestones as percentages of completion is not necessarily good because that becomes relative to something, which may not be an actual standard or a comparable control value.

The reviewer pointed out for Task III.1 “Waste to Fiber,” that while the use of deconstructed PET waste as one of the building blocks is a good approach, the sustainability of the produced fibers is unclear. Octadecyl acrylamide co-polymer and polydiacetylene monomers are not waste-based, and they are the major component in the mass. The reviewer suggested a very quick LCA (and maybe

TEA) to roughly estimate GHG emission and energy inputs. Most likely the process is not so sustainable. The reviewer believes that targeting high molecular weight polymers is good and important for fiber spinning. The milestone of achieving 60% recovery of polydiacetylene is not clear because it may be referring to deconstructing the fiber again. If so, the total recovery of the monomer should be close to 100%. Also, polyaramid is an industrial grade fiber. The reviewer recommended some quick feedback from industry if this approach is truly attractive for making a significant impact.

The reviewer provided comments on “III. 2 Shredded Automotive Waste”. The reviewer deduced that the purpose of this task may be focusing on the separation of automotive wastes. Understanding the path and process for the separation of automotive waste is very important for the planned effort and makes sense. But then, the reviewer believes the project is targeting mechanical recycling or pyrolysis. Mechanical recycling must be able to separate a very clean waste feedstock; otherwise, it would become downcycling. Removal of halogen is important for pyrolysis, and the focus on removal of halogen makes sense. Pyrolysis can treat mixed waste, but energy inputs are generally high. The reviewer suggests performing a quick LCA on the process which is important to check if the pyrolysis process seems viable from a sustainable standpoint. As the process develops, other techniques should be considered for possibly treating mixed plastic wastes, which are assumed to be most of automotive wastes. The reviewer recommended investigating several recent technologies, especially in chemical recycling, which can address some of the mixed plastic waste challenges.

The reviewer provided insights for “III. 3 Bio-derived PECAN for Steel Replacement”. The task focuses on bio-based vitrimers developed by NREL during the CCP 1.0 phase and on mixing fiber compositions with natural fiber etc. Before going to Task 3 of manufacturing demonstration, the reviewer stated that the technology needs to meet the required mechanical properties, which are unclear as stated in the project scope (e.g., 75% of PECAN CFRP). PECAN CFRP by itself does not seem to meet the required mechanical properties needed to replace steel. While it highly depends on fiber loading and types of fibers, the reviewer suggests that this task needs to clearly define and understand the baseline of the current steel or CFRPs for the targeted car parts. Low mechanical strength composites may be useful for some of the interior parts, but structural parts will require much higher strength. Also, enhancing ductility is not necessary a good thing for most of car parts. Again, the reviewer reiterated that the researchers need to carefully check required mechanical properties of each of the car parts as well as their manufacturing process. The target values of the mechanical properties (e.g., tensile strength, tensile modulus, three-point bending strength, interlaminar shear strength, etc.) need to be clearly defined with a listing of the current mechanical properties of the relevant car parts.

The reviewer commented on task “III. 4 High-Throughput Recycling of Long CF from Cured Thermoset Composites”. The reviewer observed that the approach is to develop solvolysis technology for deconstructing epoxy thermoset to recover longer CFs. This is a great technology, and the reviewer believed this is a good task. One potential challenge is solvolysis in a high-temperature, high-pressure system. The reviewer suggested carefully designing the scalability of the technology, which is tricky due to the high-temperature, high-pressure process. The reviewer added that receiving feedback from industry is important and the approach should address industry’s needs.

The reviewer commented that the technical barriers addressed by this project are the ability for low-cost, high-volume manufacturing of CFs that are sustainable and recyclable. This addresses a VTO Materials subprogram goal with a metric to reclaim 85% of composites used in automobile body

structures. The reviewer noted that the project is part of an overall effort entitled “Materials and Manufacturing Innovation for Sustainable Automotive Composites: Thrust 3 - Circularity and Sustainability of Polymer Composites” that focuses on developing low-cost, low-carbon emission routes to reintegrate wastes into the composite materials supply chain and to realize a circular economy with polymeric products for applications of composite materials used in vehicles. The reviewer explained the approach is to produce and commercialize industrial-grade polymers and automotive composites from circular or renewable feedstocks with properties rivaling petroleum-derived materials while reducing manufacturing costs by $5/kg which aligns with the overall goal of the VTO Materials subprogram. This approach is targeting a reuse amount >95% of components, saving >50% manufacturing cost, and achieving >75% GHG emission reduction and >50% embodied energy reduction which meet or exceed the VTO Materials subprogram goals for composite materials.

The reviewer remarked that this project also relies on research being conducted in another area: “Thrust 1 - Innovative Low-Cost Carbon Fiber and Alternative Fiber Technologies” to complement the research over the period of this project; however, no project schedule was presented to show this relationship. The reviewer noted this approach supports a well-designed effort that can be accomplished within a reasonable timeline. Additionally, it offers new strategies to address sustainability through use of biobased and recycled materials and scalable manufacturing methods for low-cost, low-emission technologies to reintegrate waste and renewables into the composite materials supply chain while maintaining the required mechanical properties. The reviewer concluded that all efforts are consistent with the VTO Materials subprogram goals for composite materials.

Reviewer 3

The reviewer commented that the project was well designed with new strategies to address sustainability and offer scalable manufacturing solutions to achieving low-cost, high-volume manufacturing, low-cost carbon emission, sustainability, and recyclability.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer questioned why only PET is mentioned in Task III and how the plastic sorting and collection for automobiles is put into the LCA database. The reviewer also questioned what technologies will be evaluated in relation to automobile plastics: the automobile shredder residue or automobile fluff, and/or the plastic sorting and technology. The reviewer expressed curiosity about the benefit of doing this work in terms of the LCA.

Reviewer 2

The reviewer commented that the project has demonstrated, substantial progress considering this is the first year noting the high molecular weight polyaramid was successfully synthesized. The reviewer questioned how the literature review for halogenated waste stream, tailoring the glass transition temperature, and designing the initial tests of hybrid composites with PECAN were conducted. Successful solvolysis of epoxy composites was also performed. The reviewer suggested that some of the target goals be carefully evaluated and early feedback from industry should be solicited because certain approaches may be irrelevant or off-target. The reviewer concluded that conducting an early-stage LCA or TEA to obtain ballpark estimates are important.

Reviewer 3

The reviewer commented that this project is in the initial stages and was only 10% complete as of the presentation at the 2024 VTO AMR. The technical accomplishments demonstrate early success toward meeting project goals by producing a copolymer synthesized in house from three components (TCl, polydiacetylene, and octadecyl acrylamide) that showed a molecular weight >10,000 grams per mole for the resulting poly(p-phenylene terephthalamide) and oxydiphthalic acid copolymer; publishing a report titled “Circular Economy for Automotive Shredder Reuse” on the circular economy for unwanted shredded automotive waste; conducting a techno-economic analysis and LCA on current resins got demonstrating a >40% reduction in GHG emissions resulting in an open literature publication; demonstrating that resin formulation can lead to high glass transition temperature materials which work with different reinforcements; and demonstrating a >70% reduction of embodied energy and a >75% reduction of GHG emissions relative to virgin fiber production. The reviewer noted that there was no project schedule presented that would define the project plan; however, the accomplishments are significant and consistent with the approach, project milestones, and VTO Materials subprogram goals.

Reviewer 4

The reviewer remarked that the project is on track. The team has demonstrated high molecular weight PET-derived copolymers, achieved a >70% reduction of embodied energy and a >75% reduction of GHG emissions for solvolysis recycling relative to virgin fiber production, demonstrated PECAN resin applicability and >20% reduction of first life GHG emissions through resin use alone. The reviewer praised the team for remarkable project results.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer had no project evaluation comments to share.

Reviewer 2

The reviewer noted that, besides the Thrust 3 members, outside collaboration by the project team was unclear, and added that industry engagement, at least as in an advisory capacity, would be very important.

Reviewer 3

The reviewer highlighted the collaboration and coordination between three national laboratories: ORNL, PNNL, and NREL with no stated involvement by industry or academia and noted the appropriateness of the collaboration is likely due to the early-stage research being undertaken. The reviewer praised the coordination within the teams at the three national laboratories and within the overall Materials CCP (Thrust I support for Thrust III) and mentioned that there were no other areas identified requiring more collaboration.

Reviewer 4

The reviewer praised the collaboration between, PNNL, ORNL, and NREL and mentioned that, as the project progressed, industry partners may help with scale up.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer recommended evaluating the biodegradability of the bio-derivable and recyclable composites.

Reviewer 2

The reviewer commented that in terms of their current targets, the plans for future research seemed reasonable. However, the reviewer expressed uncertainty about how well certain approaches are truly addressing the path for circularity and sustainability. Most of the targets and target values appeared to be created based on the PIs' intuition without receiving inputs from industrial personnel. The reviewer suggested that the PIs carefully think through what truly successful outcomes would be after three years. In conclusion, the reviewer questioned whether industry would rapidly adopt the proposed technology if the PI achieved the current goals. In a sense, will industry adopt rapidly if PIs achieve the current goals?

Reviewer 3

The reviewer commented that the project presentation clearly defined the future research required to achieve the project targets and goals. The reviewer explained that there were six remaining challenges identified that would require future research: (1) conversion of high-performance polymers to fibers for composites applications, (2) high molecular weight of catalytic polymerizations from waste PET, (3) halogen materials separation, (4) ensuring resin compatibility with two different polymer matrices, (5) low throughput and equipment requirements for current solvolysis methods, and (6) interfacial strength of rCF with matrix resin for new composites. These challenges will be addressed by future research efforts to demonstrate circularity in aramid fibers, investigate catalytic amidation to produce high-value polymers, demonstrate CF and matrix resin recycling from cured thermoset composites under atmospheric pressure, develop analysis models for atmospheric pressure recycling scenarios, and evaluate sorting and separation technologies.,

The reviewer further detailed the project research focus areas which included identifying impacts of halogens in the waste stream and how to separate them, utilization of automotive shredder residue materials as feedstocks for composite formulation and the development of high performing recyclable and hybrid composites. Performance progress that demonstrates a >75% strength and a 50% more ductility for CFRCs analyses that concluded hybrid composites can result in first and second life benefits, and a 50+% reduction in the cost, energies, and GHG emissions for the first life of a composite, all reflect a well-planned effort that should result in achieving the project targets.

Reviewer 4

The reviewer commented that the proposed future research has clearly defined tasks for PNNL, ORNL, and NREL, and likely achieve the targets.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer had no project evaluation comments to share.

Reviewer 2

The reviewer commented that the circularity and sustainability of lightweight materials is highly relevant and very important research activity for future.

Reviewer 3

The reviewer commented that this project is directly relevant to the VTO Materials subprogram goals and metrics for CF and composites to achieve low-cost CF, reduced manufacturing costs, recyclability, and reduced carbon footprint.

Reviewer 4

The reviewer commented that the project is timely and would provide increased sustainability in opportunities to use biobased and reutilize existing materials, generate low-cost feedstocks from automotive shredder residue, and re-integration of these materials back into in-vehicle applications. The recyclable nature of these composites will enable 25+ wt.% reduction at <$5/lb weight savings. The reviewer explained the proposed technology has the potential to achieve >70% reduction in embodied energy and GHG emissions, >50% reduction in manufacturing cost while maintaining >90% mechanical properties for second life uses in automotive CFRPs.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer had no project evaluation comments to share.

Reviewer 2

The reviewer noted that the project resources are sufficient.

Reviewer 3

The reviewer highlighted that this project has current and future funding of $1,350,000 per year over three years and is part of an overall effort under a thrust area titled “Materials and Manufacturing Innovation for Sustainable Automotive Composites: Thrust 3 - Circularity and Sustainability of Polymer Composites”. The reviewer explained that the project involves at least nine co-principal investigators and three national laboratories and use of their research facilities to conduct basic research on polymers and composite materials. The reviewer added that the funding and facilities for this project are considered sufficient to achieve the project objectives by the end of the performance period.

Reviewer 4

The reviewer commented that three national laboratories (PNNL, ORNL, and NREL) have the resources sufficient for the project to achieve the stated milestones in a timely fashion.

Presentation Number: MAT283
Presentation Title: Materials and Manufacturing Innovation for Sustainable Automotive Composites: Thrust 4 - Polymeric Materials and Their Composites in Additive Manufacturing
Principal Investigator: Vlastimil Kunc, Oak Ridge National Laboratories

Presenter

Vlastimil Kunc, Oak Ridge National Laboratories

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

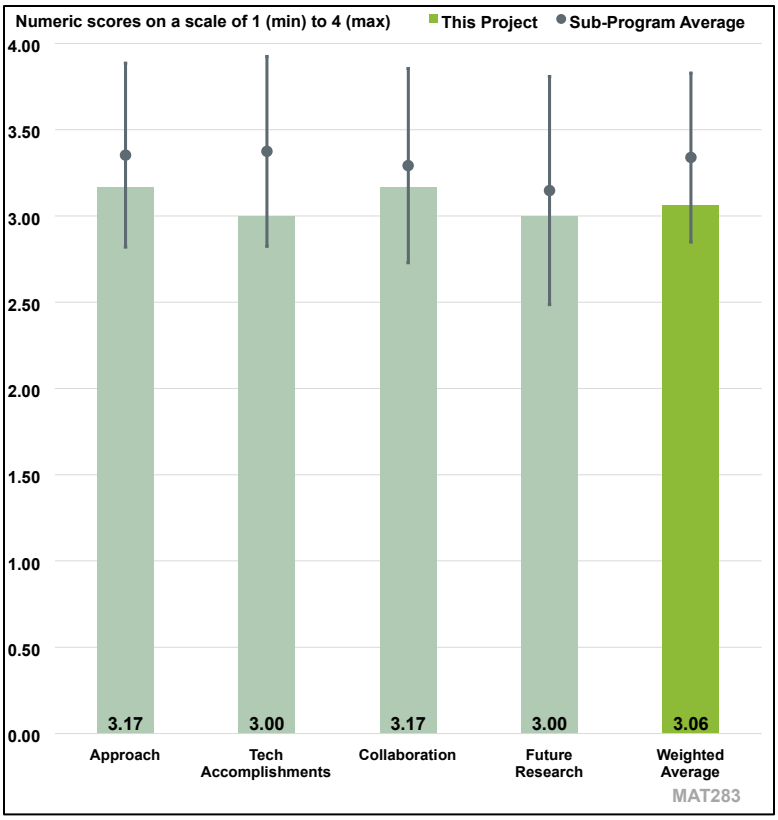

Figure 5-51. Presentation Number: MAT283 Presentation Title: Materials and Manufacturing Innovation for Sustainable Automotive Composites: Thrust 4 - Polymeric Materials and Their Composites in Additive Manufacturing Principal Investigator: Vlastimil Kunc, Oak Ridge National Laboratories

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1

The reviewer commented that the AM compression molding has been demonstrated for laboratory scale parts, but the scope of work should include a verification step to ensure that the shape complexity can be achieved in conventional injection molding and maintained. The reviewer explained that, if more manufacturing constraints to part design are required, the adoption of the technology might be limited. The reviewer recommended that the project team consult with potential Tier 1 suppliers to determine what other obstacles my exist that would prevent implementation.

Reviewer 2

The reviewer commented that there can be no argument against the barriers stated by the PI to the wider adoption of high-performance composites in commercial automotive applications. The reviewer suggested that more emphasis be placed on the production challenges that impact high labor input, geometry control, labor content, capital expense (in tooling and manufacturing

equipment), lack of standardization in the materials, etc. Nonetheless, the PI has done well to relate the current barriers to adoption (within such a broad set of project work).

The reviewer noted that the technical approach was difficult to evaluate amongst a broad set of project activities (i.e., five independent projects within the thrust area). The reviewer remarked that more effort in processing technologies to drive out cycle time is needed. Project IV.1 is a wonderful example of innovative technologies that hybridize multiple technologies (fused deposition modeling "printing" combined with continuous fiber compression molding). The reviewer commented that this technology would be more compelling if there were a more detailed definition of potential candidate parts to demonstrate part consolidation, potential weight reduction and ultimately cost/unit of weight saved. The reviewer suggested more details related to the potential of other AM technologies to meet cycle time or discussion of deposition rates that would allow one to infer cycle time based upon component mass is worthwhile. The reviewer concluded that establishing targets for the hierarchical materials may be worth considering.

Reviewer 3

The reviewer commented that AM of polymeric materials and composites is timely and of significant importance for the automotive industry to achieve light-weighting, multifunctionality, and deep decarbonization. The reviewer added that the project is well designed to address affordability, cycle time, predictability, light-weighting, and sustainability.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1

The reviewer noted that the experimental investigations and corresponding simulation are based upon materials (e.g., glass fiber and acrylonitrile butadiene styrene) that are not commonly used for automotive structural parts, so the team should consider directing future work using materials that are appropriate for the target applications being proposed. The reviewer also suggested placing a stronger emphasis on the business case for implementation of each of the specific technologies under development.

Reviewer 2

The reviewer commented that it remains a challenge to review five projects and provide a detailed assessment of technical progress when the detail contained in the project presentation is insufficient. The reviewer explained that this is NOT the fault of the program or the reporting PI but a result of limited time available to report on such a wide range of activity. Regarding project evaluation, the reviewer remarked that the five projects presented for evaluation are highly disparate in their direction and technology. This left the reviewer questioning whether this is intentional or a result of the nature of the PI's leading each project. The reviewer expressed difficulty in determining a common thread between these efforts that would suggest they belong within a singular technology thrust area but praised the progress reported. The reviewer concluded that it is not clear how the identified targets will be measured and achieved or what the established baseline is to compare against because of the early stage of research for the CCP 2.0 program.

Reviewer 3

The reviewer commented that the project, which started in January 2024, has all tasks on track and has already made considerable progress.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1

The reviewer noted that this is a multi-laboratory project that includes collaborations with academic institutions as well as Nissan as an OEM and suggested the team consider Tier 1 supplier engagements to ensure the technologies under development align with future investment plans of automotive suppliers.

Reviewer 2

The reviewer commented that the collaborating entities are identified; however, the roles and responsibilities of the collaborating institutions are not clearly stated. The reviewer noted that this would be useful to specify and would aid in judging the teaming effectiveness and how interactions will be conducted, redundancy minimized, and technology transfer (if any) will be accomplished.

Reviewer 3

The reviewer praised the team collaboration which included: Nissan North America, Orbital Composites, University of California Berkley, University of Tennessee, University of North Texas, and University of Oklahoma each of which has specific tasks and deliverables.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1

The reviewer commented that the economics and manufacturing feasibility of 3D printing at high volume (>100,000 parts per year) should be an integral part of the program to ensure the business case can compete with other emerging technologies.

Reviewer 2

The reviewer commented that there is limited information provided and insufficient time allotted to describe five projects in a 20-minute period. The reviewer assume the technical activities outlined by the technical approach will be successfully executed and anticipates seeing the project results presented at future reviews or to participants of an external industrial advisory board.

Reviewer 3

The reviewer commented that the future research will follow planned tasks and coordinated tasks with collaborators to achieve the targets.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1

The reviewer stated that the work is aligned with the VTO Materials subprogram mission statement.

Reviewer 2

The reviewer commented that the relevance of Thrust IV with the broader CCP 2.0 program should not be questioned. The reviewer explained that more focus on specific applications would favorably impact the thrust area relevance; however, it is rather early in the project to suggest that opportunity does not exist. The reviewer noted the project could benefit from more industrial partners at all points in the value chain (material and equipment suppliers, tier ones, and OEM's), however, there are many other opportunities within other VTO initiatives to engage those partners. The reviewer

concluded that it might be interesting to see where the explored technologies in Thrust IV could be injected within active VTO programs or new initiatives that are competitively bid.

Reviewer 3

The reviewer noted that new sustainable feedstocks are needed for AM of automotive composites to reduce carbon intensity, energy consumption, and production costs while improving product performance,

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1

The reviewer commented that there appears to be sufficient resources to complete the proposed work plan; however, it is not clear what TRL each of the technologies will achieve by the end of the project.

Reviewer 2

The reviewer commented that the total thrust area annual funding of $1.4 million means that each of the five projects are funded at less than $300,000 per year. The reviewer noted that these are ambitious efforts and funding seems limited, but this reviewer assessed that the appropriateness of the resources was sufficient based on technical progress reported in the budget period.

Reviewer 3

The reviewer commented that ORNL, Nissan North America, Orbital Composites, University of California Berkley, University of Tennessee, University of North Texas, and University of Oklahoma have the resources sufficient for the project to achieve the stated milestones in a timely fashion.

Acronyms and Abbreviations - MAT

Abbreviation	Definition
µm	Micrometer
3D	Three-dimensional
4M	4M Carbon Fiber Corporation (team member)
4XT	4X Technologies, LLC
A380	Designation for the most specified Al alloy that has the best combination of casting, mechanical, and thermal properties
ACMZ	Aluminum-copper-manganese-zirconium
AI	Artificial intelligence
AI/ML	Artificial intelligence/machine learning
Al	Aluminum
Al-MMC	Aluminum metal matrix composites
AM	Additive manufacturing
AM60B	A castable Mg alloy with excellent ductility, superior energy absorbing properties, and good strength and castability -
AMR	Annual Merit Review
ANL	Argonne National Laboratory
AS4	A high strength, high strain, continuous carbon fiber made by Hexcel
AZ91D	A high-purity Mg cast alloy with excellent corrosion resistance, castablilty, and good strength
BEV	Battery electric vehicle
CALPHAD	CALculation of PHAse Diagrams (software by CompuTherm)
CANMET	Canadian Centre for Mineral and Energy Technology
CCF	Continuous carbon fiber
CCP	Composites Core Program
CCP 2.0	Phase 2 of the Composites Core Program
CF	Carbon fiber

Abbreviation	Definition
CFRC	Carbon fiber reinforced composites
CFRP	Carbon fiber reinforced polymer
CFTF	Carbon Fiber Technology Facility
CNT	Carbon nanotube
Co	Cobalt
CRADA	Cooperative research and Development Agreement
Cu	Copper
DOE	U.S. Department of Energy
DRIVE	Driving Research and Innovation for Vehicle efficiency and Energy
EERE	Office of Energy Efficiency and Renewable Energy
e.g.	For example
EJOT	EJOT Group, supplier for engineered fasteners and joining technology
EJOWELD CFF®	Product name for a commercial friction welding process
EM	Electromagnetic
e-motor	Electric motor
EMI	Electromagnetic interference
etc.	et cetera (and so forth)
EV	Electric vehicle
Fe	Iron
Ford	Ford Motor Company
FSLW	Friction stir linear welding
FSP	Friction stir processing
F-SPR	Friction self-piercing rivet
FSW	Friction stir welding
FY	Fiscal year

Abbreviation	Definition
g/cc	Grams per cubic centimeter
G3-5M	A grade of cold-hardened nickel-based steel alloy with 5% molybdenum
GHG	Greenhouse gas
GM	General Motors
GREET	Greenhouse gases, Regulated Emissions, and Energy use in Technologies
h	Hour
H11	Chromium-based steel alloy from the “H” family of steels with outstanding impact toughness
HiVe	High velocity
HPDC	High-pressure die-casting
HP-RTM	High-pressure resin transfer molding
HTC	High-temperature carbonization
HTC6 and HTC8	High-temperature carbonization trial number
ICME	Integrated computation materials engineering
I, II, III, IV	Roman numerals for 1, 2, 3, 4
IMC	Intermetallic compound
Inc.	Incorporated
in/min	Inches per minute
iPP-CF30	Designation used for a specific sample
JR	Company name JR Automation
kg	Kilogram
ksi	Kilopound per square inch
KUKA	Company name for Keller und Knappich Augsburg, manufacturer of industrial robots
kWh/lb.	Kilowatt hours per pound

Abbreviation	Definition
LCA	Life cycle analysis
LightMAT	Acronym for the Lightweight Materials Consortium
LLC	Limited liability corporation
LLDPE	Linear low-density polyethylene
LMCP	Lightweight Metals Core Program
LoukusTech	Loukus Technologies, Inc.
LTC	Low temperature carbonization
M	Million
MESC	Multifunctional Energy Storage Composites
Mg	Magnesium
ML	Machine learning
MMC	Metal matrix composites
Mn	Manganese
MoS_2	Molybdenum disulfide
MPa	Megapascal
MRD	Molecular Rebar® Design
MRL	Manufacturing readiness level
Msi	Megapound per square inch
MXene	The name for a new class of graphene like two-dimensional transition metal carbon (nitrogen) compounds
N/A	Not applicable
NDE	Nondestructive evaluation
Ni	Nickel
NREL	National Renewable Energy Laboratory
OEM	Original equipment manufacturer
ORNL	Oak Ridge National Laboratory

Abbreviation	Definition
P1A	Project task within Thrust 1 of the LMCP
P1B	Project task within Thrust 1 of the LMCP
P1C	Project task within Thrust 1 of the LMCP
P1C1 and P1C2	Project task within Thrust 1 of the LMCP
P2A	Project task within Thrust 2 of the LMCP
P2B	Project task within Thrust 2 of the LMCP
P2C	Project task within Thrust 2 of the LMCP
P3A	Project task within Thrust 3 of the LMCP
P3B	Project task within Thrust 3 of the LMCP
PAN	Polyacrylonitrile
PECAN	Polyester Covalently Adaptable Network
PET	Polyethylene terephthalate
PI	Principal investigator
PMCP	Powertrain Materials Core Program
PNNL	Pacific Northwest National Laboratory
PP	Polypropylene
PVDF	Polyvinylidene fluoride
R&D	Research and development
rCF	Recycled carbon fiber
SBIR	Small Business Innovation Research
ShAPE™	Shear assisted processing and extrusion
SHM	Structural health monitoring
SLIC	Sustainable Lightweight Intelligent Composites
SMART	Specific, Measurable, Attainable, Relevant, Timely
SMC	Sheet molding compound

Abbreviation	Definition
Sn	Tin
SRNL	Savannah River National Laboratory
T6	Temper designation for Al that is heat-treated at a temperature between 325°F and 400°F to increase the strength
TCI	Terephthalolyl chloride
TEA	Techno-economic analysis
TiB_2	Titanium diboride
TPIC	Tillotson Pearson Incorporated Composites
TRA-C	Company name TRA-C Industrie, a FSW supplier
TRL	Technology readiness level
TuFF	Tailorable universal Feedstock for Forming
UCC	Ultra conductive copper
UHMWPE	Ultra-high molecular weight polyethylene
U.S.	United States of America
USW	Ultrasonic spot welding
VDA	Company name for Verband der Automobilindustrie, the German Association of the Automotive Industry
vs.	Versus
VTO	Vehicle Technologies Office
Zr	Zirconium

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